ASSESSING THE EDUCATIONAL GAPS IN AERONAUTICS AND AIR TRANSPORT

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Executive Summary

Objectives and Background

The overarching objective of EDUCAIR project was to improve the match between needs in human resources, and the educational and training offer of engineers and researchers within the Europe Union Aviation Sector for the horizon of 2020. Such objective results from an assumption that a misalignment or gap between the Competences (& Skill) required by the Industry the assumption and those provided by the Educational Institutions and Students could exist. Also, if such Gap was left unattended, it could result in underperformance of employees, with the negative consequences for the EU's Aviation Sector.

EDUCAIR project included other important objectives. A second objective of the project was to identify the key attractiveness and repulsion factors for studying and working in the Aviation Sector. These factors could be pivotal to understand how to attract more students into educational programmes in Aviation and consequently more graduates into the Aviation Industry. A third objective was to forecast the amount of jobs in the EU Aviation Sector for the year 2020. This will provide relevant information on the short term needs of graduated students. A final objective was to review and characterise the current educational offer on Aviation (and related fields) within the space of the European Union. Indeed, information on this topic is relative scarce and disperse among different institutions.

To understand the background in which this project is situated, it is important to look at the trends which have an impact on the scope. Analyzing different forecasts of manufacturers such as Airbus and Boeing help us grasp the true technological dynamics and these are then complemented with general forecasts. Two main trends can be distinguished. First of all, traffic will increase thanks to the fact that air transport becomes more accessible to people all around the world. Liberalization makes markets better accessible for airlines, which in turn charge lower prices to their passengers. This in combination with the growing wealth ensures the increase of the demand for air transport. Furthermore, people will travel more between (new) population centers. Here, it is important that the right (sized) airplanes are serving the markets. Short-haul flights will be chielfe performed by relatively small aircraft and the (very) large aircraft will mainly fly long-haul flights. The second large trend that was identified is the fact that the Aviation industry will want to keep innovating. Doing this, the costs for airlines can be reduced by increasing the productivity and efficiency. Good air traffic management and improved technology are crucial here. Furthermore, it is also important to reduce the environmental costs, fuel- and noise-related. Because more and more airplanes are needed, which also have to be eco-friendly, the demand for qualified personnel increases.

Designers, builders, technicians etc. have to have the right competences to deliver the aircraft needed. Especially engineers will be required as in the aircraft industry those jobs represent a large proportion within the sector.

Attractiveness and Repulsion Factors for Working and Studying in Aviation

The analysis to the Attractiveness and Repulsion Factors for studying and working in the Aviation Sector was based on a wide scale online survey to students, employees and graduated students in Aviation domain but working elsewhere.

Concerning the attraction factors, we could identify an overlap between employees and students' perceptions. Although varying the description among respondents, three key attraction factors emerged from the analysis of the results, as follows:

- *Attractiveness Factor 1: Fascination of Aviation sectors* – both employees and students referred often and often that a fundamental reason for ever entering an aviation or aeronautics graduation was the enthusiasm or fascination for this industry, in particular, on airships or spaceships;
- *Attractiveness Factor 2: Challenging carrier and development path* – employees' referred (and students' mentioned a strong belief) that the ever-changing and always-challenging nature of a job in Aviation was a key factor for pursuing a carrier in this sector.
- *Attractiveness Factor 3: Employment and working benefits* – the above-average conditions and benefits, coupled with high competence requirements and responsibilities was also mentioned as a positive factor.

Interestingly both employees and students agreed on the attraction factors. This denotes that the attraction factors have not been changing over time.

Looking now into the repulsion factors, the employees' answers focussed around three main repulsion factors as follows:

E1. *cumbersome regulatory and legal framework*,
E2. *heavy theoretical with unperceived connection with real practice*,
E3. *reduced amount of practical working hours*.

Whereas the students' answers allowed the identification of the following ones:

S1. *above-average difficulty and lengthy of the programme*,
S2. *excessive theoretical contexts*,
S3. *insufficient emphasis on practice*.

There is a perception in the EU about a steady decline in the level of attractiveness of Aviation industry over the last years. A total of seven factors and trends were already identified as lying at the root of this problem. Although EUCAIR's surveys cannot provide evidence to support the existence of these trends, they can be used to infer about their relevancy and validity. From the surveys we can infer the following conclusions for each trend.

Assessment of the Trends on the Attractiveness of Aviation for Working and Studying

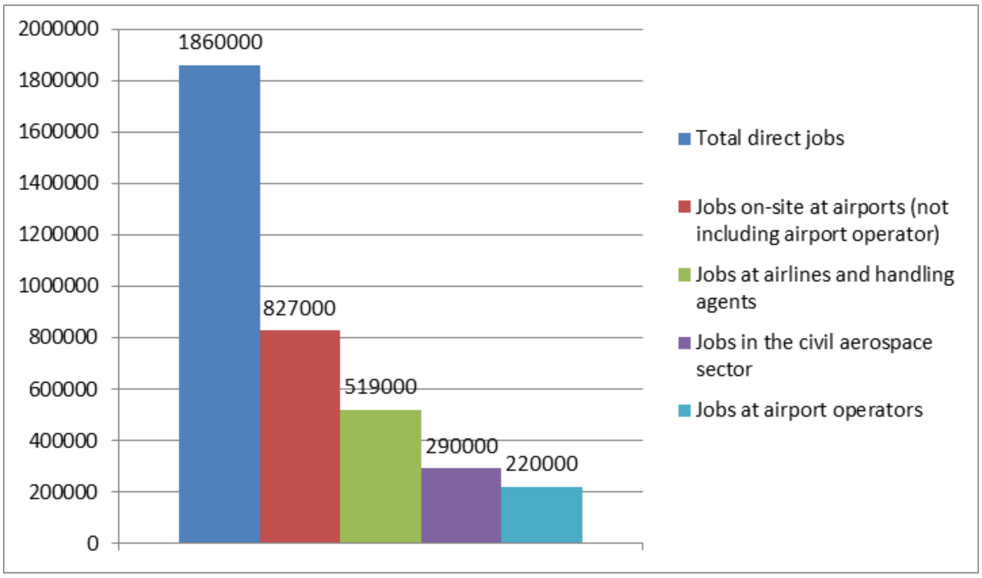
Trends	Impact on the Attractiveness	Discussion
Progressive loss of interest in scientific or technical carriers	High	Both employees and students referred that the technological nature of aviation and aeronautics was a relevant factor in their decision making process (Attractiveness factor 1 and 2);
Progressive loss of prestige of the Air Transport and Aeronautic Sectors	High	Attractiveness Factor 1 provides strong evidence towards the relevancy of this factor;
Progressive reduction of students' interest for mathematics, physics and other sciences	Some	It is indirectly supported by the surveys in the sense that some students referred that a reason to choose Aviation education was the emphasis in mathematics and analytical reasoning
Technical carrier is inferior to management carrier	None	It is not supported by the surveys, as any employee mentioned a feeling of inferior by having a more technical job.
Educational paradigm has changed favouring the teaching of soft-skills in detriment of hard-skills	Low	Surveys do not provide definitive answer, but many students complain about the too heavy lectures on mathematics, physics and other analytical disciplines (repulsion factor E2). This repulsion factor may denote that the teaching of these disciplines has not been softened.
Reduction of systems engineering-related courses	-	The surveys cannot conclude anything towards this factor.

Job Availability

One of the aims of this project was to assess the number of jobs in Aviation today and in the time horizon of 2020. In 2010, the direct employment by Aviation within the European Union is estimated to be about 1.7 million jobs, while the indirect effect includes 2 million jobs, the induced effect 0.9 million jobs and the catalytic effect due to tourism 3.2 million jobs (Air Transport Action Group, 2012b).

The evolution of employment numbers until 2020 was predicted on a disaggregated basis for airlines, airports, the (civil) aeronautics sector and ANSPs based on previous year's evolutions in relation with different independent variables such as GDP, FTK etc. As basis the share of engineering jobs in aeronautics was estimated to be between 30% and 35%, at airport operators between 15% and 25% and in airlines between 5% and 10%. The amount of direct engineering related jobs in 2010 was around [103,200; 120,400] in civil Aeronautics, around [20,500; 34,100] in Airports, and around [21,200; 42,400] in Airlines. The number of jobs in Aviation is calculated to evolve, in 2020, to about [121,000; 141,200] jobs in Aeronautics, around [34,200; 57,000] jobs in Airports, and [26,667; 53,300] in Airlines. The number of jobs for Air Traffic Control Officers is estimated to grow from between 13,236 and 13,857 in 2010 to between 16,839 and 17,628 in 2020.

Jobs supported by Aviation in Europe, 2010



Job Availability of EU Aviation Industry

Year	Airport Domain		Airline Domain		Aeronautics Domain		ANSP Domain	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
2010	20 464	34 107	21 229	42 458	103 208	120 409	13 236	13 857
2013	23 389	38 981	23 138	46 227	108 582	126 679	13 554	14 190
2017	28 926	48 210	25 093	50 186	115 263	134 473	15 343	16 063
2020	34 227	57 046	26 667	53 333	121 071	141 249	16 839	17 628

Review of Aviation Educational Offer

Educational tools and techniques also evolve remarkably: educational programs nowadays provide a more international focus. Furthermore, traditional chalk and talk teaching was (and will be) gradually replaced by active learning and learning through practice. Also the individual perspective was transformed into team work to acquire the wanted skills. In air transport education an international focus is desirable and possible, as was shown by studies by Torenbeek (2000) and Atici & Atik (2011). Furthermore, in air transport education new educational techniques are applied. One of the many examples is that ICAO focuses on competence based training, putting the focus on performing rather than just knowledge, or the use of blended training.

One major part of work performed within the EDUCAIR project relates to the identification and review of the existing educational offer (supply-side) in terms of relevant educational programmes in Aviation at EU27. As far as the 1st and 2nd cycle programmes are concerned, the review was focused on academic degree programmes in Aviation, as well as Lifelong Learning (LLL) and professional or corporate programs (Continuing Professional Development - CPD). Overall, the identified educational offering for the 1st and 2nd cycle of Aviation programmes contains (presented in detail within WP4/D4.8 Deliverable): i) 251 educational programmes offered by more than 100 Educational institutions / Educational Institutes at 22 European countries and ii) 193 LLL/CPD programmes offered by more than 25 educational institutes, key industry actors, international associations or educational institution-industry alliances.

Selected cases of the identified programmes were thereafter reviewed in more depth mainly with view to their key characteristics, structure, and course offering. A dominant observation stemming from the analysis of the reviewed 1st and 2nd cycle Aviation programmes is that engineering education varies considerably with the different educational systems. The engineering profession itself and particularly the "Engineer" interpretation differs across the various European countries and worldwide. Some harmonization of the educational studies across Europe has been achieved with the Bologna 3-5-8 scheme. Although there is substantial progress made towards the Bologna Declaration aims and many Educational institutions have adapted their programme structures to the proposed new scheme, the harmonization process has still some way to go in terms of harmonization and standardization of the educational offering. The next important steps towards harmonization and standardization are mainly related to the types of degrees offered, the duration of studies, as well as the course credits, structure and content, while simultaneously leaving some room for diversity of student profiles and flexibility to the students to build a customized / specialized portfolio of competences.

Despite some differences between countries, educational systems or programmes, there are some similarities or common features among engineering programmes in Aviation. These are mainly related to the temporal structure of studies and the main course categories offered in respective years of studies. Based on the review of engineering programmes of the 1st and 2nd cycle, it was clearly concluded that fundamental sciences and general engineering courses represent by far the dominant category in 1st cycle engineering and integrated Master's engineering programmes (MEng). Specialized aerospace/aeronautical engineering courses are similarly weighted in all cycles of engineering programmes. It is, however, important to underline the fact that airport, airline, and ATM/ATC-related courses are hardly available in engineering programmes but represent almost half of the educational offering of 2nd cycle EU Management Aviation programmes. This observation reveals the strong complementarity between relevant engineering and management programmes in Aviation. Finally, an interesting finding of the review was that although professional accreditation / licensing (directly awarded to students) is common, academic accreditation awarded on the basis of a certain academic programme is sparsely offered. Therefore, there seems to be a need for a European-wide academic accreditation system that should build on recent initiatives (e.g., PEGASUS Partnership) and pursue synergies with other accreditation bodies / associations (e.g., ENAEE/EUR-ACE, ENQA) towards the establishment of an accreditation system for Aerospace Engineering education in Europe.

Regarding the education and formation for researchers (3rd Bologna Cycle), the aim was mainly twofold: (1) to identify the current offer (supply) of educational programmes (3rd Bologna Cycle) in Aviation; and (2) to perform a review of the educational curricula of those programmes according to a well-designed template in order to compile the important information of the Ph.D. Programs.

Educational institutions fully recognise that they have the responsibility to offer doctoral candidates more than core research disciplinary skills based on individual training by doing research. Kivinen et al. (1999) emphasized that in industry and commerce, unlike in academia, a doctoral thesis is not seen as evidence of employability. Educational institutions are certainly most aware of this fact and are increasingly introducing courses and modules offering transferable skills training and preparing candidates for careers in various sectors.

The culmination of the Bologna process needed a basic line establishing two pillars of the knowledge based society: "European Higher Education Area (EHEA) and European Research Area (ERA)", in order to promote the key role of doctoral programmes and research training in the context of increasing the competitiveness of the European region.

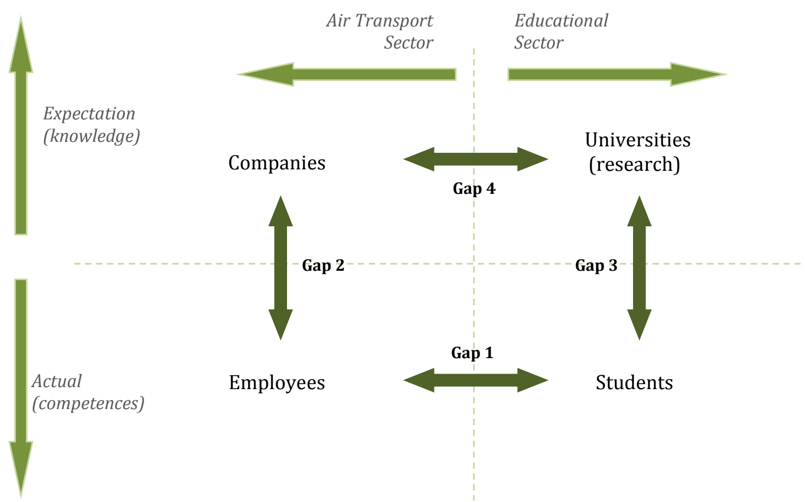
Thus, the third cycle in the Bologna Process became apparent as there was a need to promote closer links between the EHEA and the ERA in a Europe of Knowledge, and of the importance of research as an integral part of higher education across Europe. Therefore, Ministers considered it necessary to go beyond the focus on two main cycles of higher education to include the doctoral level as the third cycle in the Bologna Process. They emphasised the importance of research and research training and the promotion of interdisciplinary in maintaining and improving the quality of higher education and in enhancing the competitiveness of European higher education more generally. Ministers call for increased mobility at the doctoral and postdoctoral levels and encourage the institutions concerned to increase their cooperation in doctoral studies and the training of young researchers.

Research training and research career development - and the need to increase the number of highly qualified graduates and well trained researchers – are also becoming increasingly important in the debate on strengthening Europe's research capacity. The aeronautical and air transport sectors are not an exception regarding this need.

Skills and Competence Gaps

The following figure presents the framework used to assess the Skills & Competences Gap in the Aviation Sector.

The Four Gap Famework



This framework identifies four gaps, being:

- **Gap 1 -** Competence Gap - Gap between the competences that the employees need and the actual competences of the students (i.e. to what extend are the student's competences actually useful in their working daily activities?);
- **Gap 2** - Gap between the knowledge that the companies need and the actual competences of the employees (i.e. to what extend do the employees' competences actually fit in their companies' competences requirements?)
- **Gap** 3 - Gap between the knowledge the educational institutions generate and the actual competences of the students (i.e. is the knowledge generated in the research transferred in the courses?)
- **Gap 4** - Gap between the knowledge the companies need and the knowledge the educational institutions have (i.e. is the educational institutions' research and teaching activities of relevance for the companies?)

In theoretical terms, gaps may reveal different perceptions of relevancy, which in turn may eventually lead to some distress among agents. The point is that agents tend to naturally focus their efforts in mastering the most relevant Skills or Competences. If two agents have different perceptions about the relevancy of Skills and Competences, they will naturally concentrate their efforts in different Skills and Competences. Consequently, each one may perceive that the other is not concentrating on the fundamentals, or each one may perceive that the other is not proficient on the most relevant Skill or Competence, which may then result in some sort of stress or underperformance.

A total of seven skills were considered in the analysis, being:

1. Problem Solving
2. Analytical Background
3. Technical Background
4. Theoretical Background
5. Oral and Written Communication
6. Leadership
7. Ability to work in a multidisciplinary team

The overall results reveal that *Skill 1 – Problem Solving* was consistently ranked higher than the other Skills. Conversely, *Skill 4 – Theoretical Background* is consistently ranked lower than the other Skills. The relative positioning of *Skill 4 – Theoretical Background* was somewhat unexpected, since we were expecting that a strong theoretical background would be perceived as relevant. The results show a mixed behaviour concerning the relative positioning of the remaining Skills, with no apparent pattern emerging among the different group of respondents. In addition to the analysis of the relative valuation, an analysis to the absolution valuation of Skills also offers interesting insights. Foremost, there is a wide recognition about the relevancy of all Skills in a professional carrier in Aviation sector. The results show that Skills were valuated above 2.5 and often above 3.5 (in a scale of 1 to 4), in the vast majority of the cases. Also, the results denote a consistency and similitude of perspectives among groups of respondents since there is a visible alignment in the valuation of the Skills.

- Employees – Students Skill gap Assessment:

  Skill Gaps requiring corrective actions were not found. Minor gaps in the Aerospace and Aeronautics, Civil and Other Engineering Programmes were indeed identified, but without significance.

- Companies – Employees Skill Gap Assessment:

  Multiple minor gaps without significance in all domains, concerning Skill 3, Skill 4, Skill 6 and Skill 7, were found. Skill 6 on the other hand exhibited a relevant Gap that could require corrective actions, although the relative amount of answers does not allow reaching solid conclusions. As such, we recommend conducting further analysis.

- Educational Institutions – Students Skill Gap Assessment

  Gaps were found in the Aeronautics and Aerospace, Mechanical and Other Engineering Programmes, in Skill 2, Skill 3, Skill 6 and Skill 7. Among the Skills generating Gaps, *Skill 7 - Ability to work in a multidisciplinary team* is the only one appearing in all situations.

- Companies – Educational Institutions Skill Gap Assessment

  Gaps were found in all domains in Skill 2, Skill 3, Skill 4, Skill 6 and Skill 7. A distinction between Engineering and Non-Engineering Educational Institutions was made. In overall terms, Non Engineering Educational Institutions tend to exhibit more and more significant Skill Gaps, which can be explained by a lower knowledge about the reality and needs of the aviation sector. Also, *Skill 4 – Theoretical Background* exhibits a Gap in all domains and always with a overvaluation by the educational institutions.

  Concerning the engineering education institutions, *Skill 7 - Ability to work in a multidisciplinary team* exhibits a significant gap in all domains with the exception of ANSPs. All Gaps result from an undervaluation by the Educational Institutions. Such results may evidence a situation in which educational institutions do not perceive the relevancy of the skill in the same way as companies. More studies are required, but if proved correct, graduate students with not enough skills may be leaving our Educational Institutions.

Corrective measures depend on the location and significance of the Skill Gap. The results reveals multiple gaps, but although the vast majority exhibits minor relevancy. Considering that deviations between agents' perceptions is natural and results from different perceptions and roles, we consider not having need for any special corrective measures. In any case, we could identify three skills that may require further studies and eventually tailored actions, being:

- Skill 4 – Theoretical Background, in Companies – Educational Institutions interactions;
- Skill 6 – Leadership, in Companies – Employees interactions;
- Skill 7 – Ability to work in multidisciplinary teams, in Educational Institutions – Students and Companies – Educational Institutions interactions.

The Gap in Skill 4 results from a high valuation by educational institutions compared with the companies. This can be interpreted as a more academic, and thus theoretical, perspective by the former group versus a more practical perspective of the latter group. Obviously, we cannot state that excess of theoretical knowledge is negative, indeed, theoretical knowledge is one of the best ways, although not the only one, to develop problem solving skill which everyone agrees is essential. In worst case, graduate students simply do not make use of the skill. What could be relevant is to understand the reasons leading companies and employees' to have a low perception about these Skills. This could provide insights on actions to improve and to better explain these agents the relevancy of a good theoretical background.

The Gap concerning Skill 7, the situation is worrisome since we repeatedly identified situations in which companies overvalue above educational institutions and, to great extent, students. The results are consistent across domains and may evidence that educational institutions may not be giving enough attention in the development of these skills by the students, which can eventually lead to underperformance. This results requires further investigation and, if proved accurate, intervention mainly by incentivising educational institutions to have propaedeutic disciplines on this matter and promote working groups.

A total of 88 competences were analysed in EDUCAIR project, divided in 19 aggregated competences along 4 domains (Airlines, Airport, ANSPs and Manufacturers). Likewise the Skills Gaps, the Competences Gap assessment followed the rational laid down in Figure 5.4. It was done on a pair basis between Companies, Employees, Students and Educational Institutions. The students were asked to value the relevancy of the competences (perceived relevancy) and asked to rank their level of proficiency on every competence, so additional analysis were undertaken. It is important to emphasise that the amount of answers greatly vary among domains and agents, which conditioned the nature of the analyses. Indeed, the analyses were defined in function of the available data. Although not being optimal, this option increases the reliability and accuracy of the results.

In theoretical terms, a competence gap or misalignment results from a difference in the agents' perceptions on the relevancy of a given competence for performing a given task. Gaps may occur from asymmetric information between agents, in which one agent may feel some need earlier than other just because it has privileged access to some information. Other situation that may generate Gaps results from agents' different positioning in the value chain. That is, each agent has its own strategies, objectives, limitations and background experience. Therefore, we may expect differences of perception towards a given competence (for example: students may prefer practical experience in detriment of theoretical one, while educational institutions may prefer the opposite. While the second source of gaps does not require corrective measures, the former source does require.

In overall terms, the results to the Educational Institutions reveal two important features. Foremost, all competences are taught which means that European Educational Institutions are able to provide every required competence. Secondly, results show a wide dispersion about the frequency of teaching of the competences, albeit some patterns are recognisable. In our sample, the competences related with the domain of Airlines, Airports and ANSP are always taught is less than half of the Educational Institutions. The same does not happen with the Manufacturer related competences, in which a significant part (around half) is taught in more than half of the sample.

Looking now into each Competence gap, we have:

- Employees – Students Competence Gap Assessment

  The results show a wide Gap in all educational backgrounds and domains. Yet, the situation is likely of no major concern, since the gap results from an overvaluation of students vis-à-vis employees. Employees have already a good understanding about the relevancy of the competences, whereas students are still acquiring them and do not have yet time to grasp their actual relevancy. Even so, if required, corrective actions should increase the contact of Students with Companies, preferably in the Company's premises, if not, by bringing the Companies into the Education Institution (Open Days or Fairs).

- Companies – Employees Gap Assessment

Gaps are visible in all domains of activity for a considerable number of Competences (around half of them). The majority of the Gaps are however minor and only a fraction are significant. The situation is of concerns as the Gaps invariantly result from an overvaluation of the companies versus the employees. It may evidence a lack of knowledge by the Employees about their Company's real needs. As a consequence, the Company may be feeling needs for some given Competences that Employees are not aware of and, consequently, may be not mastering. In this case, we recommend conducting further analysis to the Gap and, if proved accurate them corrective measures should be implemented. Naturally, the measures will depend on the actual dimension of the Gap in each company, but it may include improvements in the internal communication (e.g.: strategic and management objectives, new projects or new challenges) and promotion of long life educational courses.

- Educational Institutions – Students Gap Assessment

The results reveal Gaps in the majority of the cases. The Gaps invariantly result from the students' high valuation and the relatively frequency of teaching competences, leading to a Gap. The Gaps must be analysed having in mind the discussion already undertaken in the Employees – Students Gap. Students have highly valuated every single Gap, which may indicate that students still lack knowledge on the actual importance of each gap (and, in doubt, ranked them all very high). Therefore, the Gaps between Educational Institutions and Students do not appear worrisome. In any case, corrective actions can be deployed. Indeed, the corrective action already proposed to the Employees – Student Gap can also provide help in this situation. An increased contact with Companies will lead to a more mature valuation. Other corrective actions may include improved explanations and demonstration of the validity and relevancy of the curricula, so that students could understand it and therefore adjust their expectations (like for example: a 1st-year/2nd-year series of seminars on the topic: Introduction to Aerospace Engineering).

- Educational Institutions – Companies Gap Assessment

The results reveal Gaps in all domains (Airlines, Aiports, ANSPs and Manufactures) and all Educational Programs (Engineering and Non-Engineering), although with less intensity than with Students. Gaps emerging from high relevancy and low frequency of teaching are worrisome, since they may evidence cases of misalignment between Educational Institutions' curricula and Companies' needs, which in turn may lead students to graduate with an incomplete set of competences.

Corrective actions include increasing the information exchange between Companies and Educational Institutions aiming to reduce the natural asymmetry. This can be done by the development of info days, seminars or participation in students' works. Another corrective action is to increase the flexibility of the Educational offer. Many of the competences analysed can easily be provided through short to medium-term courses. These courses can be held in parallel with existent disciplines (of the main stream programs) to external students (as lifelong learning programs) or given as extra credits. These type of courses have typically less restrictions in terms of accreditation and preparation, therefore they can be given almost on an ad-hoc basis and tailored to the Companies' actual requirements.

Based on this assessment, the following Recommendations are proposed:

1. Strengthening Companies and Educational Institutions interactions:
   - ✓ Fiscal benefits to support research;
   - ✓ Support mobility between industry and academia of employees and researchers (expand People Programme – Marie Currie and similar)
2. Improve the visibility and readability of Aviation-related courses:
   - ✓ Further support and incentives to internships or on on-job working
   - ✓ Explaining and promoting the understanding of Curricula
3. Support and incentivise Life Long Learning (recycling and updating competences)
   - ✓ Supporting Companies with their human resources' formation;
4. Incentivise Educational Institutions to offer tailored Short to Medium term Courses: Credits Awarding (reinforce Bologna Systems)

The research works of EDUCAIR project revealed a relevant flaw in the European Civil Aviation Sector: the absence of accurate and reliable data sources concerning Education and Employment. Indeed, a key problem felt during the execution of the works was the difficulty in gathering the required information. Such difficulties brought problems in the analysis to the job availability, review of educational offer and execution of the surveys.

Considering Employment, the available statistics are scarce, incomplete and only available at aggregate level. The situation concerning Education is somewhat better but still far from satisfactory. Data about students and/or graduates of engineering programmes in Aviation are not available at central EU level, while these are only sparsely available (and in some cases for engineering graduates as a whole) at national statistical agencies. Such situations prevent the development of robust statistical about the state and development of the EU Aviation Sector.

Based on the above, we recommend the establishment of an European Observatory for Education and Employment in Civil Aviation. The Observatory would be responsible for collecting standardised data about relevant Educational offer and Employment figures of the Aviation sector at EU level. The Observatory would enable the development of robust and valuable statistical analysis about the state of development of EU Aviation Sector.

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1 Introduction

1.1 Background and Motivation

The European Air Transport System is a vital element to European mobility and a significant contributor to European wealth. The resulting benefit is spread across all Member States, with an estimate of 2.6% GDP and 3 million jobs directly linked to air transport. Tourism and business travel have led to a strong development in airport capacities at a worldwide level, supporting millions of jobs in both developed and developing countries. Additionally, air transport sector has arguably been a major catalyst of Globalisation and one of the main pillars of nowadays economies and societies. The world economy is now increasingly dependent on air travel, also with a growing share of freight, in terms of value, conveyed by air. Not surprisingly, air traffic enjoys a continuous growth ever since the advent of civil Aviation, both in terms of passengers and of freight carried[1]. Looking back, since 1945 world passenger traffic grew at an average annual rate of 12%; from 1960 a 9% annual growth is reported, with freight growing at a rate of 11% per annum and mail at 7%. As the industry grew and matured, a decrease in growth rates is observed; nevertheless a growth of 5% per annum was registered in the period 1985-95. The first historical decline occurred in 1991 due to the Gulf War, followed by a slow recovery in the following years, as a result of the economic recession. The current economic turmoil is negatively impacting the growth of the air transport he recent contraction, but available forecasts say that the effect is only temporary. Indeed, air traffic is expected to continue in the future, leading to a doubling in traffic every 12 years (TRKC, 2010).

The European air transport sector has however been a victim of its own success. The notable growth has nearly resulted in a gridlock of the air transport system, with negative consequences in the respective performance or growth of the agents. In fact, the sector faces nowadays considerable challenges to its growth. Section 2 discusses in detail the major challenges currently impacting the European Union Aviation sector. In face of such challenges we may conclude that the European air transport system is at a crossroad with a need of fitting an ever-growing traffic volume into a fixed-capacity infrastructure and under an increasingly complex web of constrains. At this moment, there are no simple answers for tackling these challenges. However, we may assert with confidence that none of the above mentioned challenges can be faced without adequate human resources.

The future developments in the Aviation sectors will be fundamentally linked to the education and formation of the human resources. Indeed, it is widely recognised that the long term competitive

[1] More information on Section 2.

advantage of the European air transport system can only be sustained through the continuous qualification of our human resources.

The recent dynamics and evolutions have indisputably brought changes in the demand of professional competences for working in air transport- and aeronautics-related professions. Arguably, the very nature of the professional competences has evolved in parallel with the progressive modification in economies, societies and, ultimately, in the air transport systems. As such, we naturally conclude that prospective employees have to master the current (and ideally future) competences, so that they could aspire to become competent professionals. Since prospective employees are firstly students, this entails educational institutions and other education institutions to permanently update the courses and the curricula. In face of the constant changes, there is a risk of mismatch between the prospective employees' competences and the market's actual requirements. And if such mismatch is not addressed, there is the danger of emerging competence gaps that may eventually affect the competitiveness and efficiency of the European Aviation sectors (Figure 1.1).

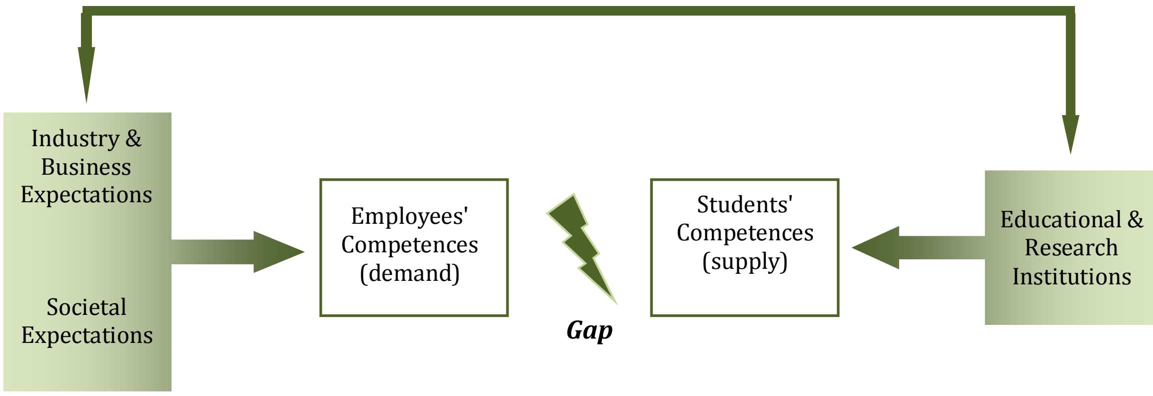


Figure 1.1 - Potential competence gap

These problems had already been identified by the European Commission, which has been deploying a series of efforts (such as: funding research, directives and regulation, or incentives and dissemination) to foster the education of students and qualification of employees aiming precisely to bridge this competence gap.

In parallel, the European Union is undergoing a profound restructuring of its higher education system. Over the last decade, the so-called Bologna Process has been progressively implemented, aiming to establish a common higher education degree structure in the European Higher Education Area[1]. The notion of higher education embraces three types of programmes:

- Educational institution programmes;
- Professional programmes;
- Vocational programmes.

So far, the main focus of attention in the Bologna process was the educational institution programme. Firstly, countries have a clear academic structure made of educational institutions, which eased the harmonisation process. Secondly, the understanding of professional and vocational is not the same in the various countries and, in some, the distinction between professional and educational institution programme is blurred. As a consequence, the first years of the Bologna process were dedicated to the educational institution programmes and, only recently, the other programmes were brought under into the process.

The Bologna process is comprised by a series of high level meetings of the Education Ministers. The following figure (Figure 1.2) presents a timeline of the meetings and respective decisions taken.

The Bologna process was based on two main pillars, being: the European Credit Transfer and Accumulation System (ECTS) and the Diploma Supplement (DS). The European Credit is the basic unit for measuring the amount of work and hence competences transmitted to the students. The ECTS is a mechanism whereby degrees are established and recognised between countries. The DS is a standardised template containing a description of the nature, level, context, content and status of the studies completed by the individual noted on the original diploma. The goal of the DS is to increase transparency of education acquired for the purposes of securing employment and facilitating academic recognition for further studies.

Also central to the Bologna process was the commitment of countries to establish a three cycle degree in higher education, being: graduation, master and doctorate. Typically, first cycle qualifications comprise 180-240 ECTS credits while second cycle qualifications comprise 60-120 ECTS credit. No harmonisation has yet been achieved for the third cycle.

[1] The European Higher Education Area embraces EU27 plus Croatia, Georgia, Iceland, Liechtenstein, Moldava, Montenegro, Former Yugoslav Republic of Macedonia, Norway, Serbia, Russia, Turkey, Ukraine and Holy See.

Timeline of the Bologna process

1998 Sorbonne Declaration	1999 Bologna Declaration	2001 Prague Communiqué	2003 Berlin Communiqué	2005 Bergen Communiqué	2007 London Communiqué	2009 Leuven/Louvain-la-Neuve Communiqué
Mobility of students and teachers	Mobility of students, teachers, researchers and administrative staff	Social dimension of mobility	Portability of loans and grants Improvement of mobility data	Attention to visa and work permits	Challenges of visa and work permits, pension systems and recognition	**Benchmark of 20 % by 2020 for student mobility**
A common two-cycle degree system	Easily readable and comparable degrees	Fair recognition Development of recognised Joint degrees	Inclusion of doctoral level as third cycle Recognition of degrees and periods of studies Joint degrees	FQ-EHEA adopted National Qualifications Frameworks launched	National Qualifications Frameworks by 2010	**National Qualifications Frameworks by 2012**
		Social dimension	Equal access	Reinforcement of the social dimension	Commitment to produce national action plans with effective monitoring	**National targets for the social dimension to be measured by 2020**
		Lifelong learning (LLL)	Alignment of national LLL policies Recognition of Prior Learning (RPL)	Flexible learning paths in higher education	Work towards a common understanding of the role of higher education in LLL Partnerships to improve employability	**LLL as a public responsibility requiring strong partnerships Call to work on employability**
Use of credits	A system of credits (ECTS)	ECTS and Diploma Supplement (DS)	ECTS for credit accumulation		Need for coherent use of tools and recognition practices	**Continuing implementation of Bologna tools**
	European cooperation in quality assurance	Cooperation between quality assurance and recognition professionals	Quality assurance at institutional, national and European level	European Standards and Guidelines for quality assurance adopted	Creation of the European Quality Assurance Register (EQAR)	**Quality as an overarching focus for EHEA**
Europe of Knowledge	European dimensions in higher education	Attractiveness of the European Higher Education Area	Links between higher education and research areas	International cooperation on the basis of values and sustainable development	Strategy to improve the global dimension of the Bologna process adopted	**Enhance global policy dialogue through Bologna Policy Fora**

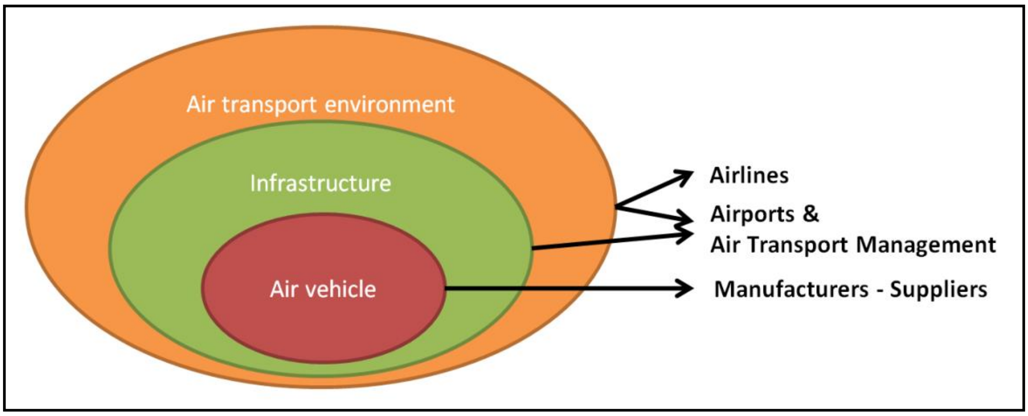
Figure 1.2 - Timeline of the Bologna Process

1.2 Scope

1.2.1 Demand Side

The demand side refers to the labour market that recruits the graduated students in Aviation. Owing to time and budget restrictions, EDUCAIR's scope was limited to the key sectors of the market. These sectors correspond to the large majority of the basic demand and the derived demand for educated staff. Foremost, EDUCAIR will only focus on the civil Aviation labour market, and restrict the geographical coverage to EU27.

EDUCAIR's demand side scope is illustrated in Figure 1.3. EDUCAIR focused on four sectors, being: manufacturers and suppliers of air vehicles, airports, airlines and companies that deal with air transport management. It is also important to add that air vehicles comprised solely aircraft.



Source: EDUCAIR (2012)

Figure 1.3 - Demand side of the Aviation market which will be studied by the EDUCAIR project

At the lowest level, there is the air vehicle. Design and construction of the air vehicle on the one hand and the maintenance of the air vehicle on the other hand can be distinguished. A large fraction of airline costs and activities are related to Maintenance, Repair and Overhaul (MRO). Some airlines do MRO themselves or do MRO for others, other use MRO suppliers or rely on the OEM (Original Equipment Manufacturers). Often, there is a combination of all three.

However, as the aeronautics and air transport sector is more than only the aircraft, we have to broaden the view and, in first instance, also look at the necessary infrastructure and infrastructure management, as well as infostructure, that is needed by the sector, such as airport landside and airside infrastructure management and air traffic control navigation and communication air infrastructure. General air transport management cannot be ignored in this analysis. Air transport management influences the Aviation environment, the aircraft specific domains and the infrastructure and makes sure that the different domains and layers work well together.

The third layer comprises the air transport environment. This environment contains aircraft operations and training, the airport operations, air traffic management and the air transport companies (airlines). It is important to add here, that, next to the air traffic management, there is also the management of the aircraft design, development, testing, certification, production and new versions along the entire life cycle. Managing an aircraft development and production programme is far more complex than managing an airline or airport and should not be omitted or ignored. For example, is it generally known that developing a new airliner costs around ten billion euros; the production of a thousand is worth 100-250 billion euros and life-cycle costs are much higher (Airliner, 2012, several articles). Development takes five to six years, production may span ten to twenty years in different versions and lifetime can be over 40 years. The process involves hundreds of suppliers at four or five levels. Therefore, the technical managers are often senior engineers after some years of experience and aircraft and equipment producers also employ economists, personnel managers etc.

1.2.2 Supply Side

The supply side refers to the higher-education and long life learning institutions that provide training in Aviation. In EDUCAIR the universe of European Union institutions was narrowed down to the educational institutions offering engineering education programmes on the 1st and 2nd level of Bologna. For the education on the 3rd level of Bologna (i.e. PhD programs) and the post doc research, also other educational areas are analysed, for example management/business economics, law, economics/public policy. In addition, lifelong learning programmes (mainly professional or corporate training) aiming to complement knowledge gained through previous education will be also examined. Table 1.1 summarizes the various supply entities that will be covered by the EDUCAIR project.

1.3 Rationale

The overarching objective of EDUCAIR project was to improve the match between needs in human resources, and the educational and training offer of engineers and researchers within the Europe Union for the horizon of 2020 in the Aviation Sector. Such objective results from an assumption that a misalignment or gap between the Competences (& Skill) required by the Industry the assumption and those provided by the Educational Institutions and Students could exist. Also, if such Gap was left unattended, it could result in underperformance of employees, with the negative consequences for the EU's Aviation Sector.

EDUCAIR project included other important objectives. A second objective of the project was to identify the key attractiveness and repulsion factors for studying and working in the Aviation Sector. These factors could be pivotal to understand how to attract more students into educational programmes in Aviation and consequently more graduates into the Aviation Industry. A third objective was to forecast the amount of jobs in the EU Aviation Sector for the year 2020. This will provide relevant information on the short term needs of graduated students. A final objective was to review and characterise the current educational offer on Aviation (and related fields) within the space of the European Union. Indeed, information on this topic is relative scarce and disperse among different institutions.

Table 1.1: Overview of levels and types of education concerning Aviation

	Level of education	**Type of education**
Academic: Educational institution	1st and 2nd cycle of Bologna	Engineering
	3rd cycle of Bologna	• Engineering • Management/ Business Economics • Law • Economics/ Public Policy
	Research (post-doc)	• Engineering • Management/ Business Economics • Law • Economics/ Public Policy
Non-academic: Lifelong learning	Professional/corporate programmes	Engineering

Source: Struyf and Kupfer (2012)

EDUCAIR project explored the roots of an eventual divergence between the demand and the supply of competences. To explore the sources and extend of the competence gap, the assessment framework presented in Figure 1.4 was used. This framework identifies four gaps, being:

- **Gap 1** - Competence Gap - Gap between the competences that the employees need and the actual competences of the students (i.e. to what extend are the student's competences actually useful in their working daily activities?);
- **Gap 2 -** Gap between the knowledge that the companies need and the actual competences of the employees (i.e. to what extend do the employees' competences actually fit in their companies' competences requirements?)

- **Gap** 3 - Gap between the knowledge the educational institutions generate and the actual competences of the students (i.e. is the knowledge generated in the research transferred in the courses?)
- **Gap 4** - Gap between the knowledge the companies need and the knowledge the educational institutions have (i.e. is the educational institutions' research and teaching activities of relevance for the companies?)

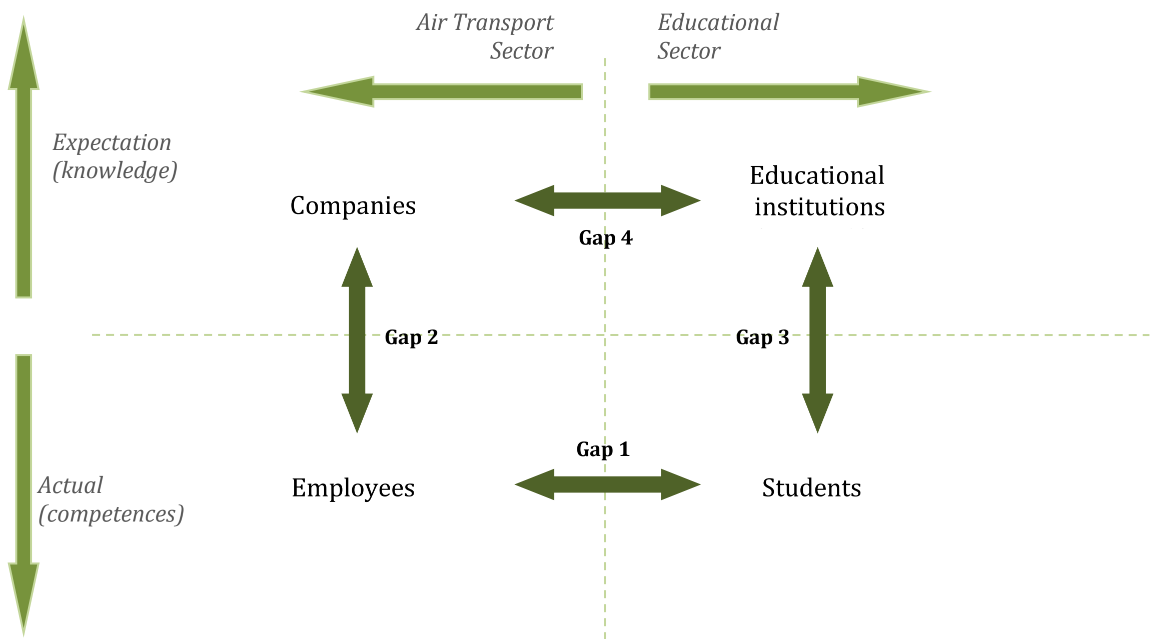


Figure 1.4 - The four gaps framework

Looking again to Figure 1.1 and using this assessment framework, we may identify the four gaps and better understand the positioning and origin of the Competence Gap (Gap). Figure 1.5 identifies the four gaps.

Figure 1.6 presents EDUCAIR's overall methodological approach to assess the four competence gaps. The methodological approach is divided into three stages, being:

1. **Conceptual development** of the competence gap framework and **Identification of the key competence**;
2. **Collection of information** (relevant stakeholder's views and perspective) on the current state of those competences;
3. **Competence Gap assessment** - cross comparison between the *demand* side and the *supply* side for those competences.

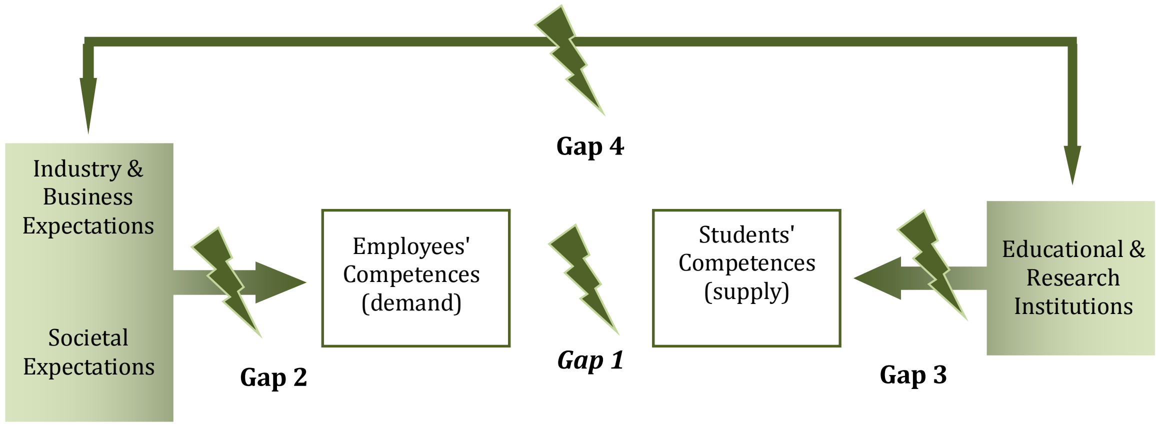


Figure 1.5 - Competence Gaps

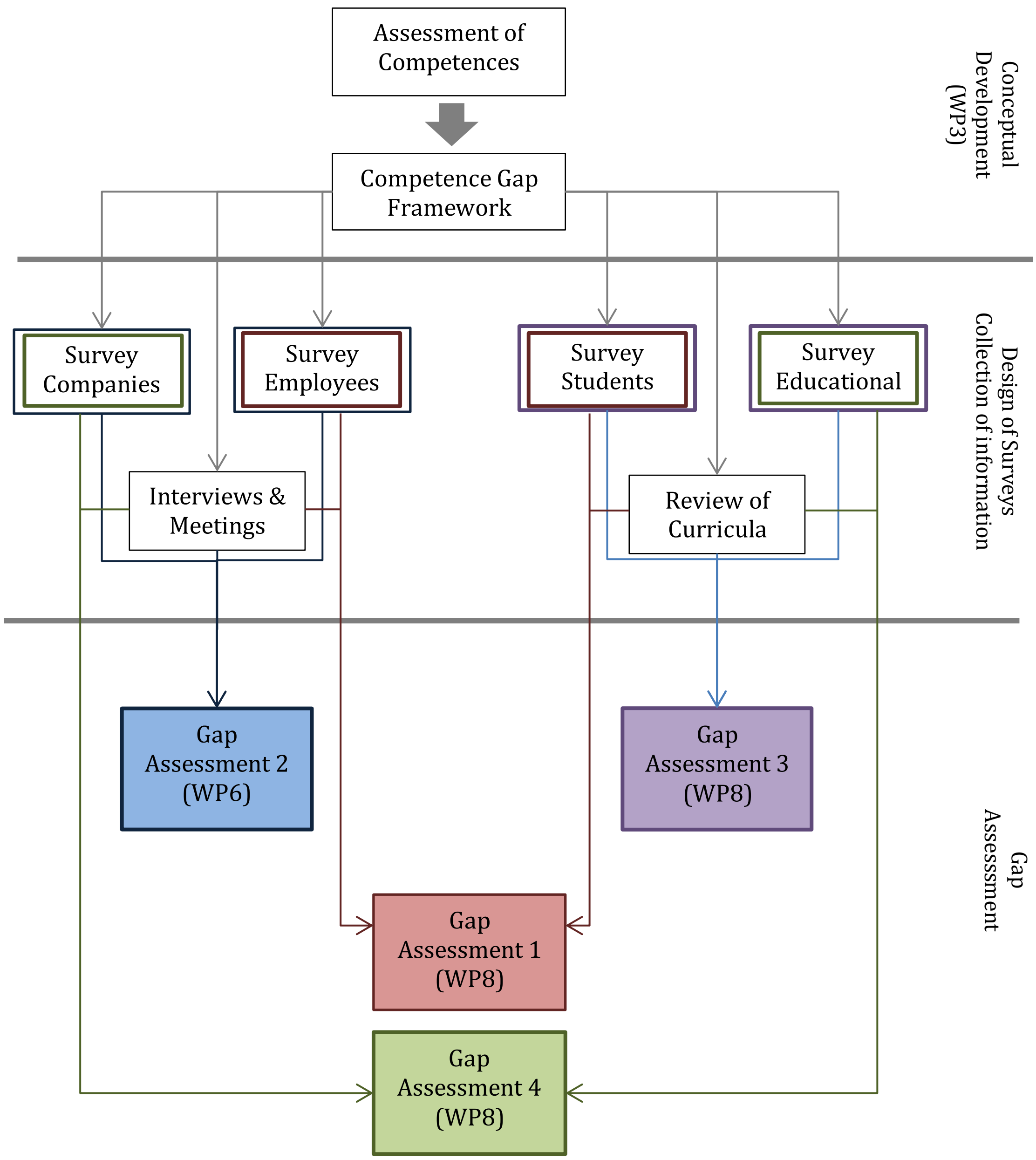


Figure 1.6 – EDUCAIR rationale for assessing the competence gaps

The first stage corresponded to the identification of the key competences in the various relevant stakeholders (that is, companies, employees, educational institutions and students) that led to the conceptual development of the Four Gaps Framework. The second stage comprehended a set of four surveys. The surveys were structured to allow assessing the competences gap. To complement and validate the surveys a set of interviews, meetings and other desktop research was conducted. Upon completion of this second stage, the surveys were disseminated and the interviews and meetings were conducted. Finally, the information from the surveys and other sources were compiled and compared, in the third stage. The assessment of the competence gaps was done through the analysis and cross comparison between the *demand* and the *supply* side on each gap.

This report is structured in 6 sections, as follows:

- **Section 1**, the present one, introduces the reader to the contents of the report;
- **Section 2** provides an overview about the Aviation Sectors in the European Union;
- **Section 3** presents the results of the job forecasting exercise Aviation Sectors in the European Union;
- **Section 4** provides an overview about the current educational offer in Aviation in the European Union;
- **Section 5** is dedicated to the assessment of the competences gaps in the Air Transprot and Aeronautics Sectors in the European Union.
- **Section 6** provides recommendations for overcoming the gaps.

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2 Aviation Sector in the European Union

2.1 Recent Market Developments

The EDUCAIR project studies the current air transport market demand and educational supply to advice on better alignment of both elements in the future. Therefore, it is important to take a good look on the future demand in the air transport sector. Moreover, in the air transport sector, as in every business, it is important for companies to develop a good strategy which ensures a certain market share in the future. To make sure that the strategy is tuned to the future market, actors develop market forecasts. Studying the forecasts of important suppliers of the air transport sector (Airbus, Boeing, Embraer, etc.) gives a look into the future demand and supply. Moreover, figures accompanying the text stem from the forecasts of suppliers.

On the one hand, there are more general forecasts that focus more on traffic evolution and do not provide an insight in the number of aircraft needed or provided in the future (e.g. Eurocontrol, 2010, International Transport Forum, 2011. Forecasts of manufacturers/suppliers, on the other hand, help us understand the true (technological) dynamics with which the air transport market is faced and are thus chosen to be analyzed in this document.

The analysis below is limited to future trends which have an impact on the scope of the EDUCAIR project; it shows developments in (upcoming) markets, in traffic, in construction and the consequences trends have for the technologies used and the competences needed. One has to bear in mind that also other important evolutions will occur, for example in the formation of alliances. However, these evolutions have small or no influence on the elements studied in the project. Therefore, these developments are not discussed.

2.1.1 Global trends influencing today's market

When analyzing future scenarios for air transportation, one needs to look at the bigger picture. Over the last twenty years, non-industry related factors have helped to drive the development of the air transport sector.

First of all, there is the liberalization in air transport that is slowly spreading globally. The Deregulation Act of 1978 loosened the government control on air transport in the US and the deregulation packages between 1988 and 1993 in Europe. From then on, it was easier for airlines to start operations.. Furthermore, open skies agreements opened up the markets for foreign access, which reduced the barriers for competition even further. This all resulted in a situation where airlines are (more) free to enter the market and therefore, competition increased. Derived effects are the decrease of airfares especially with the success of Low Cost Carriers and the improvement of service quality making air transport even more attractive and available. One could say that, also due to the deregulation, passengers have more travel options and air travel demand has increased. Also a trend towards consolidation was seen as smaller and/or loss-making airlines were absorbed by large ones.

The second trend influencing is the urbanization: more and more people tend to move to and settle in cities. For the first time in history, more than half of the world's population lives in urban centers. Cities have become a major driver of globalization and the engine of economic growth. They have quickly transformed the economies through international trade, attracting large multinational corporations, international media and foreign tourism. Importantly, a rise in urban population has historically led to an increase in per capita GDP, a key driver for Aviation (Airbus, 2011, p.18).The rise of such cities implies a greater need for secondary airports – to eventually reduce the added pressure on existing airports - and aircraft (of the right size) to serve these new markets.

Another important trend is the consolidation of large airlines and the disappearance of smaller airlines. Furthermore, the sector is confronted with the emergence of alliances and low-cost carriers. These evolutions have implications for the demand of aircraft. Low-cost carriers for example tend to use one type of aircraft.

2.1.2 The growth of the air transport sector

The Aviation industry, as any industry, faces several challenges: political turmoil, natural disasters, financial crises, etc. Nevertheless, as can be seen in Figure 2.1, the world annual traffic grew tremendously over the last decades.

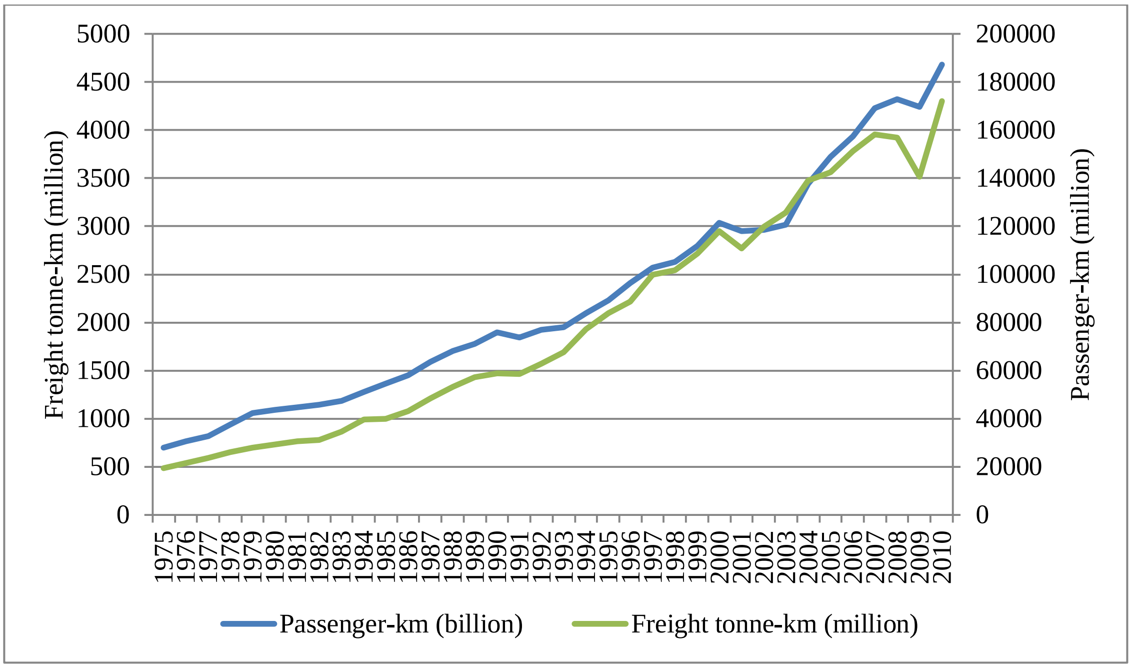

Figure 2.1 - Development of air traffic for passengers and cargo (1975 - 2010) (source: ICAO)

The air transport sector has been able to overcome the challenges it was faced with (see Figure 2.2) and, looking at Figure 2.3, one might say that the air transport sector has also overcome the recent crisis. The financial crisis of 2008-2009 reached a low point at the beginning of 2009 with a negative growth of almost -4%. Moreover, forecasts predict that the air transport sector will grow even more in the future. The emergence and development of several drivers act as engines to this growth.

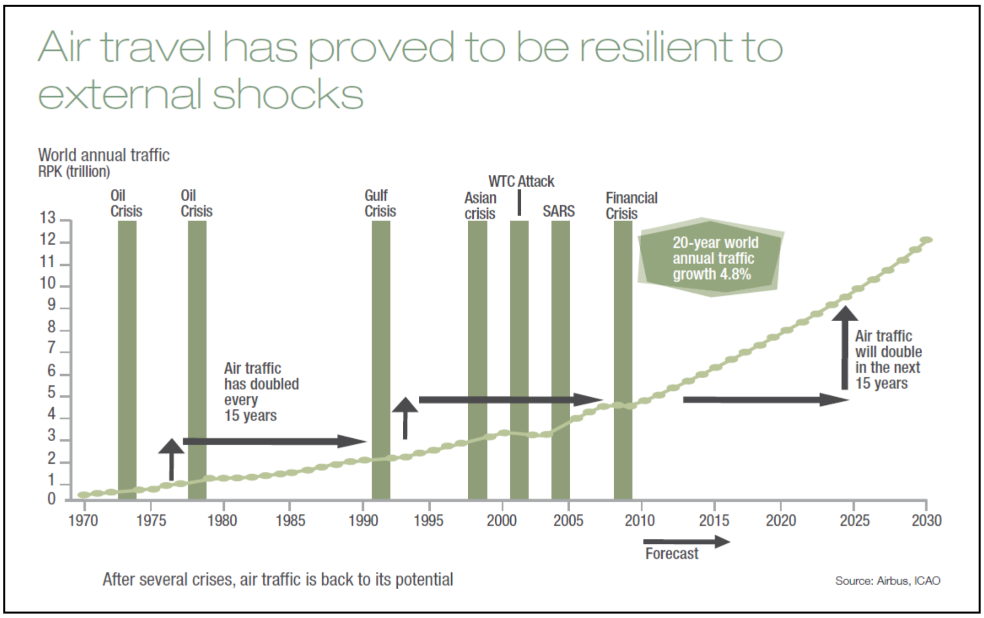

Figure 2.2: Air transport and external shocks (source: AIRBUS)

About 60 to 80 percent of the air travel growth can be attributed to economic growth, which in turn is driven by international trade. This is consistent with the observation that countries whose economies are tied to trade tend do have higher rates of air travel. The remaining 20 to 40 percent results from the value travelers place on air travel (Boeing, 2011). First of all, it became clear that people want and need to fly and therefore global mobility will expand strongly. Nowadays the miracle of flight is taken for granted. Travelling to the other side of the world is only a few mouse clicks and a trip to the airport away (Airbus, 2011, p.5). Moreover, it is observable that people "have" to fly for various reasons such as travelling to family that live abroad, visiting clients in another continent[3], etc. Migration and the globalization ensure the continuous urge to fly. What's more, at industry level, the continuing deregulation drives growth. On the one hand, the increased competition results in low airfares, which makes travelling by air also accessible for the people who are less wealthy. The advent of the low cost model also created demand. More and more people around the world are provided with the ability to fly. On the other hand, air travel becomes more attractive since a larger amount of destinations offered by various airlines.

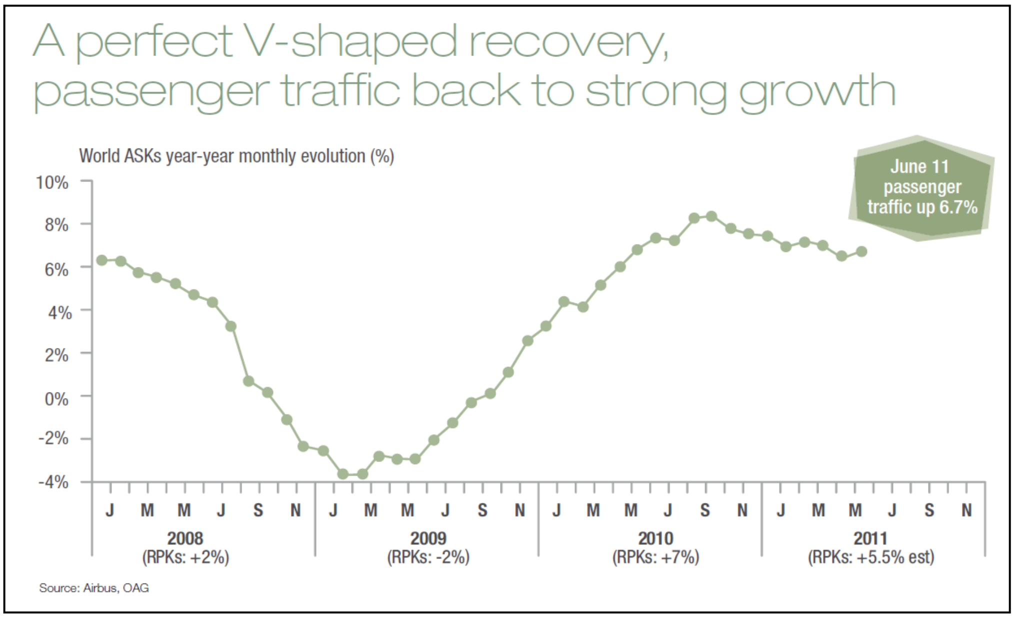

Figure 2.3 - The recovery of air travel after the recent (economic) crisis[4] (Source: AIRBUS)

The ratio between the growth that comes from economic development and the growth that is a result of the value of air travel services is an indicator of the maturity of an air travel market. For example, Western Europe and the North America are more mature markets and are therefore faced

[3]Although new technologies, such as video conferencing, lowered the need for face-to-face contact.
[4] RPK = Revenue Passenger Kilometers

with lower growth rates, compared to countries in Africa, South America, etc. Figure 2.5 shows the difference in (traffic) growth in the different regions.

Although there was a rapid rebound after the crisis, it has to be acknowledged that the crisis accentuates that the **growth is unbalanced**. Emerging countries accounted for 69% of the world population in 2010 and they account for 56% of the economic growth. Furthermore, rates of urban growth in developing countries have been higher than those of developed countries (Airbus, 2011, p.47), which results in the rise of the emerging economies global middle class.

Developed markets are more mature in the air travel market, which means that they will grow at a slower pace compared to the emerging markets. Therefore, in the coming years, a shift in the global power from west to east, and in some extent to the south (Embraer, 2011, p.6) is observable; from Europe and North America to e.g. Asia and Africa (see paragraph about Traffic Flows).

Figure 2.4: Growth of world regions over the next 20 years (Source: Boeing)

The Transport Outlook 2011 of the International Transport Forum predicts high and roughly constant **growth rates** on global level that leads to a tripling or quadrupling of the global passenger transport volumes by 2050 compared to 2000. The growth in the developed economies can be expected to be slow and gradual while the emerging economies grow very fast. (International Transport Forum, 2011)Forecasts from aircraft manufacturers predict an average annual growth of 5%. *Airbus* (2011) foresees an annual growth of 4.84% from 2010 to 2030. They say that many of the driver's growth will lead to more traffic to and from the emerging economies but that mature markets will still account for a significant share of 2030 traffic volumes. For example, the single biggest traffic flow will be the US domestic with 11.1% of all RPK's flown. Intra Western European traffic, with its well established global and LCC, will be the third largest flow with nearly 8% of world RPK's. The Chinese domestic market is forecast to grow at more than 7% per annum, moving it from the fourth largest flow in 2010 to the second.

Figure 2.5 shows that *Boeing* (2011) predicts a long-term growth rate of approximately 5% per year, 5.1% growth in passenger traffic and the cargo market will grow at 5.6% annual rate over the next 20 years.

In its forecast for 2011 to 2030, *Embraer* (2011) foresees that the world air traffic demand will grow by 5,2% per year.

Figure 2.5: Forecast of market developments (according to Boeing)

2.1.3 Traffic flows

As already stated, the urbanization continues and this results in growing cities all over the world, great and small. Given the importance of these cities, one might say that traffic is located between those points. The global route network has expanded with more than 17,000 city-pairs and since the emerging markets have more upcoming cities, a lot of those new routes involve markets in emerging countries. On the other hand, there are larger cities, which traditionally are centers of air transport demand, due to their socio-economic weight within a certain region. These cities are vital points for world trade and they are also big population centers with an enormous appeal far beyond their borders. These cities often serve as a connection hub for one or more home carriers or so called flag carriers (Airbus, 2011, p.25).

Given the fact that there will be more traffic, airports become bigger (in movements). In emerging countries, airports are growing faster and will join the top 25 of biggest airports. This is also due to the fact that emerging countries have less alternatives to air transport and do not have a good road and/or high speed train network. Some European airports, on the other hand, are operating at full capacity. As a result, traffic is likely to spread somewhat more across the airport network (Eurocontrol, 2010, p.26). Therefore hubs can be either located in developed countries or in emerging countries. Forty years ago most of the world's traffic flew from, to or between North America, Western Europe and Japan. In 2010, the North American market still dominated (see Figure 2.6). As more people around the world have embraced flight and are able to take the advantage of its benefits this has dramatically changed. In the future, the air traffic flows are centered in other parts of the world (Airbus, 2011, p.7): *Airbus* (2011) predicts that by 2030 Asia-Pacific will have the highest share of RPK's in the world (see Figure 2.6).

However, as future growth also takes place in midsized and small middleweight cities, there is a need for secondary airports and new opportunities for airlines to explore new markets with right sized airplanes.

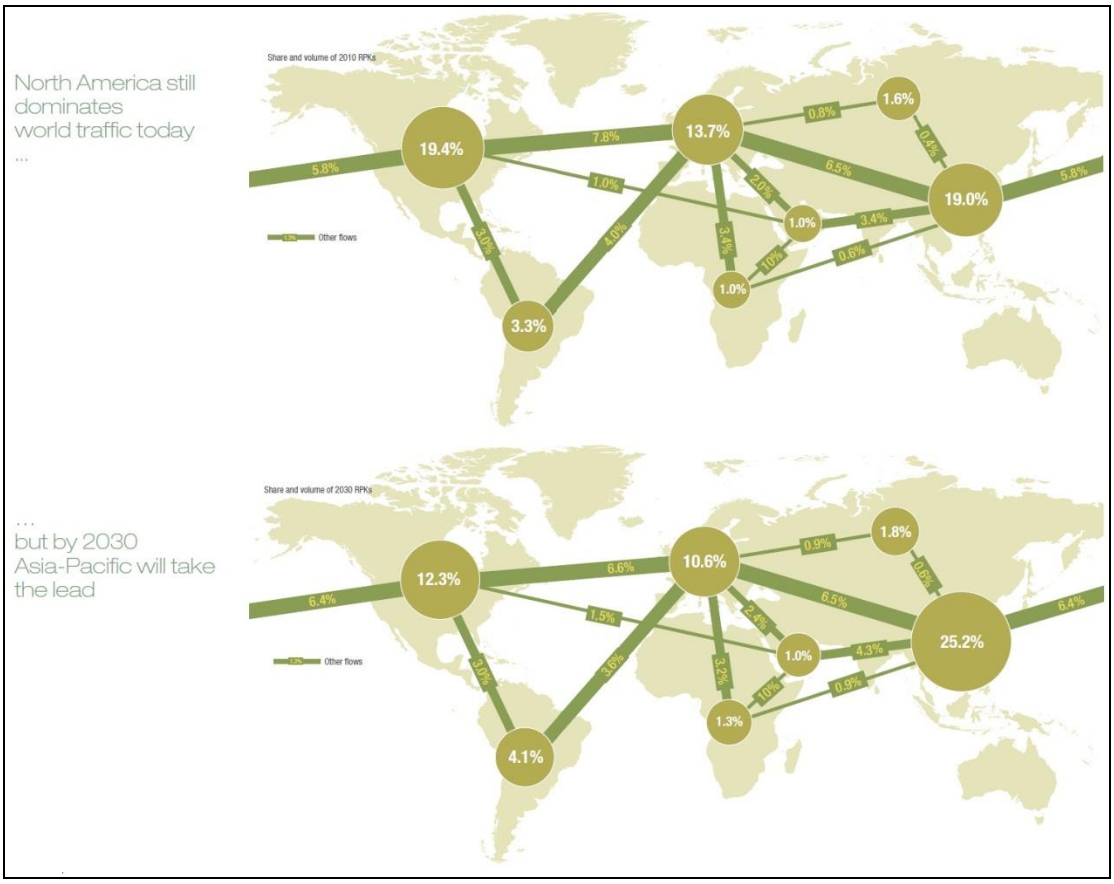

Figure 2.6: Current and future traffic flows (Source: AIRBUS)

According to *Airbus* (2011), over the next twenty years, more than 700 new city-pairs will be added on the long-haul market. By 2030, a total of 87 cities around the world will have passed the threshold of 10,000 daily passengers, to become Aviation mega-cities. The emerging regions of the world will contribute an additional 29 long-haul traffic hubs, as their economic power and wealth grows passenger traffic within these regions.

2.1.4 Demand for innovations

The future demand, the trends in passenger demographics and the need for lower fuel consumption and for meeting noise/emission targets leads to a rising demand for innovations in aircraft design as well as other areas such as air transport management. As the demand grows, the educational supply has to follow since a bigger market has a complementary need for well trained staff.

2.1.4.1 Aircraft construction

Air traffic will more than double over the next twenty years since aviation becomes more accessible to those in emerging markets as well as to those in more traditional markets. Due to this larger demand, more aircraft will be needed in the future. These aircraft have to be tuned to the nature of the markets they will serve. For example, in emerging countries different upcoming cities can be identified. This asks for more short-haul travel, performed by relatively small airplanes with less than 100 seats.

Furthermore, people will increasingly travel (between global centers) and therefore, airlines have to keep innovating and improving to reduce the costs for themselves and for the environment. Because of this, the need for eco-friendly airplanes will rise. Also other factors, like environmental regulation (e.g. emission trading schemes), pressure from customers, etc. play a role.

2.1.4.1.1 More airplanes of different sizes

The ever-growing numbers of people who will have access to aviation will result in an increase in the number of airplanes.

Airbus (2011) predicts that the world's fleet of passenger aircraft will grow from 15,000 at the beginning of 2011 to nearly 31,500 by 2030. At the same time, 14,000 aircraft from the existing fleet will be replaced by more eco-friendly models with a lower fuel consumption. Of these, 3,400 will be recycled back into passenger service, where they too will replace an older generation model. *Airbus* (2011) forecasts that 2,200 will be converted to freighters and the remaining 1,100 will be permanently retired or withdrawn from service.

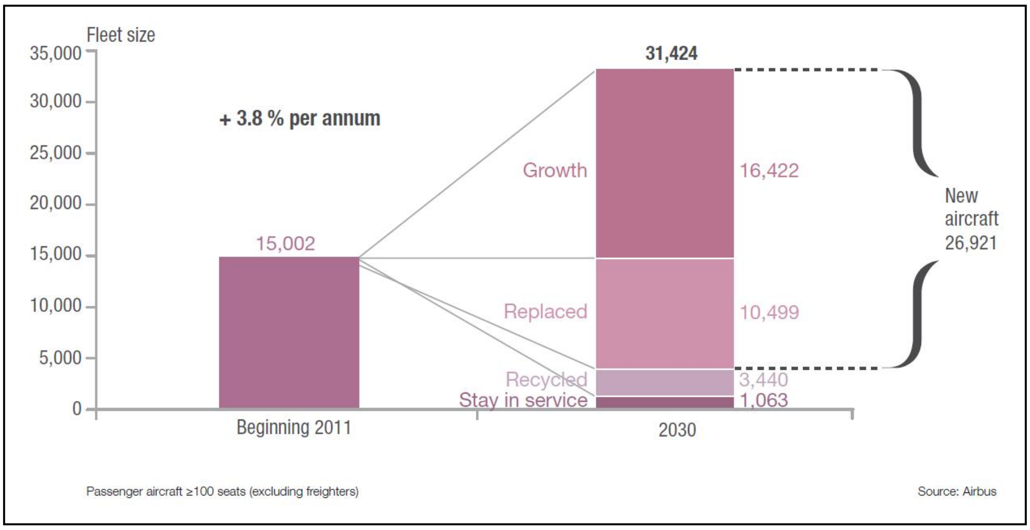

Figure 2.7: Evolution in aircraft fleet (according to Airbus)

Boeing states that the world fleet will count 39,500 airplanes by 2030. Of the 19,400 airplanes in operation today, 13,400 will be replaced over the next 20 years and not less than 33,500 new airplanes will be delivered. *Embraer* (2011) only predicts 21,770 new aircraft of which 59% (+/- 12,800) will be to support market growth and 41% (+/- 8,900) to replace old aircraft. By 2030, 30% of the current fleet in service will remain in operation. According to *Embraer* (2011), the world fleet will increase from 19,120 (in 2010) to 36,910 (in 2030).

Furthermore, people will fly between the increasing number of Aviation mega-cities and hubs so it is important to scale the (additional) aircraft to market requirements. There are three types of jet aircraft which can be distinguished.

Narrow body – single aisle

First of all, there are the narrow body, also known as single aisle, aircraft. Those airplanes have between 100 to 210 seats and are a very significant part of today's Aviation network, representing the majority[5] of the global fleet above 100 seats. Single-aisle aircraft will still be an important component of the fleet in 20 years' time and will also become the focus of new entrants due to the reduction of the environmental impact and low unit costs. Single-aisle airplanes are used to serve short- and medium-haul markets, which are the fastest growing markets thanks to the (intraregional) travel in emerging economies (Boeing, 2011).

Of the 33,500 new airplanes, predicted by *Boeing* (2011), 23,370 will be single aisle aircraft. *Airbus* (2011) predicts that only 19,200 new deliveries will be single aisles. *Embraer* (2011) predicts 16,185 new single aisle airplanes of the 21,770 new deliveries. This grasps the majority of the fleet: 70 to 80 percent of the global fleet.

Wide body – twin aisle

The twin-aisle segment, or segment of wide body aircraft, covers airplanes with a capacity of 250 to 400 seats. This segment has had some product development activity in the recent years - with two all-new product families entering service in the next few years- (Airbus, 2011, p.70), which shows that it is important for airlines and manufacturers. With an annual growth rate of 4.4% it is the fastest growing segment. *Airbus* (2011)stresses the fact that twin aisle passengers aircraft will be required to serve the existing, mainly international, markets created largely by growth on existing city pairs. They will also be used for flows from and within emerging markets and for new routes, for example thanks to the upcoming cities, which imply more traffic between mega Aviation hubs and secondary airports. Furthermore, airlines can allocate these aircraft to non-stop routes which are made possible by the liberalization.

Boeing (2011) states that 7,330 of the 33,500 (22%) new deliveries will be twin aisle aircraft while *Airbus* (2011) predicts that the number of wide body aircraft will more than double (to 7,100) over the next twenty years. Forty percent will be replacing older aircraft and 3,800 new twin aisle airplanes will contribute to the growth of the segment.

[5] Almost 80% (according to Airbus) or 62% (according to Boeing)

(Very) large aircraft

The very large aircraft are used to travel between world's major airports and cities. These airplanes have the advantage of combining minimized seat costs, minimizing fuel as well as CO_2, and enough space on board, as passengers request. Furthermore, they can be allocated to long-haul as well as trunk routes if demand is high enough. The segment will keep on growing thanks to the growing network and the need for people to fly.

Airbus (2011) foresees that there will be 1,300 very large aircraft produced by 2030, while *Boeing* (2011) predicts that 820 (2%) of the new deliveries will consist of large aircraft.

2.1.4.1.2 Environmental issues

In recent years, a lot of attention was paid to environmental issues. Fuel and noise emissions became urgent matters and government policies related to emissions and noise are expected to become even stricter. Although the emissions of air traffic account for only 2 percent of the greenhouse gasses, 2.58kg of CO2 are emitted with the use of every 1 liter of kerosene fuel (Embraer, 2011; US Energy Information Administration, 2013). New environmental regulations, such as the European emission trading schemes, will also increase the costs related to fuel (burn) (Embraer, 2011, p.7). Nowadays fuel becomes an ever increasing share of an airline's operating cost. According to Airbus (2012a), currently fuel represents more than 33% of airlines' operating expenses. Due to global problems like financial crises, political problems and natural disasters, the oil prices increase even more. This enlarges the need for more eco-friendly aircraft. Furthermore, the need to reduce fuel consumption also drives demand for new or re-engined (existing) aircraft. These aircraft would consume less fuel and will therefore be more attractive, which results in more orders.

Eco-friendliness can be achieved in various ways. First and foremost, airlines can try to limit the amount of fuel needed. Adopting new technologies, such as aerodynamic technologies, lighter structure and more efficient engines can reduce the fuel consumption. To avoid or limit costs related to environmental policies, airlines can focus on lowering the emission of the aircraft in use, for example by building new engines. Also the search for alternative fuels, such as biomass, is crucial.

Not only fuel emissions, but also noise emissions became important. Although the forecasts that were analyzed, only briefly touch the issue, Aviation noise comes with a cost. It has a severe impact on communities surrounding airports, i.e. the quality of life of people living in the areas surrounding the airport. Not only the human wellbeing is affected, also other effects appear. For example, noise depreciation of house values affect the human welfare. There are various options to deal with this; either one can ease the problem "symptoms", for example by offering compensations to the affected people, or mitigate the problems (partly) using measures such as lowering or optimizing the noise exposure limits towards the airport environment, building new airports and introducing curfews.

Taking these two environmental issues into account, it is important to realize that both issues become more severe with traffic growth. Also the objectives of lowering CO_2 and NO_x-emissions and reducing noise have different (sometimes even opposite) implications in aircraft and engine design. Then, compromises are needed.

Furthermore, airlines can reduce costs by working efficiently and or decrease weight.. The load factor of an aircraft reflects the efficiency with which it is filled. If the load factor of an airplane is too low, this results in lost revenue, higher prices for passengers and a less environmental friendly travel on a per passenger/seat or RPK basis.

2.1.4.1.3 Derived effects

The fleet expands and that has an effect on the employment in the market. The need for well-trained employees grows in proportion to the expanding global fleet. More pilots and technicians are required and will be allocated to the additional services or replace other employees. *Boeing* (2011) foresees that the market calls for 460,000 additional pilots and 650,000 maintenance technicians.

In literature, the shortage of pilots and technicians is frequently mentioned. However, also other types of Aviation operations require professionals. For example, seldom does one hear about personnel shortage concerns extending to the Air Traffic Controllers (ATCs) who will be managing increasing numbers of aircraft in our finite airspace. (ICAO, 2011a, p.20)

The air charter, corporate Aviation, and aerial work industry segments comprise an estimated 200,000 pilots and 300,000 mechanics worldwide. Given nominal growth rates, requirements for these occupations twenty years from now could increase to 500,000 and 600,000 respectively. In aggregate, the world of civil Aviation is looking at a requirement for more than a million individuals for pilots and mechanics by the year 2029. (ICAO, 2011a, p.17) One also has to take into account the retirements and the transfer of knowledge when looking at the additional requirements for pilots and mechanics.

The growing diversity of pilots and maintenance technicians in training will require instructors to have cross-cultural and cross-generational skills, in addition to digital training tools and up-to-date knowledge of airplanes (Boeing, 2011). Also here, a distinction between emerging and developed countries can be made. For example, in emerging countries there is a strong need for basic skills training for technicians to develop a local source.

Furthermore, it is important to bear in mind that there are different rules concerning safety in different countries. For example, accident rates are much lower in Europe and the US than in Africa or Russia. The fact that some airlines are banned to fly to Europe and US shows that there is a safety gap. Therefore, there is a need for personnel with the right competences, e.g. for the decision-making process.

2.1.4.2 Other new technologies

The expansion of the fleet requires a significant investment in infrastructure to accommodate the increased traffic. Furthermore, the future technological environment will need to be shaped in order to meet the future characteristics and dynamics of the market. While some airlines have already ordered some of the newest aircraft because, amongst others, of their fuel efficiency, other airlines have to follow to stay competitive.

This "new technology" is a diffuse collection of measures, which enhances air traffic control, aircraft and airport technology, including organizations (Airbus, 2011, p.38).

Future growth will be limited by the available capacity at the airports. Nowadays, traffic is highly concentrated on major airports which already have a high degree of capacity utilization. According to Eurocontrol (2007) almost all European airports with more than 50,000 departures per year declared some kind of capacity restriction (runway or airspace restrictions) in 2007. As an example, in 2011, London Heathrow operated at 99.2%[6] of its capacity. Therefore, a lot of those large airports are operating at their maximum capacity and this leads to congestion. These problems can become barriers to future growth or, at the very least, will affect the composition of the future fleet and operations in terms of aircraft size and frequency (Airbus, 2011, p.35).

Airlines focus on the most efficient and economic utilization of their fleet and can either change their frequencies or the size of their aircraft (Eurocontrol, 2010, p.22). Capacity shortages on airports may thus lead to a shift to bigger aircraft if expansion of the airport and thus frequency of services of the airline. Another effect is the traffic growth at smaller airports with less congestion, where smaller airplanes would be used.

Redistributing the existing fleet (e.g. rolling wave) is a measure that can ease the pressure on airports in the short term. Smaller airplanes are redistributed to smaller airports and the vacant slots can be used by large airplanes.

[6] Airliner World (2012) stated that, in 2011, 476,197 flights were recorded, while the maximum capacity of Heathrow is set to 480,000 flights.

2.1.4.3 Influence from policies

On the one hand, air transport operators request innovations to make their fleet as efficient as possible. However, manufacturers also have to innovate due to different policies. The influence of regulatory intervention, namely deregulation and CO_2-emmission were already mentioned in this section, but one has to bear in mind that also for example safety and security measures, changes in separation minima, the reorganization of the European airspace, the free flight concept and pricing policies (e.g. airport charges) drive the demand for innovation. Concerning safety and security, it is for example important to bear in mind that there are different rules concerning safety in different countries. For example, accident rates are much lower in Europe and the US than in Africa or Russia. The fact that some airlines are banned to fly to Europe and the US (blacklisted airlines) shows that there is a safety gap. Therefore, there is a need for personnel with the right competences, e.g. for the decision-making process.

2.2 Labour Attractiveness

2.2.1 Current Situation in Air Transport and Aeronautics Sectors

Labour markets worldwide are undergoing unprecedented evolutions. Over the last decades, Globalisation and other phenomena opened first ever opportunities for people to freely (or with low barriers) move across regions and Countries. Naturally, in parallel, employees' mobility is raising not only at geographical level but also across industries or markets. While some decades ago, to seek job in an entirely different industry was uncommon, nowadays it is a daily business and often stimulated and sought for industries as a way to acquire new skills and abilities. If this creates new opportunities for recruitment, it also creates major and new problems for companies to retain their best employees.

In human capital intensive industries, like in the Aviation, it has long been recognised that employees' knowledge, skills or abilities are fundamental for ensuring the long term sustainability of a company. Indeed, the competitive edge of Aviation industries heavily relies on their ability to attract and retain the best applicants. However, this is becoming increasingly difficult and some authors classify as "war for talent" (Axelrod, 2001, Chapman et al., 2005) the current dynamics and evolutions occurring in the labour markets.

Although this problem has emerged and grown in parallel with Globalisation, this phenomenon was not the root of the problem but simply an enabler for an already existence but latent one. The progressive freedom in moving linked to an economy-driven Society drove employees to seek better opportunities resulting in a growing mobility.

The Aviation sectors have undergone profound changes over the last couples of decades. In addition to the European Union liberalisation in the nineties and many others around the world, there were many other factors impacting the sectors, including: a growing environmental awareness, which put the industry under a major pressure and forced the industry to reduce its carbon footprint and emissions; a growing demand for air transport services, which is requiring further supply from an industry that is often working at its full capacity; a progressive increase in fuel costs; or significant technological progresses, that over the last years produced major solutions and advancements for the industry. It is within this whirlpool of constant change that AT&T companies operate and compete. Necessarily, such evolutions have brought more or less changes into the required competences of the work force. Recently, H. Deconinck (2011)[7] elaborated some of the industrial needs and requirements in aeronautics:

- Fuel efficiency (CO2), reduction of noise emission, reduction of NOX;
- New materials for light weighted aircrafts;
- Innovative aircraft configurations (flying wing, etc.);
- Innovative engines (contra-rotating propeller, etc.);
- Flow control (laminar wing …), MEMS, morphing;
- Shortening in the design cycle of new aircraft, engines, etc.;

In the Air Transport sector, the implementation of the Single European Sky by 2020 is expected to radically change the paradigm of planning, organising and managing the Air Traffic. Currently, SESAR, the technological research program of the Single European Sky initiative is conducting wide scale research projects to create the necessary technological and knowledge for the correct deployment of the initiative. It is therefore natural to anticipate significant changes in the required competences, as well as, the creation of new ones.

Aviation sectors have been suffering from this growing problem and progressively industries are reporting the difficulty in attracting sufficiently skilled employees. The reasons for such problem have already been identified and are well documented elsewhere (Deconinck, 2011, Favennec, 2011[8]). We summarise here the main identified problems:

P1: Progressive loss of interest in scientific or technical carriers

Traditionally, scientific and technical carriers ranked among the most reputed and socially relevant ones. However, along the years, they have progressively been replaced by others

[7] Decononck, H. (2011) Trends in Educational Activities and Tools for Aeronautics the example of the von Karman Institute, Aerodays 2011, 6th European Aeronautics Days, Madrid, March 30 – April 1, 2011
[8] Favennec (2011) How to get the right aerospace engineers of the future, Eurocopter, Aerodays 2011, 6th European Aeronautics Days, Madrid, March 30 – April 1, 2011

more fashionable (and eventually well paid). Among these, we include: financing and banking, management and entrepreneurship, marketing or public relationships, etc.

Rewards (promotions, salaries, societal relevancy, etc.) in the scientific and technical carriers appear (if any at all) after a long time of dedication and investment; whereas in the new fashionable carriers, it is believed to appear after almost immediately and with lower investments. Consequently, when making the trade-offs between carriers, the rewards of a scientific or technical carrier are not worth the required investment.

P2: Progressive loss of prestige of the Air Transport and Aeronautic Sectors

Air Transport and Aeronautics, in the broad sense, have always captured the interest of people, in general, and youth, in particular. The opportunity to work with a flying machine or in a related sector was often the main driver to apply for a job in this area. However, such glamour has somewhat faded over time. Endogenous and exogenous reasons may be identified. The massification of air transport contributed to the reduction of the mystic. Also, many other industries have been much more pro-active in attracting youth, like for example: car makers. A this reason is linked with the previous problem and it is related with a change in society's view on the technical related jobs (and inherently, in the Aviation sectors).

P3: Progressive reduction of students' interest for mathematics, physics and other sciences

A change in students' perception about educational needs in mathematics, physics and other sciences is underway over the last decades. Nowadays, students no longer look to these disciplines with awe and eagerness to learn. Indeed, they label them as unattractive, difficult, boring and with low connection to reality. Also, they do not see them as necessary requisite to get a gob job in the future. Instead, they are favouring other disciplines, often related with the development of soft-skills. These disciplines are often advertised as fundamental for getting the job.

No longer, the promising students are those with better grades in mathematics, physics, chemistry and other science; but, in areas related with management, entrepreneurship, marketing, etc.

P4: Technical carrier is inferior to management carrier

Although promotions and progression do occur in both technical and management tracks, in many companies, the top positions (and, consequently, the higher salaries, benefits and recognition) are restricted to those in the management carrier. There is therefore a major incentive for employees and applicants to move towards this track.

P5: Educational paradigm has changed favouring the teaching of soft-skills in detriment of hard-skills

The spread of Globalisation has led to the emergence of new business and educational paradigms, largely based on the concepts of networking and chains, and (multidisciplinary) teams. In parallel, we witnessed in many prominent management schools the emergence of novel educational paradigms, often largely based in the development of soft-skills (precisely to educate students working in the Globalised world and teams). Progressively, this trend was adopted by other schools and educational institutions. Although the relevancy of soft-skills cannot be challenged, the problem occurs when the teaching of hard-skills is reduced to a point that students lack the competencies to work in scientific or technical areas. This trend also occurred to more or less degree in engineering schools leading to a progressive reduction of knowledge on central areas for Aviation. The direct consequence was the reduction of interest of students in these industries.

P6: Reduction of systems engineering-related courses

The development of industry and labour market has favoured the specialisation of employees. In paralleled many engineering-related courses were structured in silos with low (if any) interaction among them. This has created a breath of knowledgeable engineers in a given area, but with little understanding outside their area. If this is positive in certain business sectors, the same does not occur in aviation, in which employees are required to have a systems' view and knowledge of the entire productive process. This may be leading specialised applicants to look elsewhere. Some companies are more rapid, active and offer better starting salaries than aviation: e.g. Goldman Sachs, Ernst & Young. They seek aviation students for their technical ability that they cannot find in others (economist, ….)

The following scheme (Figure 2.8) translates the conceptual idea of the job choice process. The set of all offers available in the market forms the **Universal Set.** The applicant however may not know (and, most times, does not know) about of all available offers; instead he/she is only aware of a partial set. This partial set forms the **Awareness Set**. The actual size of the Awareness Set depends on both the applicant and the company. In what concerns the former, the amount of aware job depends on his/her curiosity and resources (time, money, etc.) to look for the jobs. In what concerns the latter, the amount of aware jobs depends on the resources (marketing campaigns, participation in info or job fairs, etc.) deployed by the companies to disseminate its job offers. The applicant may not necessarily collect information about all the known job offers. He/she may discard non-fit companies or jobs offers that imply a change in location. Therefore the applicant will only evaluate (that is, gather information and evaluate the possibility of applying) a reduced set of job offers. This set is designated as **Processed Set.** The applicant evolves then to a stage in which more and detailed information is collected about the job offer and company. Here again, only a smaller amount of job offers are likely to be selected for application. The applicant may conclude that he/she does not fit into the job, the offer requires other competences or skills than his/hers, or the job is simply not attractive. This reduced set forms the **Considered or Evoked Set** and represents the set of job offers found attractive to be applied by the applicant. The applicant's job choice process can thus be summarised through a set of 3 steps of which 2 steps involved decision making (Steps 2 and Step 3) and 1 step – Step 1 – depends on the searching and dissemination efforts.

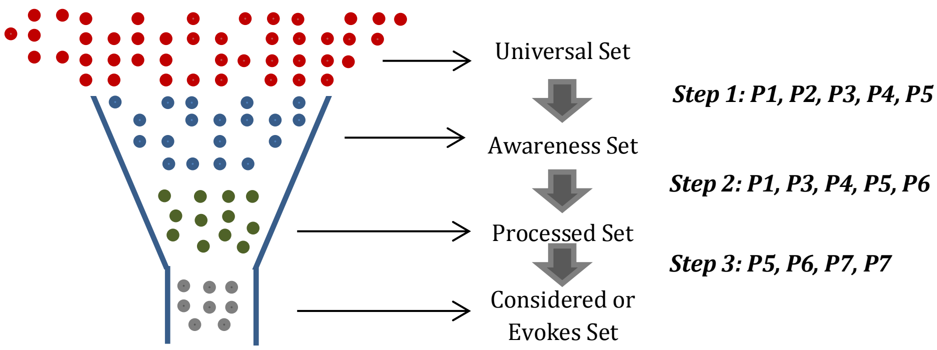

Figure 2.8 – Impact of the problems with the steps of the job choice problem

The impact of each of the abovementioned problem in the level of attractiveness varies in nature and reach. The *Progressive loss of interest in scientific or technical carriers* (Problem 1) has an earlier influence in the job choice process and, thus, in the level of attractiveness. The point is that if students do not even think in getting a scientific degree they will hardly become acquainted with jobs in the domain of Aviation (Step 1) or will immediately discarded them (Step 2). The *Progressive loss of prestige of the Air Transport and Aeronautic Sectors* (Problem 2) is another problem with the same level of impact. If Aviation sectors fail to get known to students and applicants, they will simply not search for jobs (Step 1). AT&T sectors need to adopt a pro-active positioning in order to stand above the crowd and flag themselves out. The *progressive reduction of students' interest for mathematics, physics and other sciences* (Problem 3) has a similar effect, since may lead them to divert to other domains and necessarily exclude them from searching (Step 1) and working (Step 2) in Aviation sectors.

By the same token, the fact of a *Technical carrier is inferior to management carrier* (Problem 4) may divert students from pursuing educational (Step 1) and later on a carrier (Step 2) in Aviation afraid of being relegated to inferior job positions.

The fact of *Educational paradigm has changed favouring the teaching of soft-skills in detriment of hard-skills* (Problem 6) and the *Reduction of systems engineering-related courses* (Problem 7) may lead applicants to not process Aviation jobs offers (Step 2) afraid of not having enough competences, or simply discarded them upon reading the actual requirements (Step 3).

2.2.2 Results of the Surveys and Interviews

Three Surveys were conducted to assess the attractiveness level. Each survey targeted a specific group, namely:

- *Graduates* of educational institutions and colleges with engineering programs in Aviation *who are not working* in these sectors (WP7).
- Graduated *employees* working in the Aviation companies (WP6);
- *Students* of educational institutions and colleges with programs in Aviation (WP4 and WP5);

In this section we present the results of the three surveys.

2.2.2.1 Survey to graduates who are not working in Aviation sectors

This survey has thus far yield a reduced amount of answers. Tracking former students revealed a difficult task. Over time, these graduates students loose most (if not all) ties with the Aviation fields (meaning: former professors, colleagues, educational institution, associations, etc.). They do not update their contacts in the Alumni Associations or Educational institutions' Students Office. In practical terms, the natural distributions channels (i.e: Alumni Associations, Educational institutions and Associations) were of little use. Instead, we had to rely on the professional contact network of EDUCAIR partners (both with other professors, researchers and former students). The total amount of valid answers on the 15th March 2013 was of 19. Despite the number, it was still possible to draw interesting conclusions about the attractiveness of the Aviation sectors.

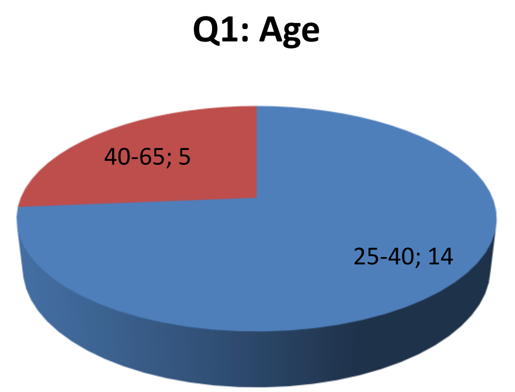

Figure 2.9: Respondents' age

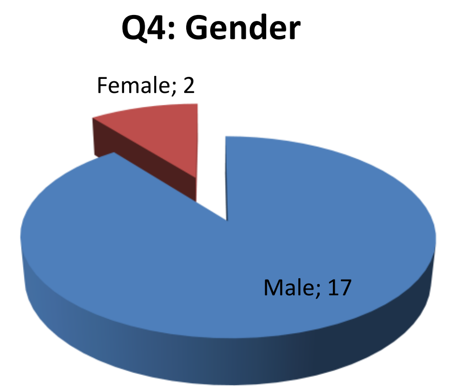

Figure 2.10: Respondents' gender

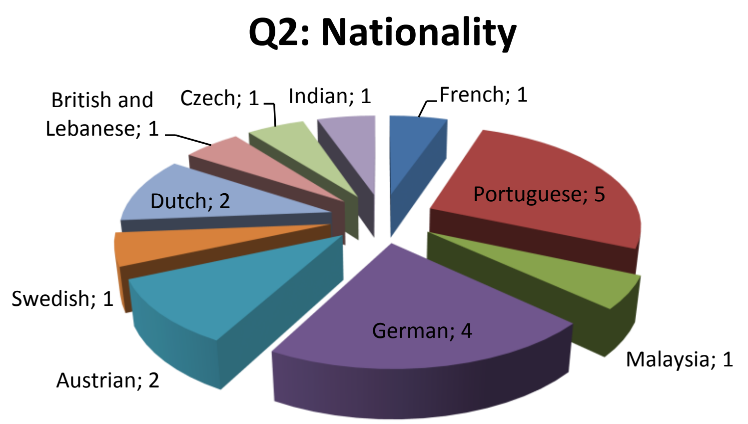

Figure 2.11: Respondents' nationality

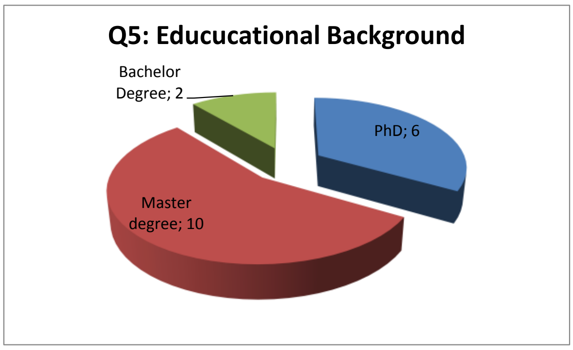

Figure 2.12: Educational background of respondents

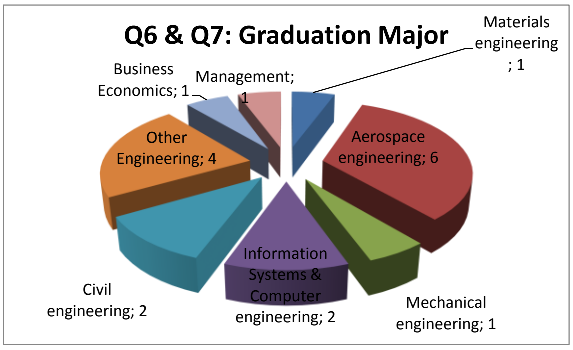

Figure 2.13: Graduation major

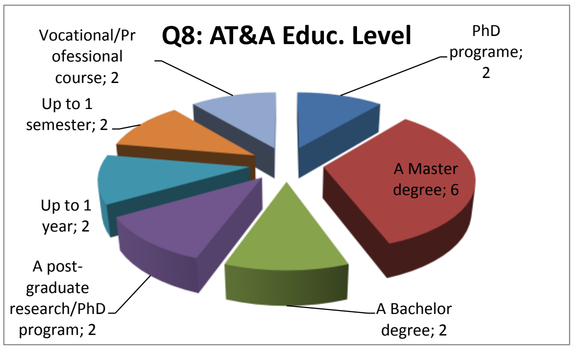

Figure 2.14: Education level of Aviation

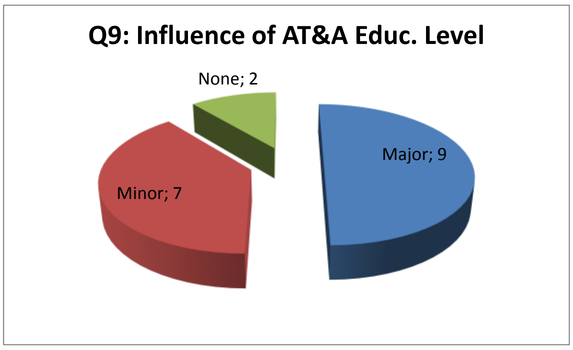

Figure 2.15: Influence of Aviation

Table 2.1 - Attraction and Repulsion Factors of the Aviation Education from the perspective of Graduates who are not working in this sector

Q11: Attraction	Q12: Repulsion
Technology	Tactics
A Dream to Put Something Flying Creative	A need for more practical teaching than theoretical
Fascinated by Aviation Interesting technology area with broad technical education	Boring and Unfair teachers
High tech industry	The fact that the air transport sector is so large and internationally interdependent makes change management (which I was studying) extremely cumbersome.
I was interested in pursuing a PHD in NPT (navigation, positioning and timing) but I couldn't secure a scholarship. Topic is attractive because it is highly transferable to other modes and disciplines, very dynamic and fun to work on.	Other areas that I found dull were ATC and ATM . Lots of boring theories , very little engagement with the core of the topic , no practical case studies were discussed in class(problem solving) or the like.
Interest in topic international working environment attractive projects attractive companies and payment	in my case : basic studies were in civil enegineering
money	-
My course content at masters in transport	-

planning at school of planning and architecture, New Delhi	

Table 2.2 - Current Employment Status

Q13: Current Company
Maintenance and operational Manager
Phd researcher in Queen's Educational institution Belfast
Self-employed technology and innovation consultant.
System developer, SAAB
I am a free lance financial consultant 03M Solutions limited
Lead System Architect for Security solutions at EADS/Cassidian
Senior researcher / Lecturer
Research in MIT-Portugal
Urban transport planner institute of urban transport (India), New Delhi

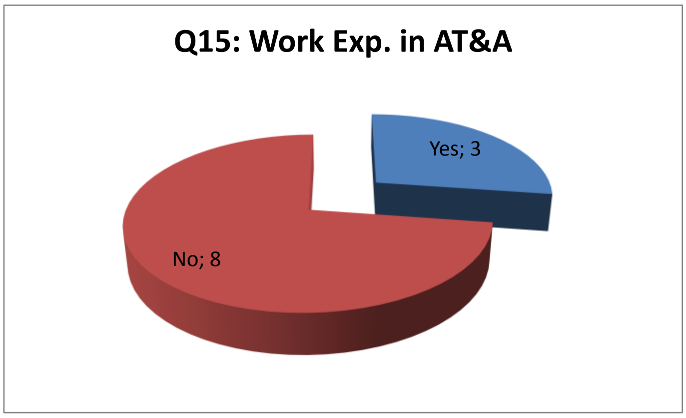

Figure 2.16 – Previous work experience in Air Transport & Aeronautics

Table 2.3 - Attraction and Repulsion Factors of the Jobs in Aviation Sector from the perspective of Graduates who are not working in this sector

Q16: Repulsion	Q17: Attraction in current Job	Q18: Req. to move back to Aviation
Personal motives	Personal motives	Challenge
At the time finishing the aeronautical engineers school there was no job available in Austria.	Broadness of technology fields to be involved in developing R&D concepts.	An interesting job offering in the field of innovation (management).
Actually, my current work retains the opportunity to act in the aero-domain. It's just that I have no current project in the domain.	My perception of the employer as seriously wanting to address issues in my area of competence. Commitment.	-
I didn't get any support from the department at my college, the	The pay seems to be much lower in the Transport sector	Proper guidance , explanation, workshops. I

suggested topics were not for me. There wasn't enough education and support to pursue a career in the sector pr a PhD . Also from our visits to the airports and the little we saw, the jobs (ATControllers, or ATM) were extremely boring and the people looked super depressed. the talks very super boring. The technological side of the control tower was fascinating though and people looked more dynamic there.	than the financial sector. Uni didnot help much in career guidance and the research dept were more interested in what topics they liked (SESAR) and not what the student wanted to do or work on.	also suggest that these companies can create a 2 year (plus or minus) program similar to those created by banks whereby they train and teach graduates with potential and then offer them careers after their graduation from the programs. These programs should be specific, intensive and concentrated whereby by the end of the program the graduate becomes specialized and can deliver much better results .
NA	Career issues and th ewish to do something new let to a change from mil. aircraft to systems business unit	career progress interesting project/programme interesting site/town/country
Lack of technical knowledge provided by courses in air transport.	Specific topic on which I did my master thesis.	Better salary
-	Urban transport planning helps to various jobs related to airport planing, transport engineering etc and there are less jobs which are specifically related to aerospace engineering in developing nations	-

2.2.2.2 *Survey to graduated employees working in the Aviation companies*

A full description of this survey can be found in the deliverable of WP6. In this section we describe only the results concerning the questions related with the attractiveness of the Aviation sectors. A total of 153 valid surveys have been collected and analysed. Despite the large amount, it is not enough to conduct wide statistical analysis. Instead, we decided to follow a mix qualitative and quantitative approach.

Questions 46 and 47 of the survey aimed to collect information about the attractiveness of Aviation educational. Around 55 respondents described their factors. Questions 53 and 53 aimed to collect information about the attractiveness of AT&T working conditions. Around 60 respondents presented their perspective.

2.2.2.2.1 Attractiveness factors in Aviation education

In Q46, respondents were invited *to specify and rank the determinant factor have led them to choose the course in Aviation.* Despite being an open question, there was a clear converge of the answers around three main topics. As such, we created three groups of answers, concerning the three topics as shown in the following table.

Table 2.4 – Attraction Factors of the Aviation Education from the perspective of Graduates Employees

Employment related factors	Carrier Development related factors		Fascination of Aviation sectors related factors	
Very good employment prospects	High degree of technical challenge, complexity, continually being pushed	The fact of being a growing Sector both in dimension and challenges.	Aircrafts' mystery	Affiliation to space
Aeronautics offers good jobs opportunities	Challenging tasks	Way of doing business in Aviation industry!	The passion for Aviation and everything related with it	Interest in aeronautics
A lot of fields to work	There is always something new and it is widely open	Highly determined and organized society with the great ratio of freedom.	General interest in aircraft	Personal attraction
Specialized engineering with high employability factor	Dealing with a broad range of topics	Science in a top level, high tech	The most determining factor was my interest in airplanes.	Interest to know how fly
Promise of a challenging job after graduating	Worldwide industry	-	Passionate about aircraft and flight	Air transport engineers can contribute to improving air transport passenger mobility (on ground (airports) or in the air)
-	-	-	Personal knowledge and passion	Aerospace domain is my passion since the my childhood

The first group *Employment related factors* refers to the positive perception of Aviation sectors in the employees, while students, about the employment and employability perspectives. The answers evidence students' strong belief (and awareness) on availability of job opportunities in the Aviation among students. But, perhaps most relevant, they demonstrate that students' understanding (and awareness) about the richness and diversity of working options in these sectors.

The second group *Carrier Development related factors* refers to the attractive conditions that a job in Aviation is expected to offer, from the perspective of a student. These can in turn be split in two sub-groups: one related with the permanent challenges of Aviation and the other about the broad and diverse options for working (both in terms of geography as well as in terms of roles).

The third group of attraction factors are related with the very nature of the Aviation industries and the inherent fascination that has driven many people over the years. Invariantly, one of the factors presented by the respondents was related with this factor. Some of the answers received for the three groups are quoted in the Table 2.4.

Besides these three groups, other attractiveness factors that do not fit in the previous ones were received. One pointed out by several respondents was the fact of Aviation education implying considerable knowledge in maths and physic. Other respondents indicated the advantage of using Aviation graduation to get a job in a different field. A third group of respondents claimed that Aviation education would prepare them in many relevant areas, besides Aviation or aeronautics.

2.2.2.2.2 Repulsion factors in Aviation education

Perhaps as important as the attraction factors, the repulsion factor evidence the drawbacks and flaws of Aviation education and that may be causing students to divert towards other fields. The purpose of Q47 was precisely to obtain the factors that the employees enjoyed the least while students and that could have led them to withdraw.

Again the answers were focussed on a small set of topics. Such coherence gives confidence on the results and denotes the existence of problems transversal to the AT&S educational sector. Three types of main problems were documented, including:

Table 2.5 – Repulsion Factors of the Aviation Education from the perspective of Graduates Employees

Cumbersome legal framework	**Heavy theoretical with unperceived connection with real practice**		**Reduced amount of practical working hours**
high level of bureaucracy	the course is very focused on theory and not what is actually done in Aviation world	most specific aerospace classes were too theoretical and had little to no relevance when considering what is done at industry level	lack of "hands-on"/concrete working material
bureaucratic works	course content too abstract/theoretical	unpreparation of the faculty professors regarding the current technology	lack of hands on subject
highly regulated	too much theoric, away from the airlines real	the lack of industry inputs to the academy	lack of practices or relations with

	needs	and academic outputs to the industry	entities within the sector to be ready to work in the real world
certification and related "administrative burden"	too theoretical, far from the real industry needs	very few practical stuff	
	lack of applicability of the studies taken	too technical (and for 90% of the people useless) preparation	lack of internship and on-job training opportunities in air transport or aeronautics companies during the course of my studies

Many respondents claimed the regulatory and legal framework was quite difficult and lengthy. The burden to acquire the duly certifications was also considered considerable and excessive.

The second problem identified by most respondents was related with the actual curricula and teaching methods. Respondents do not complain about the amount of taught theory, but only from the lack of a clear relationship with the real practice. In other words, the teaching was too abstract not in line with the needs of the industry. As a consequence, respondents claimed that the teaching was misaligned with the needs of the industry.

The problem reported in final group is in line with the previous one and it is perhaps its root. Respondents claimed for a low amount of practical studies and insufficient connection with the industry. Naturally, this resulted in the problem reported in the previous group, about a disconnection between what is taught in the classroom and what is required by the industry.

2.2.2.2.3 Attractiveness factors of Aviation job

In Q53, respondents were invited *to specify and rank the factors that they valuate the most in the Aviation industry – attractiveness factors – and that could incentivize others to pursue a similar carrier.* This was an open-question, in which respondents were free to leave their ideas and thoughts. Despite the variety of answers, again they all cluster around a small number of ideas, in this case we were able to identify three main attractiveness clusters:

Table 2.6 – Attractiveness Factors of the Jobs in Aviation Sector from the perspective of Graduates Employees

Professional prestige and recognition	**Working conditions and benefits**		**Challenging working conditions**		
to work in the field (aerospace)	organization and work conditions	stability	influence major technical and infrastructure	to be in the R&D area where things	variety of jobs ranging from concept work

			investment decisions;	evolve and change	to programming
the possibility to participate in the development of the future Aviation system at a time of intense change in the domain	interest for people and organization	income	the opportunity to develop real projects and real demonstration of technologies	job that you can have in almost any point in the globe	every day is different than the previous one
my work is valued	the job stability and very good atmosphere amongst colleagues	a profession as well as a hobby, job flexibility, work-Life balance, relatively high income	the need of rapid response and multi-discipline projects	creativity diversity of addressed problems	I have to deal with and constant learning it requires
my work helps improving efficiency in my department	relevance for the company-development influence remuneration	Good team play of multi-disciplinary researchers	high Technology environment innovation	international working environment	range of different subjects/stake holders
my superior relies on me and values my work	autonomy	family friendliness of employer	challenging environment	multidisciplinary work	creativity
flexibility potential for self-fulfilment	the people who work with me	interesting work colleagues	innovation management	freedom in research job	the diversity of tasks that need to be addressed and solved
				to be part of an international team	big company with big projects

Aviation industry still remains a substantial amount of their prestige and this is notorious in the respondents. Many of factors reported a pride and respect earned by working in these sectors. Likewise, the answers evidence that employees share a feeling of belonging to something worth and the belief of contributing to a bigger cause.

In parallel with the prestige of the industry, the above-average working conditions and benefits were also repeatedly reported by the respondents as a key attractiveness factor.

In addition to the benefits, Aviation sectors offer their employees good working conditions, in an international environment with multidisciplinary teams. In addition, employees have the opportunity to work an ever-evolving business activity.

The final group of attractiveness factors is related with the ever-changing ever-evolving nature of Aviation business and the direct consequence of employee being constantly changing and facing new challenges. This lack of routines, or at least the change in the job activities was a factor often repeated in the surveys. Employees are faced with evolving working conditions which was reported as very positive. In addition, the international nature of the Aviation industries was considered positive, since it entails working in an multinational and multidisciplinary teams. Linked to this is the opportunity to work in different regions. Some of the answers are quoted in the Table 2.6.

2.2.2.2.4 Repulsion factors of Aviation job

The final question concerning the attractiveness on Aviation jobs was placed in Q54, in which respondents were invited *to specify and rank the factors that they valuate the least in the Aviation industry – repulsion factors – and that could lead others to avoid this industry.* Like in all the other questions, respondents were free to leave their ideas and thoughts. Interestingly, the problems put forward are rather identical to the previous ones, but now seen from a negative perspective. However, conversely to the answers in previous question, the reported problems were too firm specific (for example one answer was "*lack of coaching from current boss and no team work spirit*") and, therefore, cannot be considered representative of the industry. Arguably, many companies in Aviation may have poor management or working conditions but that does not mean that cannot be generalised to the whole industry. The direct conclusion is that some respondents used the survey to convey their discomfort instead of looking. In any case, some answers do provide valuable information to understand some transversal problems and therefore may represent repulsion factors. The valuable answers were all around the same problem that is related with the lack of appropriate competences in many employees. As a consequence, they perform poorly leading to multiple problems, such as: underperformance, bad working environment or lack of empowerment. This reported problem may also reveal a lack of suitable education in this domain and may represent a tip of an iceberg. A most revealing answer of this problem is the following one: "*young engineers failing to present recommendations and judgements rather than data generated by a computer output".*

2.2.2.3 Survey to students of educational institutions and colleges with programs in Aviation

The last survey used to provide inputs to assess the attractiveness of Aviation sectors was conducted to current students enrolled in Aviation courses/programmes. The full description of the survey can be found in the deliverables of WP4 and WP5. Similarly to the previous sections, in this delivery we only describe the results concerning the questions relate with the attractiveness of the Aviation sectors. These questions are the 12 and 13. This survey has received far more answers than the previous ones. On the 15th March 2013, a total of 409 valid surveys have been collected and analysed. Despite the larger amount, it is still not enough to conduct wide statistical analysis. As such, we decided to follow a mix qualitative and quantitative approach.

Questions 12 and 13 aimed to collect information about the attractiveness and repulsion, respectively, of Aviation educational and working context. Around 80 respondents described their factors.

2.2.2.3.1 Attractiveness factors in Aviation education

In Q12, students were invited *to specify the attractiveness factors of the course (i.e., the determinant factors for choosing your course).* Despite the +76 open answers, there was a clear convergence around three focal ideas. Indeed, the convergence was so vivid that students, regardless being in different countries often used a similar wording.

Table 2.7 – Attractiveness Factors of the Aviation Education from the perspective of Students

Fascination of Aviation sectors	**Challenging work, technological and innovation driven**	**Employment and working conditions and benefits**
I was always attracted by air transport industry	complexity	good chances of having a high salary
exciting and interesting field of study	challenging and modern	job availability
curiosity and fascination of aeronautical and astrophysical phenomena	Many real complex problems	employment rate
being space related	Ability to learn about a demanding sector and broad technical skills	employability
for me it's like the space, and the excellence of the course between others		job opportunities in aerospace Career
I like everything related with space, technology and innovation		

The vast majority of students indicated a more or less interest by airships, aeronautics or aerospace as a key reason to engage in the course. One of the students wrote that "since I was 16 years old that I wanted to choose this course". Indeed, as already abovementioned, the fascination around Aviation industries is a key factor in the attractiveness of the sector.

The second most often refereed attractiveness factor was the perception of a work in Aviation being challenging and demanding. Clearly, students have built an idea about a job in Aviation industry. The job certainly is always changing, in line with the technological developments and new demands, above-average demanding, in terms of required cognitive capabilities and knowledge, and challenging.

The last attractiveness sector is related with the high levels of employability of the Aviation sectors and the (well) above average working conditions and benefits. As often as not, students indicated the high availability of jobs in the AT&S sectors, the perspectives of having a good working carrier and development and, in parallel, the expectation of a well paid job (and other benefits).

2.2.2.3.2 Repulsion factors in Aviation education

In Q13, students were invited *to specify the repulsion factors of the course (i.e., the determinant factors which could discourage someone from choosing your course).* The amount of answers was slightly fewer than in the previous one, in a total 65. This may denote a students' satisfaction towards the programmes. This is more evident when some of the students answered having no repulsion factor on the course. The answers could be grouped around three main topics, although not necessarily representing repulsion factors but simply negative (or nor positive) characteristics of the programme.

Table 2.8 – Repulsion Factors of the Aviation Education from the perspective of Students

Above-average difficulty and lengthy of the programme	Excessive theoretical contexts	Insufficient emphasis on practice
the difficulty of the subjects	too much theory and less practice	not enough focus on the practical side
being so difficult and having so few chairs about space	too narrowly focussed	very poor relation with the industry, poor organization of some subjects and lack of a more practical approach
very extend course, and also a bit difficult	extensive theoretical component	low contact with industry
time to devote to the study	much theory	a lot of knowledge is very interesting but the chance is big that you will never use it in your carrier
it is a very demanding course	The course itself has a high emphasis on theory and low emphasis on practice	
the length of the education, currently 4 years	with the current industry technology	
the amount of work during the 5 years	to have some parts that is more to memorize than to work	

Two factors that were consistently presented side by side were the inherent difficulty and the lengthy of the programme.

Bearing in mind the underlying knowledge (in terms of math or physics) behind many of the disciplines, we can easily understand why students label the programmes as being rather demanding. We cannot however say that this is necessarily a repulsion factor; instead, we see it more as a complain about the (excessive) amount of contents lectured in the period of classes (see next factor). Indeed, we can hardly conceive these students (that had previously pointed out precisely the challenging nature of the discipline as a key attractiveness factor) accepting seeing their programme reduced in its contents; neither see the industry accepting being deprived from valuable human resources.

This second factor is intrinsically related with the previous one and with the following one (see next factor). Along with the difficulty of the subjects, students also mentioned that excessive theoretical contents. They acknowledged intellectual interest, but questioned the practical usefulness of such knowledge, in particular, how it could be used in a working context. Necessarily, without a stimulus or motive (i.e. not seeing the (practical) utility of such contents), a feeling of frustration can build up within students and the sensation of difficulty will naturally emerge.

The last factor is again directly linked with the previous ones and it is related with the insufficient practical component of the programmes. Many students reported that their courses have few hands-on work components. Consequently, they often miss understanding the applicability of their knowledge. Also, of high relevancy is the fact of some students reporting a teaching gap in terms of technology and practice. That is, the contents of the lectures, concerning technological issues or practical aspects, are outdated (or simply do not report the latest developments), which creates a feeling of disappointment in the students. Some of the quotes are listed in the Table 2.8.

2.2.3 Discussion of Results

Notwithstanding our best dissemination efforts, some of the surveys got a low rate of answers, namely the one targeting the graduates who are not working in Aviation sectors. Several reasons may be pointed out. Firstly, people are less and less willing to participate in surveys. Secondly, our surveys targeted a very specific segment of the employees and students; therefore, we could never expect a large amount of surveys. This specificity raised a third limitation that was reaching the right audience. Students or companies are fairly easy to pinpoint.

The educational institutions, colleges or research centres with interest in Aviation sectors were well known of EDUCAIR's partners (besides a web based search yields a large amount of them). The response behaviour has however been rather different; while students (and researchers) have fairly answered our call; professors, lectures and so (educational institutions and research centres) have not. This denotes a higher willingness of the former in relation to the latters. Naturally, we may argue that students have more free time, although this is hardly a reason since most students reported having no spare time.

Conversely, employees and other graduated revealed being rather difficult. Companies did not show major willingness to distribute the survey among their workers. Furthermore, although we could retrieve the companies' contacts that do not necessarily mean access to the employees contacts. Consequently, we had to rely on the willingness of the human resources, marketing or other department to distribute internally. In addition, we also used our own network of contacts to reach the employees and it is our understanding that this solution was far more effective than the previous one.

Finally, the group that revealed being most difficult to be contacted was the former graduates in Aviation. The point is that most of these students lose (or broke) all the links with the Aviation sectors when they moved to another field of work. Educational institutions' alumni databases revealed of little use as contacts were often outdated. They are also outside the network of contacts of the Aviation Associations or Alumni Associations (most likely, they are not enrolled in other associations). Consequently, we could not rely on these networks of contacts because. Also, because their current fields of work are not known and since we had very limited resources, to do a call embracing all fields of work was not feasible.

Looking now into the repulsion factors on Aviation education, we can conclude for a strong consistency of the results within and between each set of surveys (that is: students and employees). As explained in each section the respondents focussed on a reduced set of negative aspect of educational system. More interestingly though is the similitude between the employees and students' answers – there is almost a complete overlapping.

The employees focussed around the main repulsion factors being: *cumbersome regulatory and legal framework*, *heavy theoretical with unperceived connection with real practice*, and *reduced amount of practical working hours*. In turn, the students answered an: *above-average difficulty and lengthy of the programme*, *excessive theoretical contexts*, and *insufficient emphasis on practice*. The employees and students coincide in the two last topics.

Starting with the different topics, employees reported difficulties to obtain the necessary legal certificates to work in some aviation jobs. It is natural students not reporting this problem, since it is very specific and only emerges when graduates apply for it. Certificates are provided by either national or international bodies. The process appears to be lengthy and involving a considerable amount of bureaucracy. Bearing in mind that a considerable amount of job, in Aviation industry, requires a valid licence, this factor is indeed relevant and should be investigated. On the other hand, this problem only seems to emerge after graduation, as students did not report it (and many of them mentioned having the intention of applying for a job that required a licence, such as: traffic operator or aircraft maintenance). Although, thus far, this problem has been limited, and therefore could not be considered as a potential factor contributing to reducing attractiveness, it should be tackled as soon as possible in order to avoid possible contagious to students.

Looking now to the students' survey, they reported as problem an excessive difficulty of the course. As already discussed in the previous section, this is not necessarily a repulsion factor, since we can hardly conceive students wishing an easy and simple programme. Furthermore, Aviation domain requires a deep knowledge on certain fundamental fields, such as: mathematics, or physics, or applied fields, such as: mechanics, fluids, materials, etc. Naturally, the contents are demanding and lengthy and, naturally, only above average students may be able to pursue such studies. For this reason, it is perfectly understandable to see labelled the programs as difficulty. However, we must not confuse impossibility with difficulty. That is, the topics must be feasible to teach and learn within to the available lecturing and studying times, even requiring major efforts and commitment by the students. Otherwise, the program is not difficult but impossible. The students fell frustrated, since they cannot cope with the requirements, with a subsequent loss of commitment and detachment from the programme. Notwithstanding this factor must not be ignored, principally, because it was consistently reported by students across the EU. This may evidence an underlying transversal problem he to EU's educational system. This problem is also intrinsically linked to the remaining two problems.

The remaining two factors were simultaneously reported in the students and employees' surveys. Such consistency reinforces the validity of the findings. Yet, perhaps, more importantly the surveys reveal that these repulsion factors occur for some time now, since employees have ended their studies some years ago. These two problems are more relevant when the employees pointed it out even after ending the programme and starting working. It is therefore relevant now to end with this cycle so that the new generations of students could have a more positive view about aviation education.

One repulsion factor is related with the excessive theoretical contents of the classes with apparently low connection with the practice. As already explained, aviation programmes are likely to have a strong emphasis in fundamental and applied fields, particularly, in the first two years, which often do not have a direct translation into the real world. Nonetheless, these topics are vital for students fully understanding the lectures in the final years, which tend to have a stronger practical component. In addition, aviation programmes are vast and often student end up working in a very specific job, doing specific tasks, which only required a few amount of the disciplines. In addition, both surveys reported that often lectures were outdated in relation to industry's practices, procedures or technological advancements. Consequently, the knowledge was not used besides reducing the students' learning interest.

The other repulsion factor is related with the insufficient practice and contact with industries. This factor is intrinsically related with the previous one but differs in nature. In the previous factor, the students and employees reported the inability to transform their theoretical knowledge into competences or tool to use at their work. This factor goes in another direction and reports that students pass too much time seated in the classroom and little time in industry context. Arguably, studying in an industry context could lead students to better understand how to deploy their theoretical knowledge and how to build tools for doing their job tasks. In any case, the bottom line is that aviation programmes appear lacking enough contact with industry and the students feel it. Laboratories are not easy or cheap to create and operate. Industry visits/stays are very useful.

Finally, the surveys also provided insights on the attractiveness factors of AT&T sectors. Again we found a full alignment between students and employees' perspectives. Three main attractiveness factors could be identified, although eventually named differently by students or employees, being:

- Fascination of Aviation sectors.
- Challenging carrier development path;
- Employment and working benefits;

Foremost, Aviation sectors still remain all of its mysticism and glamour, at least for the respondents. Indeed, many respondents wrote being fascinated by airships, air transport or aeronautics, often since adolescence. Inevitably, there were drawn into an Aviation educational programme. In addition to awe, respondents often reported that a job in Aviation is respected and admired by others (including family and peers). A very revealing picture was by a Polish employee that wrote that "Aviation industry in Mielec is most distinguished in my town and in other towns in Poland".

A second attractiveness factors is related with the very nature of the job. Students repeatedly evidence a strong belief about the challenging and ever-changing jobs that lie ahead of them. And this belief was a strong reason for pursuing a carrier in Aviation industry. The employees corroborate such belief, as many of them mentioned as very positive the dynamic and evolving nature of Aviation industry. An employee provided a blunt example about such nature: "*yesterday we were sizing rotating parts of an aircraft engine and today we are involved in the design of a regional airport*". Also reported as positive was the fact of Aviation sectors often being at the forefront of technological development and pushing forward the limits of knowledge.

The final attractiveness factor was related with the high levels of employability and above-average working benefits. The students expect and the employees confirm that Aviation employers tend to offer attractive working conditions and benefits. Also often reported, by the employees, was an interesting carrier path development that an Aviation job has to offer. Finally, Aviation sectors exhibit high levels of employability, being therefore a good attractive for students.

In Section 2.2.1, we listed the trending factors in the origin of the progressive loss of students to Aviation educational programmes. Both the attractiveness and the repulsion factors match with those trending factors, contributing to their validation. The first conclusion is that the surveys contributed to validate and reinforce the importance of those factors in attracting people to aviation educational programs. The second conclusion is that if the trends are accurate then they can actually be diverting people towards other programmes.

Just to finalise this section, we present an answer from an employee about the reasons underlying his choice for Aviation industry:

- *I wanted to be an astronaut.*
- *I liked engineering*
- *The ability of aircrafts to fly fascinated me*
- *The aeronautical field had a low unemployed percentage.*

We believe it provides a good example about the nature and type of answers.

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3 Availability of Job in the Aviation Sectors in 2020

In Europe in 2010, about 1.86 million jobs were directly[9] supported by the Aviation sector (see Figure 3.1). Of those jobs, about 519,000 (28%) are created by airlines and handling agents which include flight crew, check-in staff and maintenance crew. Moreover, 220,000 people (12%) work directly for airport operators, while 827,000 (44.5%) work on-site at airports for e.g. government agencies such as customs and security or provide retail, restaurant or hotel services.

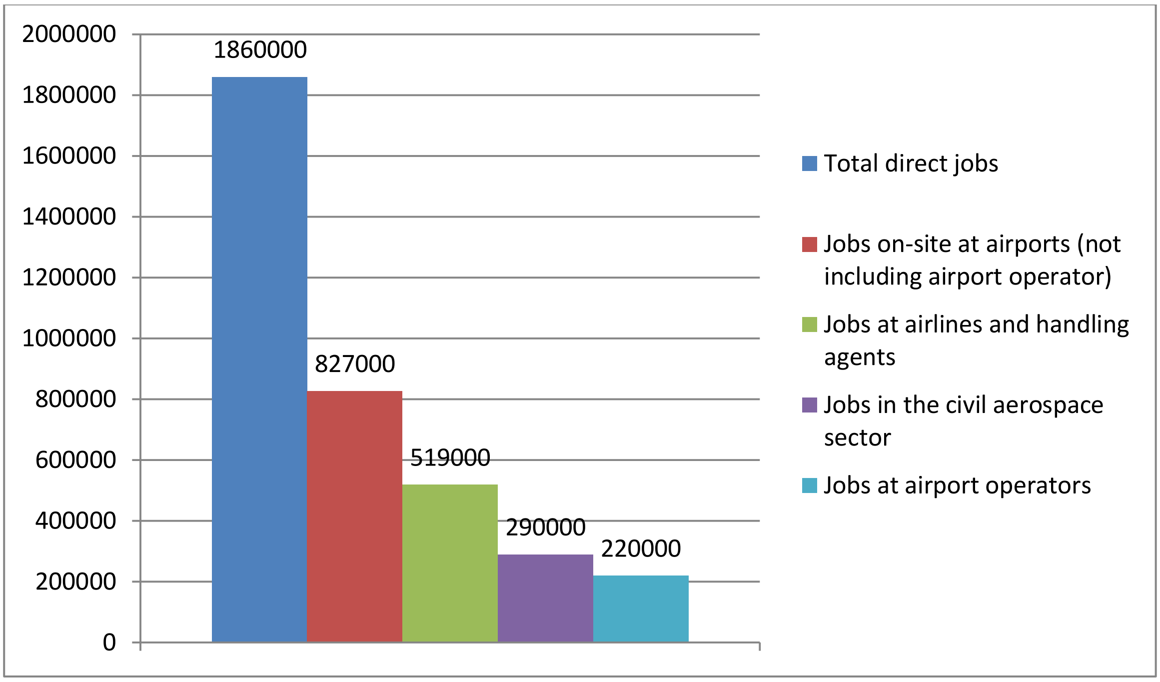


Figure 3.1 - Jobs supported by Aviation in Europe, 2010 (source: Source: Air Transport Action Group, 2012a)

The last group therefore provides the highest share of jobs in Aviation in Europe. In 2010 the civil aerospace sector such as aircraft, components, airframes and engine manufactures, employed about 290,000 people (15%). When adding the direct, indirect and induced effects[10], it can be seen that in Europe air transport supports about 5.1 million jobs, which is 22.9% of the worldwide number of jobs provided by the air transport industry. (Air Transport Action Group, 2012a)

[9] The direct effect is the employment or value added that is for most part related to the operation of an airport. (ACI & York Aviation, 2004, p.5)

[10] The indirect effect is defined as employment/value added that is generated in the economy of the region studied, in the chain of suppliers of goods and services. The induced effect is the employment/value added generated in economy of the region studied by the spending of incomes by the direct and indirect employees. Last, the employment/value added generated by the wider role of the airport when improving the productivity of business and attracting new economic activities and in the economy of the region studied, is called catalytic effect. (ACI & York Aviation, 2004, p.5)

When looking only at the European Union, the direct employment by Aviation is estimated to be about 1.7 million jobs, while the indirect effect includes 2 million jobs, the induced effect 0.9 million jobs and the catalytic effect due to tourism 3.2 million jobs (Air Transport Action Group, 2012b). Table 3.1 shows the jobs supported by Aviation in the different European countries. It is clear that countries such as France, Germany and the UK provide the most jobs in Aviation in Europe. Together those three countries provided about 55.6% of the jobs supported by Aviation in the European Union in 2010.

Table 3.1 - Jobs supported by Aviation (by country, in thousands)

	Aviation sector	+ Indirect	+ Induced	+ Tourism catalytic (total)
Austria	32	50	60	75
Belgium	36	71	84	112
Bulgaria	18.2	29.7	38.8	141
Cyprus	9.6	12.2	15.5	63.9
Czech Rep.	14	25	31	43
Denmark	29	39	45	50
Estonia	3.3	5.5	7.1	10.3
Finland	62	86	104	121
France	297	596	780	989
Germany	323	623	816	1146
Greece	53	75	100	300
Hungary	18	29	37	48
Ireland	26	42	54	117
Italy	69	152	195	382
Latvia	4.4	6.5	8.2	18.6
Lithuania	7.9	12.8	16.8	28.3
Luxembourg	8.7	9.8	11.0	14.5
Malta	3.8	4.5	5.5	31.6
Netherlands	87	138	175	287
Poland	20	45	65	84
Portugal	24	44	59	183
Romania	28	41	54	78
Slovakia	13.6	22.1	28.9	32.3
Slovenia	5.6	9.1	11.8	25.6
Spain	120	203	260	872
Sweden	44	67	83	185
UK	326	672	921	1440
EU 27	1700	3700	4600	7800

Source: Air Transport Action Group, 2012b

Before estimating the availability of jobs in the Aviation sector in 2020, the relationship between the evolution of jobs in Aviation and the evolution of air transport needed to be defined. Here, two different approaches could be followed (see Figure 3.2). The evolution of air transport could be depicted by the evolution in traffic and the construction of aircraft of by the evolution of added value[11] of the Aviation sector.

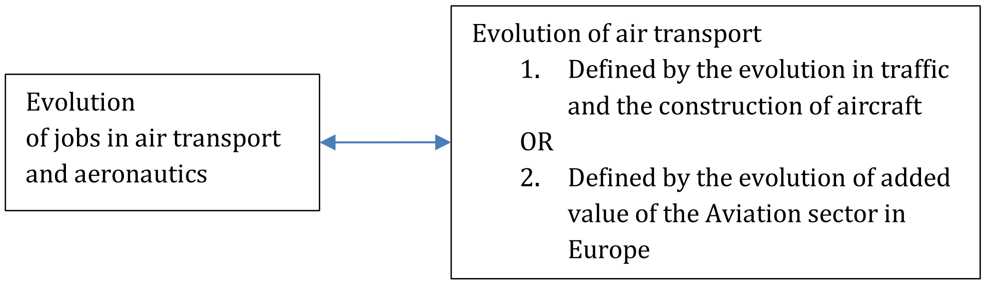


Figure 3.2 - Estimating the relationship between the evolution of jobs in Aviation and the evolution of air transport

After a thorough search of available data, it was discovered that the data as input for the analysis is scarce. The problem is especially situated in the availability of time series for a longer time period. Based on expert analysis to be able to compute the relationships between the evolution of jobs in Aviation and the evolution in air transport, historic data of at least 10 years is needed. In particular, few data is available on the evolution of jobs in Aviation at European level. Some studies can be found that analyse the number of jobs in particular countries (see for example CAA, 2004) and others that give the number of jobs in Aviation at a specific point in time (see e.g. Air Transport Action Group, 2005, 2012a,b, booz&co, 2009 and ACI Europe and York Aviation, 2004), but without giving comparable data for a longer time period.

To estimate the demand for the direct employment[12] in the Aviation sector different approaches were used, not always with reliable results. First, the relationship between the development of employment and air transport was tried to be estimated using data on an aggregated level, which means for the Aviation sector in general. Here estimations for Germany and different European countries were made. However, as the results did not turn out to be reliable, those will further not be discussed in detail. Furthermore, disaggregate estimations for the demand for employment at airports, airlines, at ANSPs and the Aviation sector were carried out. As the results from those estimations proved to be more reliable, they are discussed more in detail.

[11] The value added of an enterprise corresponds to the value that the enterprise adds to its inputs during the year, via the production process. A company's value added gives an indication of its contribution to the income (GDP) of the country or region etc. (Kupfer, Lagneaux, 2009, p.17)
[12] All estimations were made with regard to direct employment.

3.1 Existing forecasts concerning the availability of jobs for pilots, maintenance personnel and controllers

Not many forecasts can be found concerning the employment demand in the Aviation sector. One of the few existing studies concerning this topic is the "Global and Regional 20-year Forecasts – Pilots, Maintenance Personnel and Air Traffic Controllers" by ICAO (2011b). The study analyses the need for pilots, maintenance personnel and air traffic controllers worldwide and on regional level in the horizon of 2030.

Table 3.2 shows the worldwide training needs according to ICAO (2011a). The study reveals a shortfall of training capacity for 160,000 pilots, 360,000 maintenance personnel, and 40,000 air traffic controllers worldwide. (ICAO, 2011a)

Table 3.2 - Worldwide training needs for pilots, maintenance and controllers up to 2030

Personnel category	**Population in 2010**	**Population needed in 2030**	**Training needs** (estimated on an average annual basis)	**Training capacity** (estimated on an average annual basis)	**Shortage** (estimated on an average annual basis)
Pilot	463,386	980,799	52,506	44,360	8,146
Maintenance	580,926	1,164,969	70,331	52,260	18,071
Controllers	67,024	139,796	8,718	6,740	1,978

Source: ICAO (2011b)

The estimations of ICAO are based on the development of the civil aircraft fleet (for maintenance personnel and pilots) and aircraft movements (for ATCOs) and on ratios with regarding to personnel. For the forecast of pilots and maintenance personnel ratios of personnel per aircraft were used and for ATCOs ratios of movements handled annually by the controller. (ICAO, 2011b)

Concerning the forecasting of the need for pilots, ICAO worked with different scenarios depending on the pilots per aircraft ratio. For the "high scenario" a high number of pilots needed per aircraft were assumed, for the "low scenario" a low number of pilots per aircraft. The estimation shows that in 2030 between 1,214,006 and 800,469 pilots are needed worldwide which can come down to a training shortage of up to 24,978 pilots.

Table 3.3 - Pilot population in 2030 and training needs[13]

		Pilots needed: 2030	**Training needs** (estimated on an average annual basis)	**Training capacity** (estimated on an average annual basis)	**Shortage/ surplus** (estimated on an average annual basis)
Worldwide					
	High scenario	1,214,006	69,338	44,360	-24,978
	Most likely scenario	980,799	52,506	44,360	-8146
	Low scenario	800,459	39,555	44,360	4,805
Europe	High scenario	325,668	20,127	7,955	-12,172
	Most likely scenario	262,329	15,552	7,955	-7,597
	Low scenario	214,046	12,090	7,955	-4,135

Source: ICAO, 2011, Global and Regional 20-year Forecasts – Pilots, Maintenance Personnel, Air Traffic Controllers

For Europe, an annual shortage of training capacity for between 4,135 and 12,172 for pilots is expected (ICAO, 2011b)

Concerning maintenance personnel, Europe has high training needs because of their large existing aircraft fleet which in 2030 will amount to 28% of the total world fleet. Although in Europe there will be a relatively modest fleet growth and a relatively high training capacity is present, the shortage for maintenance personnel will amount to 8,352 annually.

Table 3.4 - Population of maintenance personnel in 2030 and training needs[14]

	Maintenance personnel needed: 2030	**Training needs** (estimated on an average annual basis)	**Training capacity** (estimated on an average annual basis)	**Shortage/surplus** (estimated on an average annual basis)
Worldwide	1,164,969	70,331	52,260	-18,071
Europe	330,522	22,977	14,625	-8,352

Source: ICAO, 2011, Global and Regional 20-year Forecasts – Pilots, Maintenance Personnel, Air Traffic Controllers

Last, the need for Air Traffic Control Officers (ATCO) was estimated by ICAO. As mentioned, the forecast was made using the development of aircraft movements as well as using a ratio of 370

[13] An annual attrition of 4% is assumed in the forecast.
[14] An annual attrition of 5% is assumed in the forecast.

movements/ATCO for the final estimation. The estimations show that in 2030 there will be a worldwide need for ATCOs of 139,796 in 2030 and of 32,616 in Europe. Therefore, the annual shortage of ATCO training capacity is estimated at 1,978 worldwide and 315 in Europe. (ICAO, 2011b)

Table 3.5 - Air Traffic Control Officer population in 2030 and training needs[15]

	ATCOs: 2030	**Training needs** (estimated on an average annual basis)	**Training capacity** (estimated on an average annual basis)	**Shortage/surplus** (estimated on an average annual basis)
Worldwide	139,796	8,718	6,740	-1,978
Europe	32,616	1,755	1,440	-315

Source: ICAO, 2011, Global and Regional 20-year Forecasts – Pilots, Maintenance Personnel, Air Traffic Controllers

3.2 Data and Method

The relationship between the evolution of jobs in Aviation and the evolution of air transport can be taken as basis for the estimation of the general development of jobs in the Aviation sector (see Figure 3.3). Furthermore, the future need of engineering jobs can then be calculated using the share of PhD/Engineering jobs in the different Aviation sectors.

To estimate the future employment at airports, airlines, the aeronautics sector and at ANSP's, existing data from previous years needs to be collected. However, as mentioned earlier the public domain does not offer reliable data for employment in the different sectors for a longer time period (>10 year old). Moreover, it does not suffice to rely on fact that the historic trend in employment will simply proceed in the future. Also other variables, such as GDP and future air transport demand, can affect the future employment in the different sectors. Therefore, these variables were also taken into account when estimating the future employment in the aviation sector. The advantage of working with historical data for the forecast is, that also possible efficiency gains over time are taken into account.

[15] An annual attrition of 5% is assumed in the forecast.

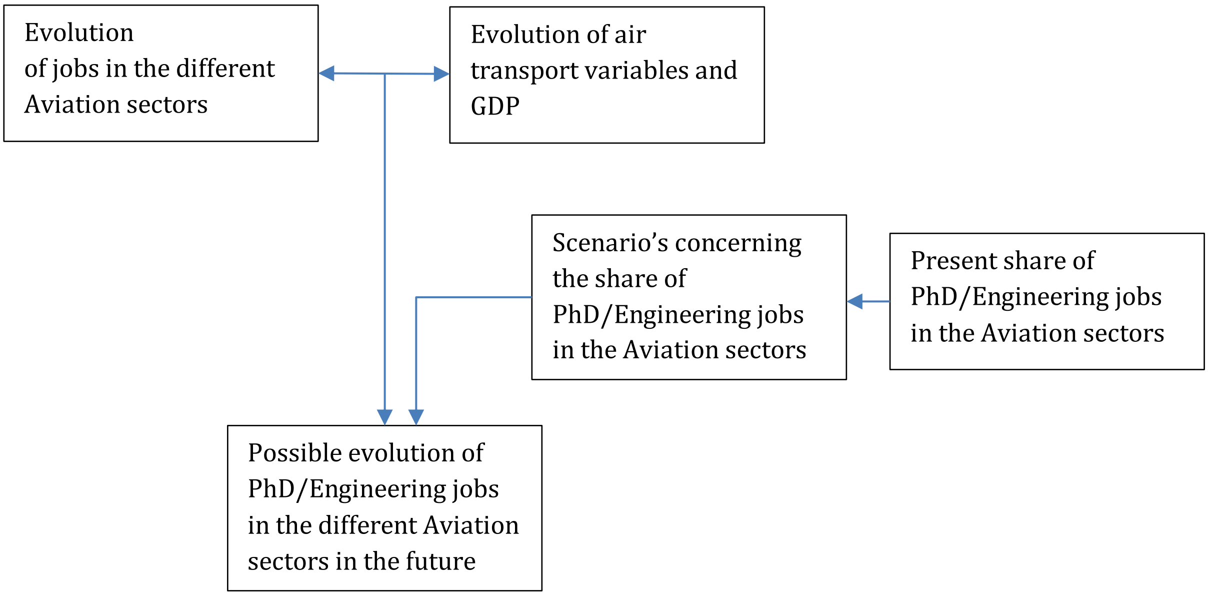


Figure 3.3 - Estimating the possible evolution of PhD/Engineering jobs in the different Aviation sectors

For all estimations data of the GDP, freight tonne-kilometre (FTK) and revenue passengerkilometre (RPK) were used based on expert analysis and consensus in the project team. Data for the GDP in Euro per capita in Europe could be retrieved from Eurostat (2013). For the FTK and RPK in the end data of IATA was used. Data for FTK and RPK on European level was not found for a sufficient long time period (data was only available from 2006). However, when calculating the share of the European FTK and RPK in worldwide traffic it could be seen that this does not decrease considerably with the available data. This is why the worldwide numbers could be used as proxy.

Movements of aircraft in Europe were used for the estimation for the airline sector, the airport sector and ANSP's, again based on expert analysis and consensus in the project team. The average daily movements used in the estimations are based on booz&Co (2009, p.6) and Eurocontrol data (Eurocontrol, 2013).

Furthermore, data for the orders and deliveries of aircraft were used for the estimation of the development of employment in aeronautics. Those data was retrieved from Boeing (2013) and Airbus (2013) as they are the largest civil aircraft manufactures in the world.

Concerning employment, data was needed for the amount of employed people at airports, airlines, the aeronautics sector and at ANSP's. For the direct employment[16]at airports, data from booz&Co (p.49) and Eurostat country data were used. To fill the gaps in the database, numbers were estimated by using the average growth in the previous and/or last year. The latter was validated by analysing statistics of the direct employment at airports in Europe from ACI. Regarding employment in airlines, estimations for Europe were based on data from booz&Co (p. 27) and IATA (for 2008-2011). Data for the employment in the European (military and civil) aeronautics sector was taken from ASD for Europe[17]. To calculate the share of the employment in civil aeronautics, the share of civil employment in Germany (Bundesverband der Deutschen Luft- und Raumfahrtindustrie e.V., 2012) and the share of incoming orders of the European civil aeronautics sector (ASD, 2012) were used as a proxy. Eurocontrol ACE benchmarking reports were used to calculate the employment in ANSP's. This data was completed by estimations for Poland for 2001 since data for this year was not available in the Eurocontrol benchmarking reports.

To forecast the future employment in the different sectors MatLab and Excel were used to relate the employment with the different variables mentioned above such as GDP, FTK, RPK etc. (see Figure 3.2). First, the data was normalized to eliminate the effects of the magnitude of the absolute values. Thereafter, the ordinary least square linear regression method is applied to estimate the coefficients of the independent variables (GDP, FTK, RPK etc.). Here the independent variables were assumed to have a linear additive (instead of a multiplicative) effect on the dependent variable (employment). This assumption was made as the European air transport market behaves as a mature market, small changes will have a small result. In the equation relating employment to the different independent variables, a constant factor was not included as this would presume that there is an inheritor organic growth in employment, even without growth in the independent variables.

After estimating the coefficients for the different independent variables an average European growth of employment was calculated for the different sectors, by feeding the linear additive relations with its sector specific coefficients with experts forecasted growth data. Table 3.6 shows the forecasted growth data for the independent variables. When more detailed yearly growth data was available (as for example for GDP) or could be estimated, then the latter was used in the calculation of the employment.

3.3 Availability of jobs in the airport sector

To estimate the future employment in the airport sector, FTK and RPK growth data were used in the specific segment linear additive model. During the estimation process it was seen that other

[17] ASD (AeroSpace and Defence Industries Association of Europe) represents the Aeronautics, Space, Security and Defence industries in Europe which comprise amongst others aerospace and defence companies as well as suppliers.

variables such as GDP and movements proved to be insignificant[18] or their coefficient equalled to zero.

To calculate the overall growth in airport employment the following equation was estimated:

$$\Delta E_{airp} = 0.8691\,\Delta FTK + 0.3897\,\Delta RPK$$

Where: ΔE_{airp} = growth in employment in the airport sector

ΔFTK = yearly growth in freight tonne-kilometres

ΔRPK = yearly growth in passenger tonne-kilometres

With an R^2 of 0.66 and RPK and FTK significant at a 5% level.

Table 3.6 - Forecasted growth data for the independent variables

Independent variable	**Average growth (until)**	**Source**
Deliveries	1.05% (2020)	Airbus, Global Market Forecast 2012-2031
RPK	4.10% (2031)	Airbus, Global Market Forecast 2012-2031
FTK	4.80% (2031)	Airbus, Global Market Forecast 2012-2031
Movements	3.00% (2019)	EUROCONTROL Seven-Year IFR Flight Movements and Service units Forecast 2013-2019
GDP	2.05% (2017)	International Monetary Fund, World Economic Outlook Database, October 2012

It can be seen that the explanatory value of the model is relatively low as the R^2 is quite low. This can be attributed to the lack of qualitative time-series data, especially for the employment at airports.

It can be seen that the growth in FTK and RPK have an impact on the employment at airports. That the growth in FTKs have higher impact than the growth in RPKs can be due to the relatively lack of long time-series with which the estimation could be carried out.

Table 3.7 shows the growth of employment in the airport sector until 2020. Also the development of engineers in the airport sector is shown Figure 3.4. Based on information from the surveys, a share of 15-25% of engineers in the airport sector can be assumed. The calculations show that the need for engineers working at airports can be assumed to grow from between 20,464 and 34,107 in 2010 to between 34,230 and 57050 in 2020, with an average yearly growth of 5.3%.

[18] A coefficient was assumed to be significant if at least significant at a 10% level.

Table 3.7 - Employment at airports 2010-2020 (estimations 2010-2020)

	General	Engineers 15%	Engineers 25%
2010	136,427	20,464	34,107
2011	140,238	21,036	35,059
2012	147,813	22,172	36,953
2013	155,924	23,389	38,981
2014	163,944	24,592	40,986
2015	172,377	25,857	43,094
2016	182,323	27,348	45,581
2017	192,842	28,926	48,210
2018	203,968	30,595	50,992
2019	215,735	32,360	53,934
2020	228,182	34,227	57,046

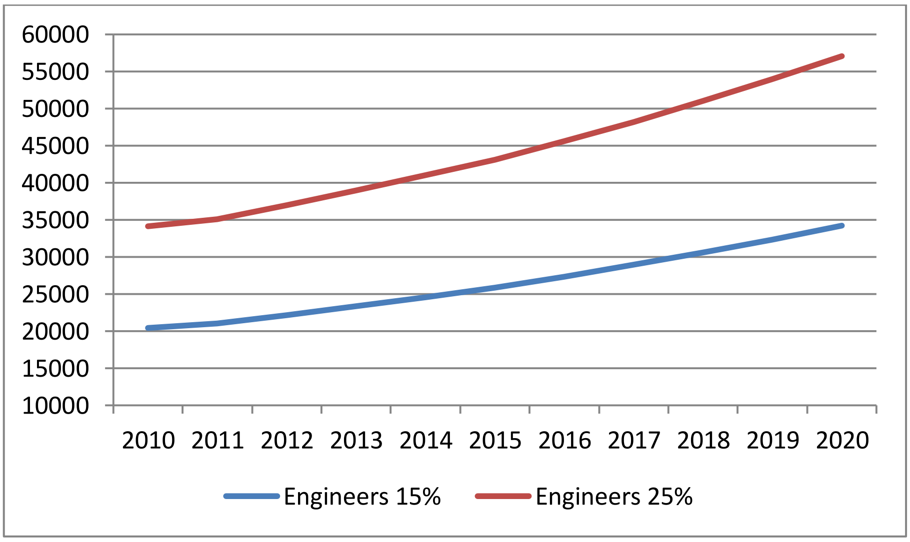


Figure 3.4 - Employment of engineers at airports 2010-2020 (estimations 2010-2020)

3.4 Availability of jobs in the airline sector

To estimate the future employment in the airline sector, FTK and movement growth data was used. During the estimation process it was seen that other variables such as GDP and RPK proved to be insignificant or their coefficient to be zero.

To calculate the overall growth in employment at airports the following equation was estimated:

$$\Delta E_{airl} = 0.2297\ \Delta FTK + 0.3152\ \Delta Mov$$

Where: ΔE_{airl} = growth in employment in the airline sector

ΔFTK = yearly growth in freight tonne-kilometres

ΔMov = yearly growth in movements

With an R^2 of 0.69 and FTK and average daily movements significant at a 1% level.

Also here the R^2 is relatively low, which can be attributed to the lack of reliable time-series data especially for the airline employment.

It can be seen that the growth in FTK and movements have an impact on the employment at airlines. The important RPK key performance indicator seems to be highly correlated with movements and is therefore not significant.

Table 3.8 shows the growth of employment in the airline sector until 2020. Also the development of engineers in the airline sector is shown (see Figure 3.5). Based on information from the surveys a share of 5-10% of engineers in the airline sector can be assumed. From interviews with airlines validating this information we can assume, however, that this percentage will be closer to 5% than to 10%.

The calculations show that the need for engineers working at airlines can be assumed to grow from between 21,229 and 42,458 in 2010 to between 26,670 and 53,330 in 2020, with an average yearly growth of 2.3 %.

Table 3.8 - Employment at airlines 2010-2020 (estimations 2012-2020)

	General	Engineers 5%	Engineers 10%
2010	424,582	21,229	42,458
2011	444,377	22,219	44,438
2012	453,479	22,674	45,348
2013	462,767	23,138	46,277
2014	472,245	23,612	47,224
2015	481,917	24,096	48,192
2016	491,787	24,589	49,179
2017	501,860	25,093	50,186
2018	512,139	25,607	51,214
2019	522,628	26,131	52,263
2020	533,333	26,667	53,333

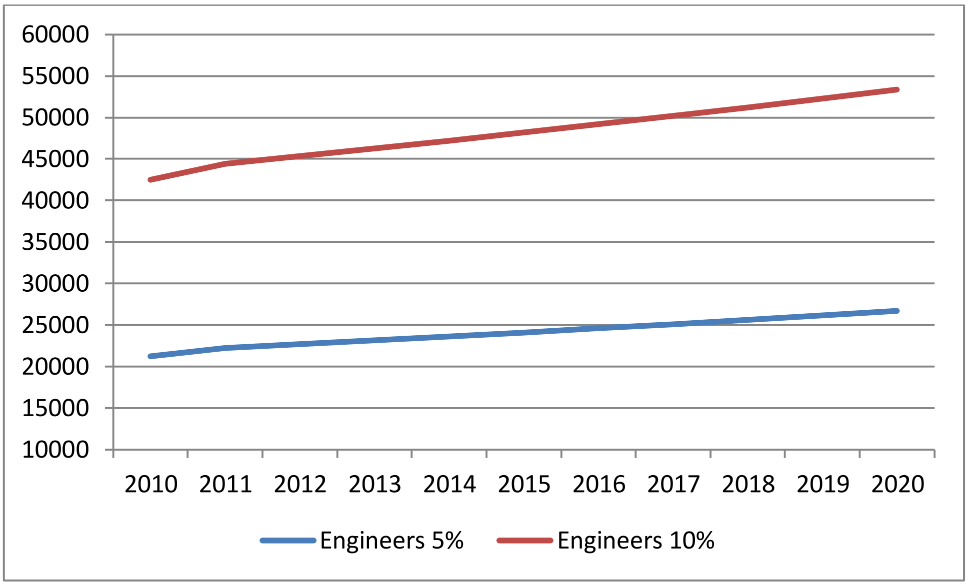


Figure 3.5 - Employment of engineers at airports 2010-2020 (estimations 2012-2020)

3.5 Availability of jobs in the aeronautics sector (civil)

To estimate the future employment in the aeronautics sector (including suppliers), growth data about deliveries, GDP and passenger tonne-kilometres was used. During the estimation process it was seen that other variables such as FTK and movements proved to be insignificant or their coefficient to be zero.

To calculate the overall growth in employment in the aeronautics sector the following equation was estimated:

$$\Delta E_{aero} = 0.2034\,\Delta Del + 0.6860\,\Delta GDP$$

Where: ΔE_{aero} = growth in employment in the aeronautics sector

ΔDel = yearly growth in deliveries

ΔGDP = yearly growth in GDP

With an R^2 of 0.97 and the growth in deliveries and GDP significant at a 10% level.

In contrast to the other estimations has the estimation for the employment in the civil aeronautics sector more explanatory value with a high R^2 of 0.97. This could point to the good quality of the used data from ASD for the employment in the aeronautics sector.

It can be seen that next to the growth in GDP, the growth in deliveries, but not the orders, has an impact on the employment in the aeronautical sector. The orders turned out not to be significant. This can be explained with the fact that orders can apply to aircraft which are delivered a number of years from now and of which the production does not start right away.

Table 3.9 shows the growth of employment in the aeronautics sector until 2020. Also the development of engineers in the aeronautics sector is shown. Based on information from ASD, a share of 30-35% of engineers in the aeronautics sector can be assumed. It can be seen that the employment of engineers in the civil aeronautics sector growth from between 103,208 and 120,409 in 2010 to between 121,071 and 141,249 in 2020, with an average yearly growth of 1.6%.

Table 3.9 - Employment in the civil aeronautics sector 2010-2020 (estimations 2012-2020)

	General	Engineers 30%	Engineers 35%
2010	344,025	103,208	120,409
2011	359,700	107,910	125,895
2012	359,957	107,987	125,985
2013	361,941	108,582	126,679
2014	366,523	109,957	128,283
2015	372,118	111,635	130,241
2016	378,072	113,422	132,325
2017	384,209	115,263	134,473
2018	390,501	117,150	136,675
2019	396,953	119,086	138,933
2020	403,569	121,071	141,249

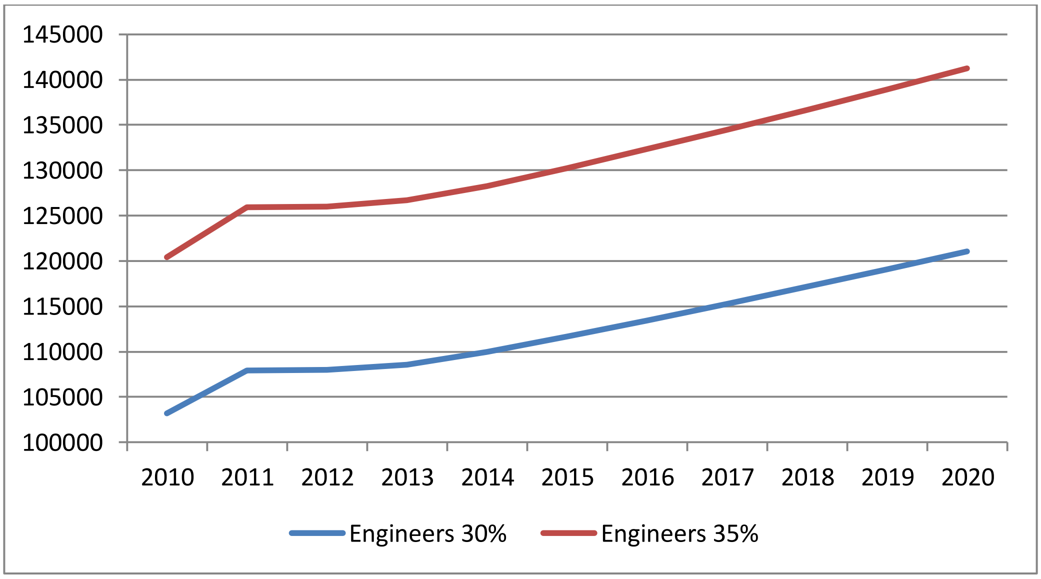


Figure 3.6 - Employment of engineers in the civil aeronautics sector 2010-2020 (estimations 2012-2020)

3.6 Availability of jobs at ANSPs

To estimate the future employment in the ANSP sector, data about the average daily movements were used. During the estimation process it was seen that other variables such as GDP, FTK and RPK proved to be insignificant or their coefficients to be zero.

To calculate the overall growth in employment of the ANSP's the following equation was estimated:

$$\Delta E_{ANSP} = 1.0494\,\Delta Mov$$

Where: ΔE_{ANSP} = growth in employment in the ANSP sector

ΔMov = yearly growth in movements

With an R^2 of 0.66 and the growth in movements significant at a 10% level.

It can be seen that the growth of movements has a very high impact on the employment at ANSPs. This high impact is far from surprising as the work at ANSP's depend mostly on the movements of aircraft. However, as with the estimations of the employment at airports and airlines, the R^2 and therefore explanatory value proved to be quite low.

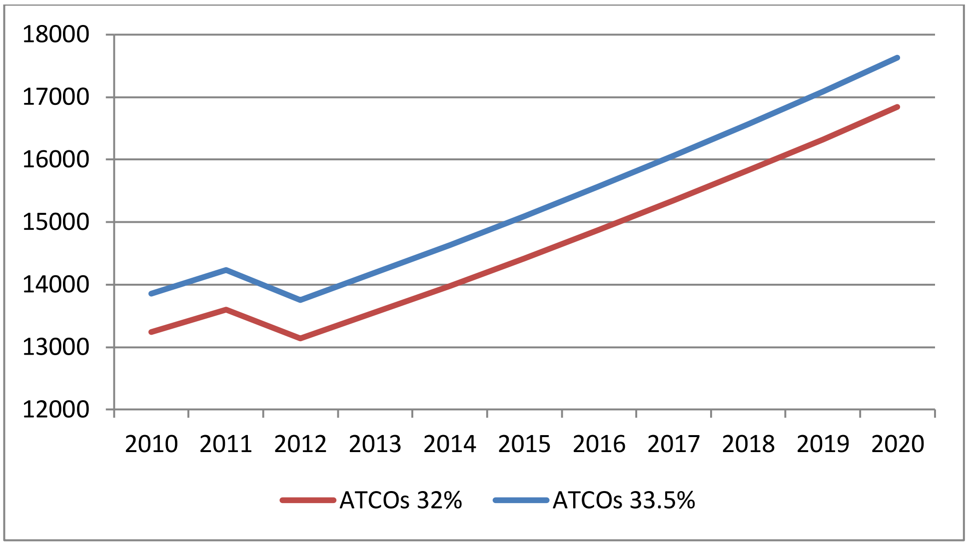
Table 3.10 shows the growth of employment in the ANSP sector until 2020. Also the development of Air Traffic Control Operators (ATCO) in the ANSP sector is shown (see also Figure 3.7). Based on information from various Eurocontrol ACE benchmarking reports a share of 32-33.5% of ATCOs in the ANSP overall employment can be assumed. It can be seen that the employment of ATCOs at ANSPs grows from between 13,236 and 13,857 to between 16,839 and 17,628, with an average yearly growth of 2.4%. This average yearly growth can be considered quite reasonable. This knowing that the worldwide growth of controllers was forecasted by ICAO between 2010 and 2030 to be 3.7% and keeping in mind that the European market is a mature market.

Table 3.10 - Employment at ANSPs 2010-2020 (estimations 2011-2020)

	General	ATCOs 32%	ATCOs 33.5%
2010	41,363	13,236	13,857
2011	42,500	13,600	14,238
2012	41,064	13,141	13,756
2013	42,357	13,554	14,190
2014	43,690	13,981	14,636
2015	45,066	14,421	15,097
2016	46,485	14,875	15,572
2017	47,948	15,343	16,063
2018	49,458	15,826	16,568
2019	51,015	16,325	17,090

2020	52,621	16,839	17,628

Figure 3.7 - Employment of engineers at ANSPs 2010-2020 (estimations 2011-2020)



Comparing the estimates with the regional forecast of ICAO concerning the need for ATCOs it can be seen that ICAO forecasts a higher need for ATCOs in Europe. (ICAO, 2011b) In 2030 they estimate a need of 32,616 ATCOs in Europe. The reason is first, that another geographical scale was used, our estimation looked at ATCOs in the EU while ICAO looked at the European level, and therefore the base of the estimation differs. Second, another methodology was used in the estimation. While the forecast of ICAO is based on a ratio of 370 movements/ATCO for the final estimation next to the development of aircraft movements, our methodology is based on historical data. The advantage of working with historical data for the forecasting, an increase in efficiency can be taken into account. Based on those data the relationship between the development in the number of employees at ANSPs and the development of aircraft movements were determined and projected into the future. Furthermore, it should be mentioned that the forecast is based on present trends, not incorporating disruptions or increase in efficiency due to for example SESAR.

3.7 Comparing the demand and supply side of aerospace/engineering graduates between 2010 and 2020

The review of selected academic degree programmes within WP4 concluded with some preliminary estimates of the numbers of engineering graduates (discussed in detail within WP4/D4.8 Deliverable). These can provide a starting basis for a first approximation of the pool of engineering graduates (prospective employees/supply side) who enter the job market and compete for jobs in the sector on annual basis. Based on the identification of the existing educational offering of relevant engineering programmes and the average number of engineering graduates (student outflux per programme), some preliminary conclusions can be drawn on the estimated number of students annually graduating (outflux) from the targeted engineering programmes in 2012 (Table 3.11).

Table 3.11 - Estimates of Numbers of Engineering Graduates in 2012 (outflux)

EU Engineering Programmes in Aviation			
Estimates Annual Student Outflux	1st Cycle 5.890	2nd Cycle 2.370	1st + 2nd Cycle 2.720

Based on the estimation above, the number of engineering graduates of Aviation programmes in 2012 for EU27 (for a sample of around 170 programmes considered directly relevant to our analysis) is approximated as follows: i) 5.890 graduates at 1st cycle, ii) 2.370 graduates at 2nd cycle and iii) 2.720 graduates of MEng programmes. Certainly, this is only a rough approximation that should be treated with caution due to certain assumptions with the most important being the targeted/identified sample of Universities/Educational Institutes and educational programmes, as well as the estimated average numbers of graduates for each category of programme.

For the estimation of the overall population of graduates of all cycles, it would be oversimplifying (and overestimating) to sum up the estimated numbers of graduates of each cycle for two reasons. First, the outflux of 1st cycle programmes is typically the influx for 2nd cycle programmes (and therefore, there will be several duplicated "entries"). Second, the graduates of the 2nd cycle may also include engineers having obtained their 1st cycle degree in a non-Aviation related topic (and therefore, it would not be accurate to disregard 2nd cycle graduates altogether to avoid double counting). On the other hand, graduates of MEng programmes (1st+2nd) do not typically "overlap" with 1st cycle graduates since MEng are integrated Master programmes covering both cycles at a single degree (and therefore, their graduates can be safely added on top of 1st cycle graduates). Based on the above, and under the assumption that there is a large overlapping between 1st and 2nd cycle graduates (influx from 1st to 2nd cycle), it is reasonable to expect that the overall population of aerospace/aeronautical engineering graduates at both cycles should be roughly 9.000-10.000 in 2012 for the examined sample of around 170 educational programmes considered relevant to this analysis. As it was not possible to obtain data for other years than 2012, we assume that the average population of graduates of all cycles remains relatively stable over the short/medium run and overall 9,000-10,000 students per year will enter the job market after graduating. That means that between 2010 and 2020 about 90,000 to 100,000 aerospace/aeronautical engineers are expected to enter the market.

When looking at the demand side for aerospace/aeronautical engineers, we can use the forecast made in this chapter to get an idea about the labour market evolution of aerospace/aeronautical engineers working in the different air transport/aeronautical sectors.

Table 3.12 - Summary of labour market evolution 2010-2020

Sector	Share of engineers & PhDs / ATCOs	2010	2020 (F)	Growth of labour market 2010-2020	Estimated attrition 2010 - 2020 (at 4% per year)
Airports	15% engineers & PhDs	20 464	34 227	13763	11638
	25% engineers & PhDs	34 107	57 046	22939	19397
Airlines	5% engineers & PhDs	21 229	26 667	5438	10602
	10% engineers & PhDs	42 458	53 333	10875	21204
(civil) Aeronautics	30% engineers & PhDs	103 208	121 071	17863	49410
	35% engineers & PhDs	120 409	141 249	20840	57645

Table 3.12 shows a summary of the results of the forecast, the expected growth of the labour market in the different sectors between 2010 and 2020 and the estimated attrition[19] during the same time period. To calculate the estimated attrition, an annual attrition of 4% was assumed, which was also applied by ICAO for the 20-year in the forecast the demand for pilots (ICAO, 2011b).

As result we see in Table 3.13 that assuming the scenario's with a low percentage of engineers in the overall employment (15% for airports, 5% for airlines and 30% for civil aeronautics), the labour market will grow with about 37,060 people. Furthermore, 71,650 people are estimated leave the AT&A sector between 2010 and 2020, which brings the total demand for aerospace/aeronautical engineering graduates between 2010 and 2020 to about 108,714.

Table 3.13 - Calculation of total demand for aerospace/aeronautical engineering graduates 2010-2020

	Growth of labour market 2010-2020 (all sectors)	Estimated retirement 2010-2020 (all sectors)	Total demand for aerospace/aeronautical engineering graduates
Scenario with low share of PhDs/engineers	37,064	71,650	**108,714**
Scenario with high share of PhDs/engineers	54,646	98,248	**152,902**

[19] Attrition is defined by ICAO (2011b) as "the reduction [...] in the number of professionals, mainly as a result of resignation, retirement or death". (ICAO, 2011b)

If the share of engineers/PhDs in the sector is assumed to be higher (25% for airports, 10% for airlines and 35% for civil aeronautics), the labour market is expected expand with about 54,600 people between 2010 and 2020, with 98,200 people expected to leave the sector during the same time period. This will lead to a demand in aerospace/aeronautical engineering graduates 152,900 between 2010 and 2020.

A last step in this analysis is to compare the outflow of aerospace/engineering graduates with the demand for new employees from the industry. When we consider the scenario with a low share of PhDs/engineers in the sector, there will be an additional demand for about 108,700 engineers/PhDs in the AT&A sector (see Table 3.13.). Assuming that per year between 9,000 and 10,000 students enter the industry from universities between 2010 and 2020, 90,000 to 100,000 graduates will have entered the market by 2020. Therefore, in 2010 there will be an estimated lack of about 8,700 (108,700 new jobs but only 100,000 graduates) to 18,700 (108,700 new jobs but only 90,000 graduates) trained aerospace/aeronautical engineers in the sector. Analogous, assuming that the share of engineers/PhDs in the sector is even higher, the lack of trained aerospace/aeronautical engineers is expected to grow to between 52,900 (152,900 jobs and 100,000 graduates) and 62,900 (152,900 jobs and 90,000 graduates).

However, it should be stressed that this is only a very rough estimation which should be treated with care as certain assumptions had to be made. First off all, the supply and demand for engineers/PhDs between 2010 and 2020 is only an estimation with the assumptions explained in the corresponding parts of this deliverable. Second, the calculations do not take into account the different specializations that students graduated with. A mismatch of the specializations chosen by students and the specialization needed in the market might even increase the lack of trained aerospace/aeronautical engineers/PhDs. Furthermore, the calculations do not take into account that some graduates might find work in a different sector than the air transport and aeronautics sector. On the other hand, not only graduates from aerospace/aeronautical programs work in the AT&A sector, but there is also an influx from other engineering programs which might, to a certain extent, limit the gap between labour demand and supply in the AT&A sector.

4 Education and Curricula in Aviation

4.1 Review to the Educational Tools and Techniques

Since education is a key social structure, it is impacted on by globalization. Therefore, the trend of globalization is also reflected in the education. Nowadays, educational programs provide an international focus and curriculum planners tend to internationalize the higher education systems. The reason for this movement is threefold. Politically, higher education is an aspect of the foreign policy. Culturally, the goal of internationalization is to extend the values and principles of the national culture. And economic, international higher education is the main source of both short term and long term income.

Moreover, educational institutions are considered the main measure of progress in a country and provide the basis for the dynamic competition of a country in the region and in the world. So, strengthening the international aspect of higher education is strengthening the country in the regional and international competition. (Ardakani et al., 2011).

Furthermore, aviation is strongly international at all levels (operation, certification, market and airlines). This is why education cannot be an exception.

4.1.1 Impact of international focus on students

Students should be able to function in a one-world environment, intellectually as well as professionally and socially. This is especially important in the Aviation sector as they often recruit international employees and have an international scope of operations. According to Parkinson et al. (2009), it is important that (engineer) students develop a global competence. This implies that students should appreciate other cultures and that they should be able to communicate across cultures. Therefore, they should also be able to speak different languages, on conversational as well as professional level. Furthermore, they should understand and be able to deal with the cultural differences. This makes them view themselves as citizens of the world as well as citizens of a particular country. To achieve this, students should be provided the opportunity to be exposed to international topics and have a chance to work in a global context.

Furthermore, the last few years, traditional “chalk and talk” teaching was gradually replaced by active learning and learning through practice. Furthermore, the individual perspective was transformed into team work to acquire the wanted skills. Some papers for example talk about learning with board games or simulation games to get a good notion of the material they have to learn. Others refer to project-based learning instead of lecture-based learning. This shows that, next to gaining knowledge, it is also important to be submerged in what you're studying by gaining some experience and practice.

4.1.2 Implementation of the international focus in education

Setting up such an international education, can be done by infusing the international aspect in the existing curricula or by developing a curriculum which is international.

4.1.2.1 Introduction to foreign cultures

The first option implies that students are exposed to foreign cultures, professors and students in their own context. Setting up traditional international activities, such as visiting international conferences or organizing guest lectures of foreign speakers, introduces students to foreign cultures. This way, students learn to understand the (slight) difference of the position of their own culture in comparison to other cultures. However, these international contacts are limited. Students only experience the international aspect in a short term.

4.1.2.2 International curriculum

A good curriculum has 3 aspects: good coverage of basics, the same quality as it peers and a unique differentiation in specific areas. An international curriculum allows the universities/institutes to offer quality with diversity and allows students to establish longer and more profound contact. This can be achieved the traditional way; students can either travel abroad, for several months, to study. This way, there is a more in-depth exposure to the foreign culture. Here, extended field trips, internships or even research activities abroad spring to mind. Furthermore, double degrees show mutual confidence between universities.

On the other hand, thanks to technology, international experience can also be gained without leaving the own office.

The last 10 to 15 years, technology and telecommunications have developed a lot. The Internet made real-time communication with virtually anyone, almost anywhere in the world possible and relatively inexpensive Therefore, the Internet became indispensable for our day-to-day communication. The importance of this technology becomes more and more apparent: a study, performed in 26 different countries by GlobeScan commissioned by BBC (2010), showed that worldwide 80% of the people find that Internet access is a human right, next to freedom of speech and clean drinking water. The study highlighted that the majority of the respondents stated to see the Internet as a source of information, rather than entertainment. The rise and importance of this technology virtually made the world smaller.

Nowadays, students can follow courses and lectures by using internet-based tools. This, is called e-learning. These tools can however also bring students from different educational institutes all over the world together in virtual classrooms. The drawback from this distance learning is that students only make virtual contact with foreign cultures and are not really submerged in it.

Table 4.1: Overview of different educational techniques focused on global education

Introduction to foreign cultures				
Short Term	Hours, days	International conferences, guest lectures, ...	Travel abroad or on own campus	Regular degree
International curriculum				
Medium Term	Months	Extended field trips, internships, research or learning abroad, summer programs, Exchange students, ...	Travel abroad	Degree with international experience
Medium Term	Months	E-learning, virtual class rooms, ...	On own campus, *distance learning*	Degree with international experience
Long(er) Term	Months, years	International dual degree, ...	Travel abroad	(Partly) international degree

Source: own composition

Moreover, education is not always about teaching, learning and courses. Interacting with other international students and professors is also very important to keep our knowledge up to date. This interaction can also be virtual and this has also been facilitated through technological developments, such as the Internet. International knowledge bases and even laboratories appear more and more in the virtual world.

This international focus facilitates student exchanges. Therefore, the competition between educational institutions increases which entails that offering a qualitative international education program becomes more important.

4.1.3 The effect on air transport related education?

The air transport sector includes various disciplines and is very internationally focused. Therefore, a global or international focus is also needed in the air transport related education.

In his editorial, Torenbeek (2000) showed that, although design educators had been in contact, for example on international conferences, Professor Rodrigo Martinze-Val of ETSIA believes that the quality of teaching aircraft design could benefit from more regular exchanges of experiences. Therefore, European Workshops on Aircraft Design Education are held regularly (every two years). This is done to continue active collaboration, to discuss problems as regards research and education and to enhance close cooperation for these two aspects aforementioned.

This shows that, also in air transport related research and education, an international focus is desirable.

A paper by Atici and Atik (2011) shows that **distance learning** is applied in the Turkish Air Forces (for lifelong learning programs). The paper highlights that the need for education is increasing, but the resources are limited. "*At this point, distance learning is applied in many education institutes as an alternative solution to satisfy the demand*". The study stresses the fact that the cost of face to face learning is threefold the cost of distance education. On the other hand, institutions have to weigh the cost of face to face learning with its advantages and compare this to distance learning.

Jenkinson et al. (2000) state that *"aircraft design courses at educational institutions have attempted to simulate industrial design practices. This has generally involved both the synthesis of students' knowledge in their core subjects and a requirement to work in teams."* They highlight the fact that, nowadays, thanks to the rapid development of information technology, it is possible to **team internationally**. The educational objectives of the collaboration between a educational institution in the US and a educational institution in the UK are

- to model modern, international industrial design practices;
- to broaden the perspective of student aircraft design projects;
- to improve student understanding of communication and organizational skills;
- to enhance students' personal development;
- to benefit faculty experience.

They will achieve this in different ways, such as case studies, parallel teams, where student groups in each country independently work on the same design proposal, and integrated teams, which involves that students in each country work together on a joint design project.

Such a project can only become a success if several prerequisites are fulfilled. For example, a common educational objective for the project work is needed. Furthermore, there should be a good professional relationship between the academic staff involved and the academic calendars should be aligned. Although, this way of working also comes with some challenges, such as dealing with delays, communication problems, etc., it can be said that international teaming projects have been very successful. "*They have provided an enhanced educational experience for students and enjoyable* *link between academic staff at the two institutions. In the six months of working alongside each other (albeit 5000 mile distance for most of the time) the students had built up mutual trust and respect to produce very effective teams. Working with students from different social, cultural and educational backgrounds did not lead to any discernible problems."*

These examples show that, also in air transport education, international education becomes possible thanks to the technological developments and showed to be rewarding for the students as well as the educational institutes.

To illustrate this, it can be added that also IATA works with distance learning technology. They refer to several courses being available as e-books or for e-learning. This distance learning is possible for courses in International Aviation training, international travel and tourism training and international cargo training.

4.1.4 Changes in Aviation-related training: some examples

As stated before, Aviation today faces a series of pressing challenges. It has to improve its safety record in the face of traffic growth, address the need for increased innovation, ensure air transport's more sustainable and environmental-friendly future, take advantage of the latest technologies and processes to make aircraft more secure, etc. (ICAO, 2011b, p.3)

ICAO stresses the fact that more effective training has an important role in pursuing these challenges. Therefore it has begun to coordinate the sector-wide response through its Next Generation Aviation Professionals (NGAP) initiative. Some of these programs, such as the Multi-crew Pilot License MPL, are very successful. (ICAO, 2011b, p.3)

The New ICAO Training Policy focuses on competence-based training, putting the focus on performing, rather than just knowing (ICAO, 2011a, p.3). The **Multi-crew Pilot License (MPL) approach** is a good example since it focuses on the competencies required of a co-pilot on a transport-category airplane. It is a multi-disciplinary approach that brings together expertise in training, licensing and organizational certification. Unlike in flight training which is a global methodology that focuses on achieving quality objectives, in the approach of MPL, performance benchmarks are developed against a detailed job task analysis, partially specific to each air carrier. Continuous assessment of the trainees against these established baselines bypasses other traditional skill assessments (e.g. written examinations and flight tests)which only provide a momentary snapshot of a trainee's ability to perform.(ICAO, 2011b, p.6). However, both training types are needed for a good/qualitative training. Also an increased use of simulators can be seen e.g. in pilot education, ATC and emergency training.

Furthermore, the International Federation of Air Line Pilots' Associations (IFALPA) has recognized that relying solely on a pilot's technical knowledge and skills it not sufficient to safely operate complex aircraft in today's flying environment. **Crew Resource Management (CRM)** was developed over 30 years ago to help address this issue. It can improve the proficiency and competency of individual pilots and flight crews as a whole, especially when it is implemented as an error management strategy. It is a define set of skills that supports pilot technical and decision–making flying capabilities by providing them with the skills needed to address human error by managing resources within an organized operational system. (ICAO, 2011b, p.13) It is important to note that CRM is not just aircrew-centric; it does not start and stop with the captain or crew. Effective CRM must be embedded within the cockpit and safety culture of the airline. (ICAO, 2011b, p.14)

Air Navigation Service Providers seek to enhance their existing training to anticipate the significant technological and operational evolution in virtually every aspect of the world's **Air Traffic Management (ATM)** system. For air traffic controllers, training is a career-long activity. They face requirements for periodic training to refresh their knowledge, as well as training on new equipment and procedures implemented throughout their careers. Combinations of academic, simulator and on-the-job training are created and adapted to meet the specific needs of the provider. It is important to provide quality and comprehensive training to the current controller workforce on new technologies, tools and procedures to implement new systems and simultaneously continuing to operate the air traffic control system and devoting conservable training resources to ensure adequate numbers of new controllers to meet future demands. (ICAO, 2011b, p.38)

The ATC production line in its simplest form can be described in three key phases: requirement and selection; basic skills training; and on-the-job training (OJT). Airways New Zealand developed its proprietary Total Control simulator with the objective of improving training quality and safety while reducing overall ATC training costs and timetables. (ICAO, 2011a, p.46) Also in Denmark, the training of air traffic controllers with the help of simulators has been the practice for many years. (ICAO, 2011b, p.41)

Also **maintenance training** has to be optimized since, over the past four decades, a great deal has changed in terms of how effective maintenance training programs are provided and measured. Methodologies have evolved from classroom presentations via computer-based training modules to on-site training with portable training media. This in turn has helped realize the "virtual classroom" where even complex troubleshooting tasks can be simulated. The role of a professional training staff has also changed; from the old-styled lecturer to engaged instructor, to a personal coach of sorts and, more recently, trainers have evolved into a type of "media and information manager". (ICAO, 2011a, p.4) Lufthansa Technical Training GmbH uses the concept of "Blended Training". The concept has three key elements: a competency based-approach that is student-paced and instructor-guided; a fully-integrated use of the most state-of-the-art training and simulation media; and the availability of training notes available digitally and complemented by a quick-reference handbook that features high-quality system schematics and concise system descriptions. (ICAO, 2011a, p.6)

Within IATA, the IATA Training and Development Institute (ITDI) is concerned with education. ITDI believes in the power of the blended learning concept. There is an in-company training delivery model to reduce corporate training costs, foster innovative thinking and reduce the environmental impact of travel. The forum-style setting for classroom and onsite courses fosters a dynamic and engaging learning experience geared to improving business results. In addition, every year ITDI brings to market innovative e-learning programs that offer students flexibility for distance learning. (ICAO, 2011a, p.50)

Moreover, aircraft manufacturers offer engineering students, in coordination with their educational institutions, stays (typically of 6-12 months) to perform relatively detailed technical work as an assessment of skills and selection tool for recruitment.

4.2 Bachelor and Master Programmes (1st and 2nd Level of Bologna)

This section summarizes the key findings of the identification and review of the existing educational offer (supply-side) in terms of relevant educational programmes (1st and 2nd Bologna Cycle) in Aviation at EU27. A more detailed discussion of these results is provided in the EDUCAIR/WP4/D4.8 Deliverable titled "Quantitative and Qualitative Assessment of Educational Supply". For the identification of the existing educational offer (supply-side), two basic categories of programmes were considered relevant:

1. Educational programmes in Aviation offered by various types of Educational Institutes (e.g. Universities, Polytechnics, Universities of Applied Sciences) at the 1st and 2nd level of Bologna. These include only programmes involving explicitly a degree (rather than just individual courses) in Aviation.
2. Lifelong Learning (LLL) programmes in Aviation with special emphasis on professional or corporate programmes offered by key industry actors or educational institution-industry alliances (e.g., ECATA, Lufthansa Technical Training, Airbus, Emirates College, IATA, ACI, ICAO), also found as Continuing Professional Development (CPD) or Continuing Professional Education (CPE).

The review of academic degree programmes initially aimed to develop a comprehensive inventory/list of relevant programmes comprising the existing educational offering in Aviation at EU27. The list has been populated through desktop research complemented by relevant PEGASUS Partnership sources (PEGASUS Partnership, 2009), and eventually validated by the EDUCAIR Consortium and its Advisory Board. The primarily targeted educational programmes were engineering programmes in Aviation at 1st and 2nd Bologna cycles. Furthermore, integrated Master's engineering programmes (MEng) covering simultaneously both 1st and 2nd Bologna cycles were also considered. The list of (engineering) programmes was enriched with undergraduate and graduate programmes in Aviation with management (e.g., air transport / aviation management, airport planning and management, airline management) or other relevant orientation (e.g., air safety, aviation technologies, aircraft maintenance, flight operations). Overall, the identified educational offering contains 251 educational programmes offered by more than 100 Educational Institutes at 22 European countries. Table 4.2 provides an overview of the existing educational offering in Aviation at both Bologna cycles (including MEng) for three generic types of orientations (pure Engineering, Management, Other) of academic degree programmes in Aviation. The detailed list/inventory of programmes can be found in WP4/D4.8 Deliverable.

Table 4.2: Overview of Existing Academic (Degree) Programmes in Aviation

Orientation	1st Cycle	2nd Cycle	1st + 2nd Cycle	ALL
Engineering	64	64	40	**168**
Management	22	23	-	**45**
Other	15	23	-	**38**
ALL	**101**	**110**	**40**	**251**

A subset of the identified educational programmes was selected for a more in-depth review based on the following criteria: i) full spectrum of engineering programmes in Aviation, ii) representation of different types of orientations or subject(s) of studies in Aviation programmes, and iii) geographical coverage in EU27. The selected programmes offer a broad coverage at both geographical and educational (level, type, and system of Aviation studies) terms and were reviewed with view to their key characteristics, structure, and course offering. In addition, relevant information about engineering programmes in the United States with emphasis on the National Center of Excellence for Aviation Operations Research (NEXTOR II) Educational institutions has been also elicited. In total, 44 educational programmes grouped in five categories were reviewed:

- 11 EU Engineering Aviation Programmes of the 1st Cycle (1st EU ENG),

- 17 EU Engineering Aviation Programmes of the 2^{nd} Cycle (2^{nd} EU ENG),
- 8 EU Engineering Aviation MEng Programmes covering both the 1^{st} and 2^{nd} Cycle (1^{st}+2^{nd} EU ENG),
- 4 EU Management Aviation Programmes of the 2^{nd} Cycle (2^{nd} EU MNG), and
- 4 US Engineering Aviation Programmes of the 2^{nd} Cycle (2^{nd} US ENG).

A dominant observation stemming from the analysis of the reviewed programmes is that engineering education varies considerably with the different educational systems or even with programmes delivered within the same educational system. The engineering profession itself and particularly the "Engineer" interpretation differs across the various European countries and worldwide (PEGASUS Partnership, 2009). In some countries (e.g., Italy, Germany), these variations expand further since there are two different levels of "engineers": an upper level (after 5 years of higher studies) and a lower level (3 to 4 years).

Some harmonization of the educational studies across Europe has been achieved with the Bologna scheme known as 3-5-8 according to the Bologna Declaration and its subsequent refinements. According to the Bologna scheme, European countries were encouraged to rearrange or adapt their educational systems to a three-cycle structure of comparable degrees based on common terminology and standards. The first cycle (3 years) covers undergraduate studies after 3 years of post-secondary education and typically leads to a degree corresponding to the traditional Bachelor of Science (BSc). The second cycle (after 2 more years from first cycle or 5 years of higher education) deals with graduate studies and leads to a degree corresponding to the traditional Master of Science (MSc). During the last decade, there has been an increasing trend towards MEng programmes constituting alternative, integrated Master's (engineering) programmes combining both the first and second cycle and providing students, within the scope of a single programme, with the educational qualifications required for accreditation for a professional career in the relevant area or as preparation for a PhD. They have initially appeared in UK but are now increasingly adopted by other countries as well (e.g., Portugal, Bulgaria, Germany). Finally, the third cycle (after 3 more years from second cycle or 8 years in total) covers doctoral studies (PhD) that are covered in the subsequent section.

Although there is substantial progress made towards the Bologna Declaration aims and many Educational institutions have adapted their programme structures to the proposed new scheme, the harmonization process has still some way to go. First, it seems that there is not absolutely common denomination of the degrees offered by various programmes. Furthermore, MEng programmes have been adopted and delivered in several different variations. For example, there are cases in which BEng is explicitly offered as an intermediate (1st) level degree before MEng, whereas other MEng programmes do not offer BEng at entry or offer it only in exceptional cases (if any at all). In general, some national systems (e.g., UK, Italy, Germany) demonstrated traditionally two separate cycles (intermediate and longer programme), a fact that resulted in a smoother transition to the 3+2 Bologna scheme, while other countries followed two cycles (e.g., 2+3 in France, 4+2 in Spain) or even a single 5-year cycle (e.g., Greece) that cannot be directly aligned with the new scheme. As a result, the adoption and alignment with the Bologna scheme, in most cases, was not a straightforward task and required more than simple rearrangement of existing programmes.

As far as the U.S. system is concerned, some notable differences can be identified. First, the Bachelor's degree corresponds to four years (+4) of higher education. Second, the overall duration of studies for the Bachelor's and Master's degrees in the United States is not strictly specified by the Educational institutions. In practice, degrees are awarded on the basis of successful completion of a certain number of credits (including often conditions on grades), but there is not typically a (minimum) time limitation on the completion of studies (PEGASUS Partnership, 2009).

The strong international dimension and orientation of the reviewed engineering programmes was another interesting observation coming out of the review. International students have substantial representation (over 20% and slightly higher in 2nd cycle programmes) with UK Educational institutions and Delft Educational institution of Technology (DUT) exhibiting substantial international penetration. Furthermore, many programmes (above 40%) deliver also the courses in a second language (mostly in English, less in French). However, the aforementioned percentages seem to be somewhat overestimated since many programmes apparently reported international students and second (other than the native) language, while these are only offered in specific course modules within the framework of Erasmus programme or for only a part (e.g., semester, year) of the programme.

Regarding the student recruitment / selection criteria, some form of entry exams (at the Educational Institution or national level) represents the dominant criterion in undergraduate and MEng programmes. On the other hand, the dominant criterion in graduate programmes of the 2nd cycle is some measure of the Grade Point Average (GPA) with certificates of languages and other specific criteria such as mathematical skills or previous (Bachelor) degree from a relevant engineering department being important as well. As far as graduation requirements are concerned, successful completion of all required courses (or the equivalent of course credits, e.g., ECTS) is obviously the dominant requirement. Thesis is also an important requirement mostly in 2nd cycle graduate programmes (including MEng). An alternative form is some kind of a final project (or final year project) that is envisaged by many programmes at all cycles. Final exams is an essential criterion in some countries (e.g., 1st cycle engineering programmes in Italy), while spending some time (one semester or year) in industry is a typical option in Educational Institutions especially in UK and the Netherlands. The situation is similar (courses and final project) for the reviewed programmes with management orientation (EU MNG), but students are usually required to have some form of industrial training. In US ENG programmes, students are typically required to successfully complete all courses and usually a research-based thesis. Regarding the required number of courses and credits (ECTS) per year, the situation was found to be rather harmonized across the three categories of engineering programmes reviewed. With only very few exceptions, most programmes require on average 10-11 courses or the equivalent of 60 ECTS credits per year. For US programmes, the average number of credits is approximately 30 US credits per year (120 US credits for a Bachelor's degree and 30-40 more credits for a Master's degree).

An interesting finding of the review was the lack of harmonized accreditation or quality assurance systems. In some countries (e.g., Italy, Greece), national authorities or bodies establish rules upon which accreditation is granted as long as programmes conform to the rules. In other countries (UK, Portugal), degrees are accredited (and periodically re-confirmed) through an "a posteriori" evaluation process by a professional association or government-appointed body. The most typical types of accreditations were those exhibited by UK Educational institutions (e.g. Royal Aeronautical Society, Chartered Institute of Logistics and Transport) and the Netherlands and Belgian-Flemish higher education institutions (e.g. Accreditation Organisation of the Netherlands and Flanders - NVAO). As a matter of fact, although professional accreditation / licensing (directly awarded to students) is common, academic accreditation (awarded on the basis of a certain academic programme) is sparsely offered. Therefore, there seems to be a need for a European-wide academic accreditation system that will *inter alia* promote quality assurance and student mobility. This system should build on recent initiatives undertaken by the PEGASUS Partnership towards the establishment of a voluntary accreditation system for Aerospace Engineering education in Europe. In addition, it should pursue synergies with other accreditation bodies / associations with special emphasis on: i) the European Network for Accreditation of Engineering Education (ENAEE) offering the EUR-ACE[20] framework, set of standards, and accreditation system for engineering degree programmes at 1st/2nd cycle and ii) the European Association for Quality Assurance in Higher

[20] http://www.enaee.eu/eur-ace-system

Education (ENQA, 2004)[21] offering accreditation models and quality assurance best practices for higher education.

Regarding the educational curriculum and course structure/content, despite some differences between countries, there is an evident pattern and common features among the reviewed engineering programmes. Almost half of the 2nd EU ENG programmes and one third of the 1st EU ENG and MEng programmes offer specializations with the most frequently appearing being: Aeronautics, Space, Aerodynamics, Propulsion and Structures, as well as Flight Systems and Mechanics. Furthermore, some similarities in the course structure of full 5-year and 3+2 programmes are summarized below:

- The first two years are mostly focused on courses related to fundamental sciences (e.g., mathematics, chemistry, physics) or basic/general engineering content (e.g., mechanics, electronic engineering, software engineering). Some aerospace engineering topics may be introduced during the second year.
- The third year, which may also lead to an intermediate (Bachelor's or equivalent) degree, introduces more course modules and topics on aerospace engineering that are complemented by general engineering courses.
- The last two years (fourth and fifth) offer specialized and advanced topics on aerospace engineering along with opportunities for undertaking more research-oriented topics in laboratories and industrial internship or final year project. Finally, the last two years of highly specialized studies are typically complemented by general management/business courses, financial/economics courses, as well as aeronautical regulation/law courses.

The logical sequence or dependency relationships among courses, and most importantly, the magnitude of the various course categories (e.g., fundamental sciences, basic/general engineering, aerospace engineering, other general courses, final year project, industrial internship) varies substantially from programme to programme. For example, the industrial internship is often envisaged for the final year of studies, but it can also take place well before (third year) or even not at all. Another notable variation is observed in the magnitude of basic/general engineering courses and mainly other general courses, which may range from few courses to a substantial part of the educational curriculum. Furthermore, the profile of a given programme is also affected by the country and the underlying educational system (PEGASUS Partnership, 2009). As a general rule, countries with a strictly regulated and administered educational system (e.g., Italy, France)

[21] http://www.enqa.eu/files/ENQAmodels.pdf

demonstrate little variation in their programmes' profiles. On the other hand, countries that traditionally exhibited a decentralized educational system (e.g., UK, Germany, the Netherlands) show a larger dispersion and diversity in their programmes' curricula. Along the same lines, certain countries (e.g., UK) put strong emphasis on the offering of specialized courses on aerospace engineering hence leaving less room for more general or other courses. Finally, the duration and educational format of the courses may also strongly vary ranging from a few weeks duration to several months and from 3 to 12 ECTS.

For a more detailed analysis of the course offering of the reviewed programmes, we have identified 15 categories of courses that are the most representative in aerospace engineering programmes in Europe. The identified categories were based on a similar review of PEGASUS Aerospace Engineering Programmes (PEGASUS Partnership, 2009) and were slightly expanded and adapted in the EDUCAIR context. More specifically, categories 8-10 were added to account for competences of actors/stakeholders (e.g., Airports, Airlines, ATM/ATC authorities) that are particularly targeted by the EDUCAIR (online) survey. Furthermore, the last two categories include course modules on: i) Fundamental Sciences (e.g., mathematics, chemistry, physics) or Basic/General Engineering content (e.g., mechanics, electronic / electrical engineering, software engineering) and ii) Other courses on general management/business, financial/economics, aeronautical regulation/law and other specialized management-related courses (e.g., quality management, knowledge management, marketing, human resources, project management, supply chain management) excluding foreign languages. The remaining categories correspond to more or less specialized aerospace engineering topics that are widely taught in relevant programmes.

1. Aerodynamics, Gas Dynamics, Heat Transfer
2. Structures and Materials
3. Aircraft Design, Subsystems and Integration
4. Rotary Wing Systems and Non-conventional Aircraft
5. Performance, Stability and Control, Flight Mechanics
6. Propulsion and Combustion
7. Production and Maintenance
8. Airport Planning, Design and Operations
9. Airline Operations
10. ATM/ATC
11. Aircraft Operations and Safety
12. Aircraft Navigation, Avionics, Communications
13. Space Engineering and Technology

14. Fundamental Sciences / General Engineering
15. Other

An “average” or “typical” profile of the educational curricula of the reviewed programmes is presented in the figures below for the four types of reviewed programmes in Europe (1st EU ENG, 2nd EU ENG, 1st+2nd EU ENG, 2nd EU MNG). The educational profiles discussed below include both compulsory and elective courses and report in relative terms the percentage of the identified course categories over the total number of ECTS offered in the specific programme. In other words, they provide a measure of magnitude, focus or degree of specialization offered by the reviewed programmes in the selected course categories / topics.

It is clear that fundamental sciences and general engineering represent by far the dominant category in 1st cycle engineering and MEng programmes since a large number of such courses are typically offered as a background or introduction to engineering studies during the first two years. Furthermore, the “Other” category (e.g., general management/business, financial/economics, law, marketing, human resources) is comparably represented at all engineering programmes. Specialized aerospace/aeronautical engineering courses (especially Categories 1-7) are also similarly weighted in all cycles of engineering programmes. A notable exception is observed in 2nd cycle of EU Management Aviation programmes in which the “Other” category normally represents the dominant category in the absence of engineering courses. Finally, it is important to underline the fact that airport, airline, and ATM/ATC-related courses are hardly available (at least on a stand-alone basis) in engineering programmes. On the contrary, the aforementioned categories represent almost half of the educational offering of 2nd cycle EU Management Aviation programmes. This observation reveals the strong complementarity between relevant engineering and management programmes in Aviation and justifies the study path of several engineers pursuing a “complementary” management degree after completing their 1st cycle engineering degree.

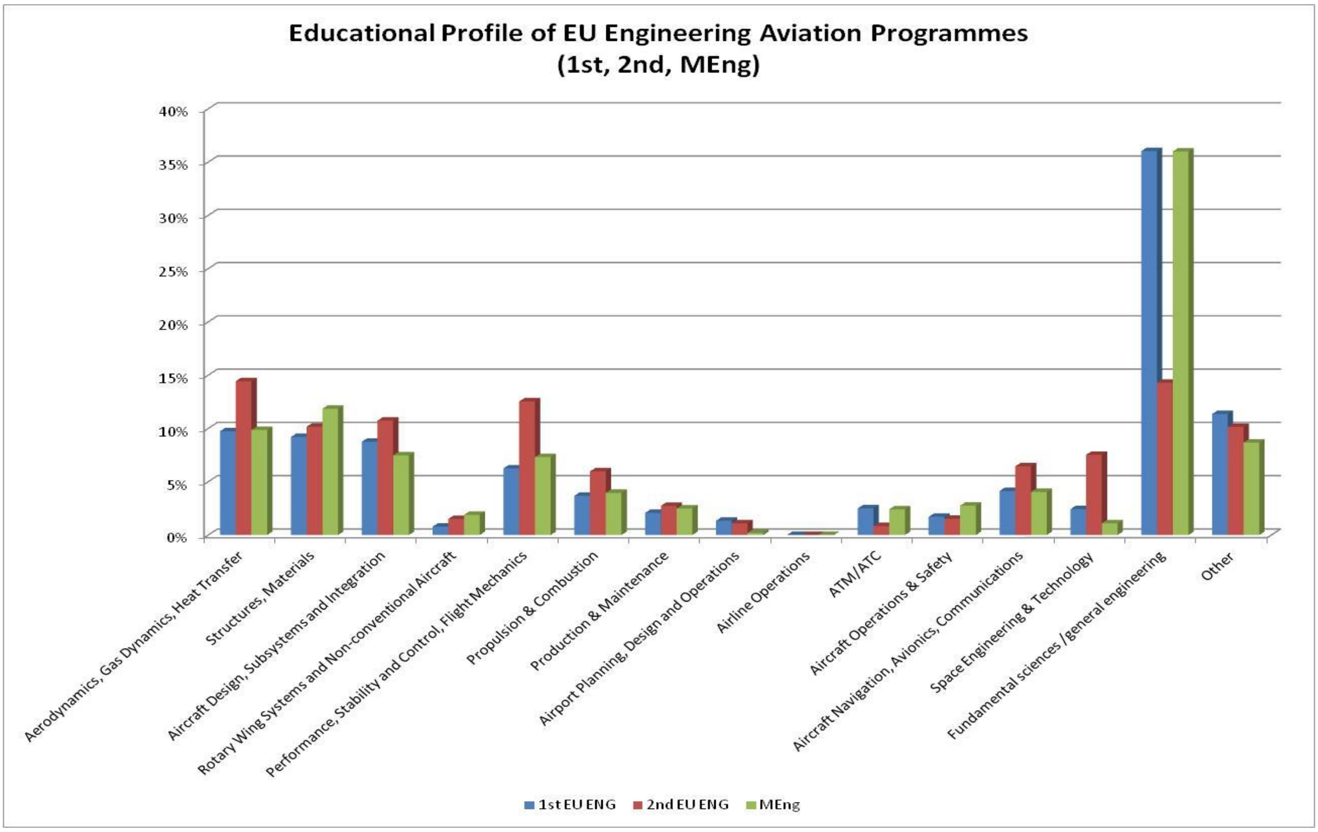


Figure 4.1 – Educational Profile of EU Engineering Aviation Programmes (1st, 2nd, MEng)

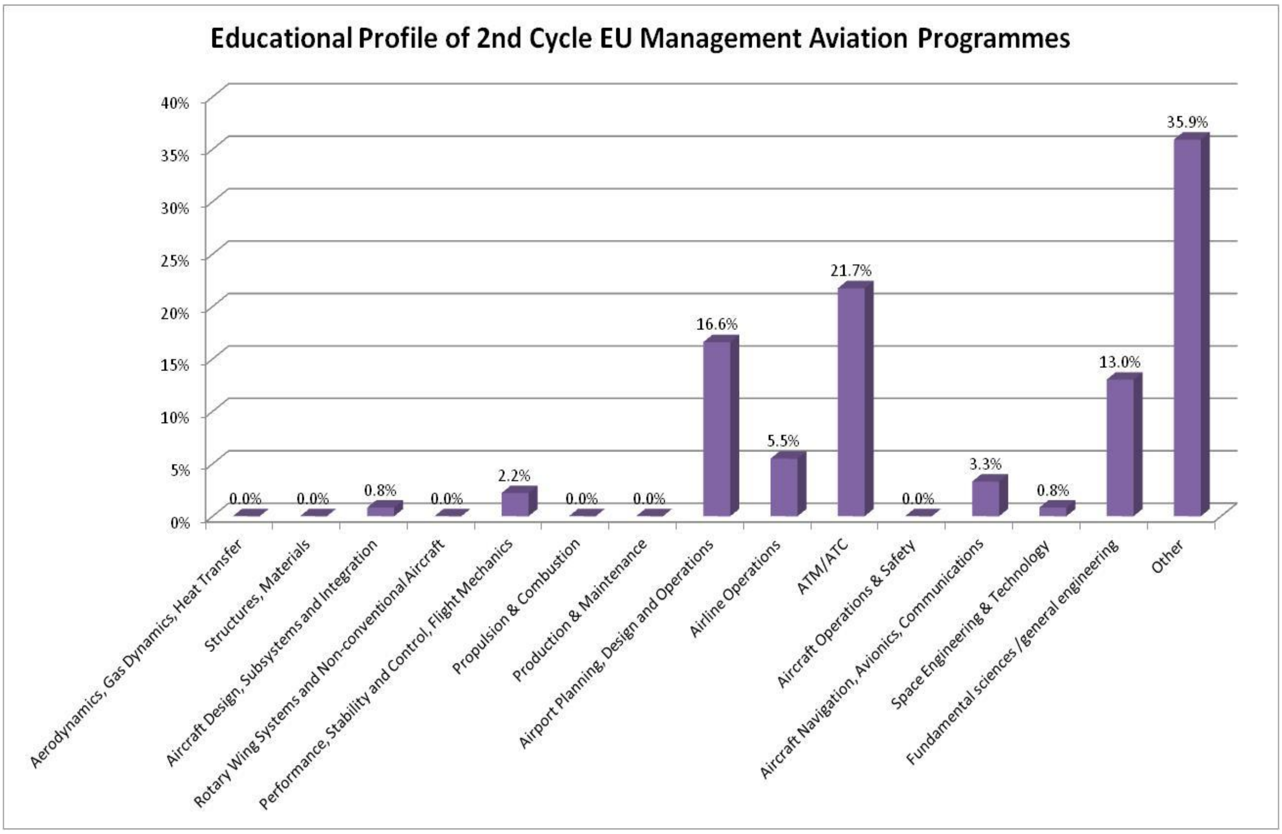


Figure 4.2 – Educational Profile of 2nd Cycle EU Management Aviation Programmes

The analysis presented above is not intended to include a comprehensive list of all course topics offered or to prescribe the "best mix / educational offering"; it rather attempts to develop a typical profile of the existing educational offering and identify course categories / areas that are over or under-represented. Furthermore, despite some differences between countries or programmes, there are some clear similarities and common features among the reviewed engineering programmes. These are mainly related to the temporal structure of studies and the main course categories offered in respective years of studies. Finally, most of the programmes provide - to varying degrees though - the option to their students to freely select a certain number of courses (or ECTS) from the entire course catalogue of the programme, the Educational institution or even other cooperating Educational institutions (e.g., PEGASUS partner). This provides ample opportunities for students to shape their own, customized / individual profile and build their own portfolio of competences especially through the selection of elective courses at home or other foreign partner Educational institution. The diversity of student profiles contributes to increasing the flexibility and mobility of students and to a more spherical coverage of specialized industry needs. On the other hand, it makes difficult to assess and compare the educational offering of programmes or Educational institutions since their educational "output" (various student profiles) is already highly customized.

Based on the review of selected academic degree programmes, some preliminary estimates[22] of the numbers of engineering students - especially those graduating on annual basis - have been made (discussed in detail within WP4/D4.8 Deliverable). These can provide a starting basis for a first approximation of the pool of engineering graduates (prospective employees) who enter the job market and compete for jobs in the sector on annual basis. According to this estimate, the number of engineering graduates of Aviation programmes in 2012 for EU27 (for a sample of around 170 programmes considered directly relevant to WP4 analysis, that is engineering programmes in aviation for the 1st and/or 2nd cycle) can be approximated as follows: i) 5.890 engineering graduates at 1st cycle, ii) 2.370 engineering graduates at 2nd cycle and iii) 2.720 engineering graduates of MEng programmes. Under the assumption that there is a large overlapping between 1st and 2nd cycle graduates (influx from 1st to 2nd cycle) but there is no overlapping (with few exceptions, e.g., in the Netherlands) between 1st cycle and MEng programmes, it is reasonable to expect that the overall population of aerospace/aeronautical engineering graduates at both cycles should be roughly between 9.000 and 10.000 in 2012. Certainly, this is only a rough approximation that

[22] Based on average numbers (after removing outlier values such as enrolling students and graduates for DUT) of engineering graduates (student outflux per programme) extrapolated to the overall (relevant) educational offering.

should be treated with caution due to certain assumptions with the most important being the targeted/identified sample of Educational Institutes and educational programmes, the estimated average numbers of graduates for each category of programme, as well as the degree of overlapping between 1st and 2nd cycle graduates. It is also important to note here that relevant past estimates (e.g. ASTERA Study, 2004; PEGASUS Partnership, 2009) have considered substantially smaller sets of targeted programmes/Universities that do not allow direct comparisons; albeit they can provide some reasonable confidence to our rough estimates.

The review process examined also the current offer (supply) of professional or corporate programmes (CPD), as well as Lifelong Learning (LLL) programmes in Aviation. Overall, the identified educational offering contains 193 LLL/CPD programmes offered by more than 25 educational institutes, key industry actors, international associations or educational institution-industry alliances. These programmes address a large spectrum of educational, both management and engineering-related orientations / specializations in Aviation such as programmes with: i) pure aerospace engineering content, ii) infrastructure, facilitation and maintenance content, and iii) air transport management background. Similarly to the academic degree programmes, a subset of the identified LLL/CPD programmes was further reviewed. These were basically professional or corporate training programmes (e.g., ECATA, Lufthansa Technical Training, Airbus, Emirates College, IATA, ACI), offered by key industry actors or educational institution-industry alliances. Similarly to the academic degree programmes, an interesting finding of the review of LLL/CPD programmes was that there is no uniform certification or accreditation for those programmes. Besides maintenance training (which is based on international legislation), organizations are seeking different methods for international accreditation. Furthermore, short courses have focused topics and subjects of study, while programmes of longer duration (>1 year) show a mix of subjects (soft and hard skills). New e-learning programmes like the Harvard and Stanford IATA model have comparable duration with conventional programmes and include 6-11 small courses. Finally, more organizations are delivering facilitating and management programmes, whereas less pure aerospace engineering LLL/CPD programmes were found.

4.3 Doctoral Programmes (3rd Level of Bologna)

In this section, we present the results of the questionnaire developed to gain some insight of the doctoral programmes in the field of aerospace, aeronautics and air transport.

4.3.1 The questionnaire

It is evident that for the Aviation sector characterized by an increased competitive environment there exists a growing awareness of the importance for Europe of increasing its research potential which is mainly interlinked with the third Bologna cycle that are offered at the educational institutions which are the main providers of doctoral programmes in the EU. Thus, the educational institutions are responsible for providing the unique environment in which young researchers are trained by and through research. In the present adverse financial circumstances, this role has to be reinforced in order to prepare the next generation to compete in the global world.

This section provides a succinct summary of the results obtained by the questionnaire developed by ULPGC for compiling information for the development of task 5.2 (see WP5 and deliverable 5.9). Throughout the web sites of different educational institutions and other vital information obtained from different networks as PEGASUS, EASN, ASD, ECATA and EREA

The PEGASUS network of European aerospace educational institutions was founded in 1998 in Toulouse. The idea of PEGASUS originated from a growing awareness within academia that the European aerospace industry was on the track of a strong concentration with no equivalent in any other industrial sector. PEGASUS was first conceived as a restricted network of the main aerospace educational institutions of the main aerospace countries and their partners, so the initial founding members group was deliberately limited to 20 educational institutions from 8 European countries. In a second phase, PEGASUS has begun to open its membership to more aerospace educational institutions. PEGASUS was born as an initiative of academia to accompany research and industry in their move towards more synergy and effective co-operation.

The European Aeronautics Science Network has as its main long-term goal to built up an open, unique European platform in order to structure, support and upgrade the research activities of the European Aeronautics Educational institutions, as well as to facilitate them to respond to their key role within the European Aeronautical research Community in incubating new knowledge and breakthrough technologies. Any individual with interest in Aeronautics and Aeronautics related research may become a member of EASN. In addition, entities such as Research Establishments, SMEs, Industries and Educational institutions are welcome to join the EASN. EASN is a network involving more than 100 educational institution institutes and research groups dealing mainly with research, possibly in co-operation with other stakeholders.

The AeroSpace and Defence Industries Association of Europe, ASD, represents the aeronautics, space, defence and security industries in Europe in all matters of common interest with the objective of promoting and supporting the competitive development of the sector. ASD pursues joint industry actions which require to be dealt with on a European level or which concern issues of an agreed transnational nature, and generates common industry positions. ASD has 28 member associations in 20 countries across Europe. In 2011 over 2000 aeronautics, space and defence companies in these countries employed more than 730.000 people and generated a turnover of almost €171.5 billion. The essence of the Association is to provide a single platform for the development of joint positions for the industries it represents. Adept at spreading the word regarding new policies and possible legislative development, ASD raises awareness and promotes the values and positions of its members to all EU institutions.

The Institute/Industry ECATA Consortium (European Consortium for Advanced Training in Aerospace), composed of seven leading Aerospace Institutes and the major Aerospace Manufacturers, is widely recognised as one of the leaders in these fields. With a tradition of innovation since its creation in 1988, ECATA has developed a range of courses designed by professionals for professionals. In particular it is quite relevant the annual "Aerospace Business Integration" course which has been attended by engineers and scientists from more than 30 European companies, research centres and government agencies in Europe. ECATA aims at identifying the high level training needs of the Aerospace Industry and jointly developing appropriate training programmes. Academic know-how, experience and knowledge of the profession are combined to organize a range of courses fitted to the needs.

EREA, the association of European Research Establishments in Aeronautics, is a non-profit organisation which gathers Europe’s eleven most outstanding research centres active in the field of aeronautics and air transport. These organisations gathered in EREA with the goals to: promote and represent joint interests; intensify the co-operation in the field of civil, military and space-related aeronautics research; improve and intensify the co-operation with third parties in the field of aeronautics, and to facilitate an integrated management of joint activities, thereby contributing to Europe’s role as a global player in aeronautics.

The template questionnaire consists of four different parts. In the first part of the questionnaire, basic information of the responsible staff is asked such as, the name of the program, Director, email, Secretary and email. Then we ask whether the program consists of some teaching modules. If we obtain a positive answer we ask about the number of modules, names and if possible list of competencies acquired.

The second part of the questionnaire was dedicated to gather information about the structure of the programme, whether the program was developed and controlled by one department, interdepartmental, Doctoral School, a European Joint Programme or under other circumstance. We also obtain information about if research groups are involved; the grade of collaboration and cooperation with the industry; the length of the programme in years; and finally the fee in euros.

A third part is devoted to obtain the following information: (1) the recruitment Criteria or how the candidates are selected (Master, CV, Personal Statement, Ph.D. proposal and Other); (2) the Funding Scheme (Percentage of students with grants or fellowships); (3) Status of Doctoral Candidates with grants (Student, Employee, Researcher and other).

In the final part of the questionnaire we ask the respondents about: (1) the process for monitoring and assessment; whether the students need to fill some forms that need to be validated by the supervisor or the educational institution provides some on-line students Logs and websites; (2) the implication for supervision; in this item we obtain if there exists some other qualification requirements beyond being a Ph.D.; whether the duties are clearly stated in a code; and if there exists some workload (hours) for the duties of the supervisors; (3) a list of supervisors in the last five years which is quite important for the next step of the surveys of educational institutions; (4) the requirements for the Doctoral Thesis; whether there is a need to have a number of ISI Papers published, a number of papers published, an external Commission or a supervisor; (5) requirements for the Defense, whether there exists some rule about the configuration of the number of the members Committee; if there exists a public or private session; if the mark is obtained by unanimous judgment or emitted in a private ballot; and if the candidate can fail in the act of the defense; (6) the system to track the Ph.D. Graduates; the number of Ph.D. Graduates in the last 5 years with a list of dissertations and contact email if possible; (7) the efficient ratio calculated as "# PhD Graduates / # PhD Candidates in the five-years cohort".

We first gather from web site inspection a list of 25 potential respondents for the survey that basically correspond to the programs developed at the level of the EU27. However, due to a non-response ratio, we finally got 13 valid surveys. In most of the cases, the partner involved contact the head of the programs directly by phone. Unfortunately some key players at the European level as Cranfield Educational institution and Technical Educational institution of Delft did not respond to our questionnaire. However, we think that our results can be considered a valid sample as more that the fifty percent of Ph.D. graduates in the Pegasus networks belong to the educational institutions of our sample.

Nevertheless, it is interesting to remark some common features that doctoral programs present as in the last decades, air transport, aeronautics and aerospace has been characterized as one of the most research-intensive industrial sectors in developed countries. In some cases the activities for R+D achieve percentages near the 30% of the overall revenues - a much higher percentage than in any other high-tech sectors. Consequently, the need of the evaluation of the Doctoral Programs in the EU27 is even more needed than in the past, because talented young engineers and scientists have become an indisputable competitive advantage for the companies which contract them. The competition for the most brilliant doctoral students is part of a race at a global scale, with aerospace companies trying to attract the best, high-potential employees not only from their home educational institutions but from everywhere. This competition has become even more acute at a time when the motivation for long, hard scientific studies is decreasing among the young people in developed countries.

4.3.2 Teaching modules, structure, industry participation, fees and length

We observed that 62 per cent of the doctoral programs under analysis have some teaching modules. However, in-depth analysis of the surveys show that the figure has to considered with caution, as in most of the European countries teaching modules are not anymore mandatory for doctoral programs, as these are largely based on previous specific master courses. It is for the students whose provenance is not any master course in aeronautics, aerospace or air transport for whom these modules are compulsory and the doctoral commission designs some individual teaching activities for each candidate.

This routine allows other candidates to concentrate their time in pure activities of research, the ultimate goal for the existence of doctoral programs. In any case, teaching activities are usually grounded in some master programs of the educational institution in which teaching is usually based on some modules which can be taken in one or two weeks periods; thus candidates dispose of the rest of the time largely free of structured teaching for more independent learning, reflection and research. Normally, candidates need to submit a thesis proposal in order to be accepted in the program.

Regarding the structure of the program, 38 per cent of the doctoral programs are developed under the umbrella of the doctoral school and 62 per cent are under the control of individual departments. We have already explained that there is an increasing tendency in many European countries towards structured programmes with doctoral candidates grouped in research/graduate/ doctoral schools. However we have found certainly difficult to explain that there are no conjoint programs at European level in spite of the existence of strong links between some academics who have met in different European projects or consortiums.

In all the programs under analysis (100 per cent), it has been observed that they are run under the umbrella of closely connected research groups. These research groups act as catalysers helping to incorporate doctoral candidates into research teams, projects and excellence centres. They also provide a research environment that guides the candidates in their research career. The involvement of research groups provides also an additional positive aspect of the doctoral programs which is the creation of the feeling of belonging to a particular community of doctoral candidates with similar needs and interests.

The industry is involved in the 87 per cent of the programs. In such dynamic and competitive context as the observed in the aeronautical sector, the development and characteristics of collaborative doctoral programmes established between educational institutions and industry can be considered vital for the strength and positioning of the European aerospace industry. It is time to trigger the process at a governmental, educational institution or industrial level. The importance of these collaborative programmes is evident because more than 50 per cent of doctorate holders in Europe are moving into careers beyond the academic sector. In this respect, there is a need to foster the Ph.D. dissertations from the industry itself. There many positive features that can be highlighted in such cooperation, in particular we can cite the transferable skill components developed and the wider employment horizons opened.

Regarding the fees in euros, we observe that in most of the cases the Ph.D. programs is highly subsidized as most of the programs only charge a symbolic fee for less than 500 hundred euros for administrative issues and medical insurance. However there are also two outliers of 6000 and 19500 euros, respectively. It is evident that finding a global pattern of the funding for doctoral education in the doctoral programs under analysis is complex. As with other higher education institutions and cycles, funding generally comes from broad panoply of different sources. For doctoral education sources include state and regional governments (mainly through funding of public higher education institutions and systems and also through research grants to individual professors and occasionally to academic institutions and several different kinds of loan programs), tuition and fees paid by students –this cover the smallest proportion of the total budget, educational institution endowments, philanthropic foundations and businesses of various kinds. The mix of funding can vary very much depending on the program, therefore generalization is difficult.

Needs for creative funding schemes are evident during this period of economic crisis as we are assisting to a decreasing public funding for public educational institutions and higher education systems, there is a tendency of important public disinvestment in higher education that can affect the future and viability of some Ph.D. programs and the professional careers of some doctoral candidates. This is affecting particularly to the countries that are experiencing important problems in the euro zone, as Portugal, Italy, Ireland, Greece and Spain.

Regarding the length of the doctoral programs it has been observed that the majority of the programs last 4 years with some exceptions for some programs that can last 5 or 6 years. In any case this issue depends very much on the type of the doctoral candidate, i.e., full-time vs. part-time.

The seventh basic principle agreed from the discussions in Salzburg of a set of ten basic principles was that the duration for doctoral programmes should be in accordance of an appropriate time (three to four years full-time as a rule). Thus, it can be concluded that all the programs under analysis satisfied this requirement.

4.3.3 Recruitment, grants and status

Regarding the educational institution's policy admission to doctoral programs, it can be seen that the most common requirement asked to the candidates is the master. Nevertheless, it can be seen that there are other additional requirements that doctoral candidates have to fulfil in order to be admitted in the doctoral programmes, as CV, personal statement, research proposal and others. These additional requirements vary by educational institution and go as follows: (1) Recommendation letter(s), acceptance of supervision by a Faculty Member, specific grade requirements posed by supervising faculty, requirements for international students (e.g., relevance of degree, Master equivalent degree and Educational institution); (2) Application Form, acceptance of supervision by a Faculty Member, requirements for international students (e.g., relevance of degree, Master equivalent degree and Educational institution), selection of Ph.D. topic (without a detailed Ph.D. proposal); (3) Relevance of previous degree(s), acceptance and recommendation letter from prospective Ph.D. Supervisor, other recommendation letters, previous research experience (e.g., publications), current employment, duration of undergraduate studies, Grade Point Average (G.P.A.); and (4) Two recommendation letters and a certificate of English level. There are additional requirements for those programs which show a higher involvement with the industry, on top of them, additional company interviews and/or follow company standard human education can be cited.

After the Bologna process reform, in the European Union, the basic academic requirement is the master. Only for some adequate candidates there exists some exception and Bachelor can be sufficient if the candidate got his-her degree before the Bologna process. In these cases, the CV of the candidate has to show enough evidence of the fulfilment of 300 ECTS. This is also valid for international students not subject to the common European regulation.

In the cases where the candidate develops a case study within the industry as the Ph.D. dissertation, then the candidate may have a legal status of an employee of the company. For this reason, candidates also followed the standard internal human resources procedures for recruitment.

The analysis of the grants shows that the percentage of candidates with some type of grant varies from 65 to 95 per cent and it can be seen that the majority of doctoral candidates are also considered students. It is necessary to have in mind that in some cases the candidates are considered to have a multiple legal status depending on the condition and year of their career. It is obvious that funding and legal status of the doctoral candidate are closely related. In doctoral programmes with a high involvement of the industry, a status of employee or research fellow can be granted to the candidate according to the policy in place, and in some cases the firms can normally pay a high proportion of the salary of the doctoral candidate. In other occasions, it is not uncommon that the candidate is self-employed or employed by a department or academic institution and that he/she does only have a status as a doctoral candidate (at the stage of undertaking a doctoral project their aims may simply be to enhance their employability prospects and/or satisfy their intellectual interests).

Throughout Europe fellowships and scholarships grants tended to have a three-year limit on funding. However, this tendency was changing in the recent years in some countries as the average completion time of doctoral studies is four years. Thus, there was a try to accommodate the financial situation of most of the doctoral candidates avoiding the need of finding a new job to solve their financial situation (often as teaching assistants) at the time when they should fully concentrate on the completion of the dissertation. The problem of accommodating the duration for the Ph.D. and the grants obtained was already posed by many countries in different fields, so there exists a proactive policy to control this gap existing period.

4.3.4 Monitoring, assessment, supervision and defence.

Regarding the rights and duties of each party – educational institutions, supervisors, doctoral candidates and external partners if exist, it is clear that supervision of the doctoral candidates, monitoring of the progress of research, reporting periods and deliverables for assessment, evaluation of placement conditions and analysis of dedication in terms of different activities carried out during the yearly or semester periods are basic ingredients to evaluate the progress of the doctoral candidates.

We observed that in most of the cases there are particular forms that need to be filled up by the candidates and validated by the supervisors. In other cases, it is common to see a quite decentralized process that depends strongly on the requirements / procedures followed by the respective supervisor.

In none of the cases a decentralized process of students logs and websites exist. In these cases not only the supervisor is responsible for the monitoring process of the doctoral candidates but also a Commission for the doctoral programme is responsible for it. We also obtain that in some cases the doctoral candidate is supervised by both the academic and firm counterpart. Thus, supervision of the educational institution is independent from the supervision in company. In any case, we would like to highlight here that it is advisable to install a monitoring system in place which can be considered more participative in order to receive regular feedbacks, going further than the simple academic supervisor who is responsible for all the process of monitoring. In having this type of supervision, a more decentralized system that can be accessed for more members than simply the supervisors, the arrangements, the assessment and the feedbacks can be better than that for a normal procedure. Progress reviews can be undertaken each every semester or annually with the members of the commission and supervisors involved. These reviews are helpful not only for monitoring, but to identifying training needs and future work.

It is well known that the doctoral thesis is a core element of any doctoral programme and a proof of independent research performance and competence of the doctoral candidate. We observed that there is still an important bond between the doctoral candidate and the supervisor, as in most of the cases the thesis is not ready to be defended until the supervisor emits a positive evaluation.

In recent years, and due to the quality assurance programmes established in the EU it is becoming very popular to add additional requirements in terms of publications for the admission of defence. Of course, the main quality requirement for any thesis is that it should produce a new insight or knowledge – an innovation in the field, a new scientific method or an application of a known method to a new field. The thesis should present an original piece of research work and place it in the context of the theoretical knowledge and the literature in the field. The thesis (or at least a part of it) should be publishable in a peer reviewed scientific journal or as a peer reviewed book.

It can be seen that some educational institutions, the defence of the thesis requires the publication of partial results of the candidate's research. The required number of articles in peer reviewed journals can vary from one to five depending on the type of the thesis. In other cases, prior to submission of the thesis, doctoral candidates have to pass an external examination in the discipline and sometimes in a foreign language if the European Doctorate is pursued. These practices are really positive, however, the time lag between submission and publication in many journals is a major obstacle to achieve this goal. Another important issue to be resolved is the theme of authorship. Many educational institutions require a declaration signed by the doctoral candidate that the work (thesis) is based on one's own original research. This is particularly an issue in the case of a doctoral candidate's active participation in research groups, educational institutions need to ensure clear rules on co-authorship in order to protect the intellectual property of the doctoral candidate as well as that of other members of the research group.

We also observed that, in most of the cases, the act of the defence of the thesis is usually public and the information about it is publicly announced prior to the event (minimum ten days before the event). This practice is common in most of the programmes under analysis except in some cases where the defence of the thesis is private and it is usually organised as an oral examination (a viva) with one internal and one external examiner.

The thesis is usually firstly reviewed before the defence by two to three reviewers who submit written reviews. The thesis defence committee is composed of internal and external professors and experts in the field including the reviewers. The presence of the supervisor in the defence committee is usually forbidden and in some programmes there is at least one member of the committee who comes from abroad to ensure an assessment at an international level. Such a practice, although it poses additional financial costs, contributes to improving quality standards of the doctoral programmes across the EU.

5 Assessment of the Skills and Competence Gaps in Aviation Sector

5.1 Concepts and Definitions

In this section we briefly recall the key concepts underlying the assessment of the competence gaps (a more comprehensive presentation is available in Deliverable 3):

- Knowledge,
- Skill,
- Competence.

5.1.1 Knowledge

Knowledge can be defined as the "inferred capability which makes possible the successful performance of a *class of tasks* that could not be performed before [a] learning [process] was undertaken" (Gagné, 1962, pp 355). In turn, learning process can be understood as capacity of an individual of, in face of a set of stimulus, to acquire the capability to solve a given class of tasks. As such, knowledge is the outcome of the interaction between an individual's capacity to learn (intelligence) and his opportunity to learn (Winterton et al, 2005). Knowledge thus depends on the social context where the individual is embedded.

Knowledge can be segmented accordingly its purpose and nature. General knowledge refers to knowledge that is necessary for a person's daily activity and interaction with others in the Society. This type of knowledge is irrespective of any occupational context. Conversely, specific knowledge refers to knowledge gained in a specific context and it is necessary for meeting specific requirements or conducting specific tasks. In addition, knowledge is cumulative since firstly, an individual gains an explicit and factual knowledge on a given task (declarative knowledge), which will support the capability of utilising the knowledge in new tasks and different context (procedural knowledge) (Winterton et al, 2005).

Knowledge is cumulative and built over time based on previous acquired knowledge. The individual's mental and cognitive abilities determine his capacity of building knowledge.

5.1.2 Skill

Skill can be defined as "goal-directed, well-organised behaviour that is acquired through practice and performed with economy of effort" (Proctor and Dutta, 1995, 18). In other words, skill refers to how good an individual is able of executing a given task.

The definition of skill requires further explanations. First, a skill is a goal-oriented behaviour denoting that it is manifested in response of an external demand. Second, a skill is a well-organised behaviour meaning that it exhibits structure and a coherent set of patterns. Third, a skill is acquired and improved over time through repetition andfourth, the efforts and cognitive demands reduce as the skill improves (Winterton et al, 2005).

Different types of skills have been identified, depending on the nature of the external demand, namely:

- *Perceptual skill* is related with an individual's ability to make distinctions and judgements;
- *Response skill* is related with an individual's ability to promptly react to a specific demand. This type of skill can be improved and, eventually, become automatised, if practiced over time.
- *Motor skill* is related with an individual's ability to perform some motor-related behaviour, such as speed and accuracy of physical movements, or dexterity. Indeed, this type of skill was one of the firsts to be identified (Swift, 1904, 1910, Bryan and Harter, 1897 and 1899).
- *Problem-solving skill* is related with an individual's ability to solve new (or unknown) tasks. This skill is dependent upon intellectual and mental models.

5.1.3 Competence

The literature is populated with definitions on the concept of competence and, the related term, competency (Winterton et al, 2005, Hoffman, 1999, Elleström, 1997, Robotham and Jubb, 1996), yet, thus far no consensus has been reached. The reasons are discussed elsewhere in detail (Jeris and Johnson, 2004, Cseh, 2003, Pate et al., 2003, or Boon and van der Klink, 2002), but may be ascribed to different epistemological assumptions, cultural differences or, even, differences in the context of the study (or nature of object of analysis). Indeed, the Mansfield (2004) identified three different contexts where the notion can be applied, being:

- Competence is a characteristic that describes how an individual performs (and fulfils) his job's demands. The better he meets (and fulfils) his job's demands, the higher his competence will be. This notion is focussed on the outcome of an individual's job's activity.
- Competence refers to an individual's attributes and traits to meet the job's demands. This notion is focussed on the individual's intrinsic properties.
- Competence refers to the tasks that an individual do. The tasks are defined by the type of demands of the job. This notion is related with the individual's job's tasks.

For the purpose of this study, we adopted Woodruffe's (1991) definition on competence and competency. The author defines *competence as a (job's) task that an individual can perform*, and *competency as an individual's capability (or characteristic) of doing well a given (job's) task*. This definition was supported by other authors, such as Le Deist and Winterton (2005), Hartle (1995) or

Tate (1995)[23]. The definition of competence has a functional nature, being related with the properties (and functions) of a task or job; while competency has a behavioural nature being related with an individual's can achieve.

The individual's competence is built over time, and several factors influence its development, namely: ability, knowledge, understanding, skill, action, experience or motivation (Weinert, 2001). Among these, skills is a fundamental prerequisite.

5.1.4 Interaction between Knowledge, Skill and Competence

Although knowledge, skill and competence refer to different psychological components of human development, they influence each other and their development is determined by the others. Yet, it should be noted that as with any psychological component, many other factors influence their development. For the purposes of this research, it is relevant to highlight the cascade of influence between these three components. Figure 5.1 shows the cascade of influence between the three components. An individual's intellectual capabilities are required for the development of knowledge. In turn, the practical utilization and "operationalization" of knowledge is condition for developing skills. Finally, all these components are necessary prerequisites for the development of competences.

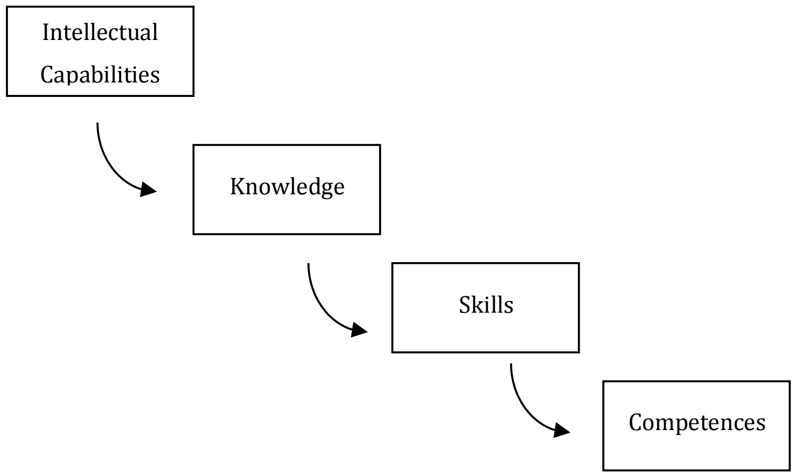


Figure 5.1 - Influence between knowledge, skills and competences

[23] It should be noted that other authors consider precisely the opposite, or with other meanings. For example, Mangham (1986) related competence with a personal models; McClelland (1976) related competency with superior performance; or Dale and Iles (1992) use both terms interchangeably.

5.2 Methodological Framework

To explore the sources and the extent of the competence gap, an assessment framework was drawn up (Figure 5.2).

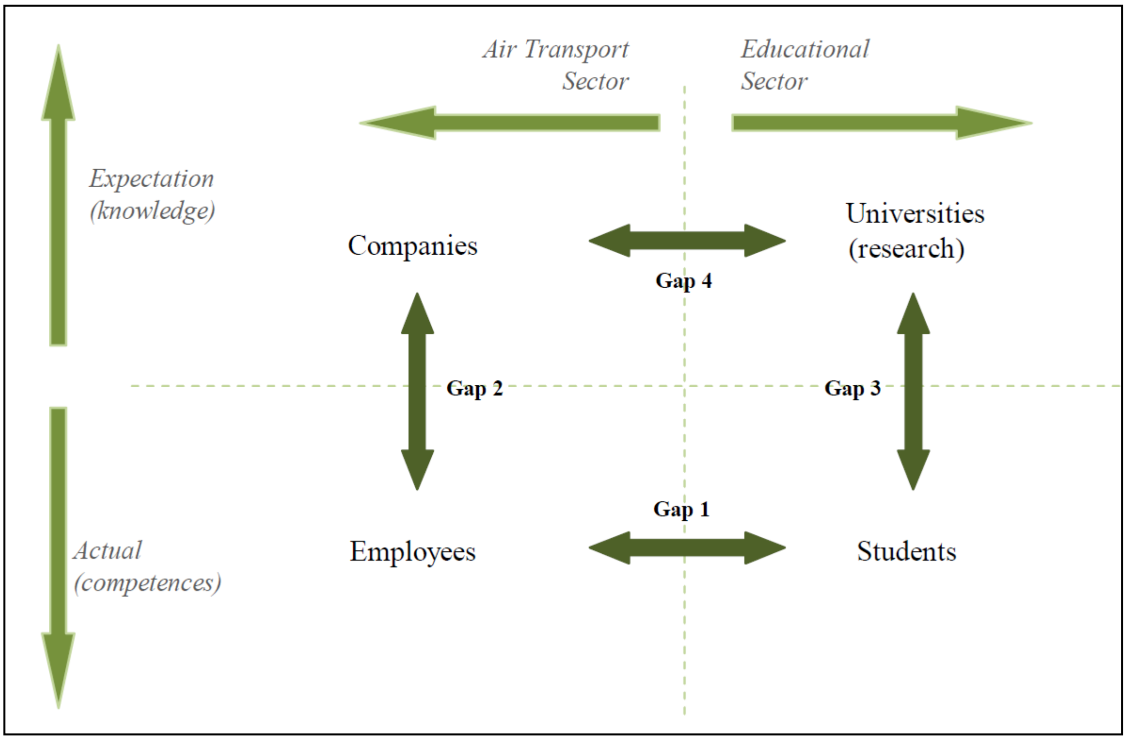


Figure 5.2: Four gaps framework

In the framework, four (potential) gaps can be distinguished:

- **Gap 1** - Gap between the competences that the employees need and the actual competences of the students (e.g. to what extent are the student's competences actually useful in their working daily activities?)
- **Gap 2** - Gap between the knowledge that the companies need and the actual competences of the employees (e.g. to what extent do the employees' competences actually fit in their companies' competences requirements?)
- **Gap 3** - Gap between the knowledge the educational institutions generate and the actual competences of the students (e.g. to what extent are the competences that the Educational institutions aim to build actually acquired by the students when graduating?, is the knowledge generated in the research transferred in the courses?)

- **Gap 4 -** Gap between the knowledge the companies need and the knowledge the educational institutions have (i.e. is the educational institutions' research and teaching activities of relevance for the companies?)

In the EDUCAIR project, we try to grasp in what extent there are gaps between the four different stakeholders (companies, employees, educational institutions & students). Therefore, the four gaps identified were translated into 2 kinds of questionnaires:

An industry survey with two sub questionnaires:

- To professionals involved in the management and recruitment of new employees (human resources) in the Air Transport or Aeronautics sectors
- To employees working in the Air Transport or Aeronautics sectors

And an education survey with two sub questionnaires:

- To Professors or Lectures of Educational institutions or Colleges in Engineering programs, Research or PhD programs in Air Transport or Aeronautics domains. Furthermore, also vocational and professional training institutions are addressed
- To students (Bachelor, Master and Doctoral) and Researchers of Educational institutions, Colleges or Institutes in Air Transport or Aeronautics

Table 5.1 gives an overview of who will be approached as respondents. The upper panel shows which companies/institutes will be addressed, while below the actual targeted respondents are listed.

Table 5.1: Overview of target group of survey

INDUSTRY	EDUCATION
• Airlines • Airports • Companies involved in air traffic management (such as air traffic control organisations) • Aircraft manufacturers and suppliers	• Educational institutions and colleges with engineering programmes involving air transport/aeronautics • Educational institutions and colleges with research and PhD programmes in air transport/aeronautics • Vocational training institutes • Professional training institutes
Here we address 1. Managers of new employees and people recruiting new employees 2. New employees (max. 5 years' experience) 3. The employees/professionals (with more than 5 years' experience)	Here we address 1. Heads of departments related to air transport/aeronautics OR full professors 2. Graduating students only

Figure 5.3 shows what will be gauged in the survey and how this is linked to the specific targeted respondents. This is aligned with the assessment framework (Figure 5.2). The link between Table 5.1 and Figure 5.3 is shown by use of colors.

The sub questionnaire for the employees, also addressed the employees as the (graduated) students. After all, each employee was once a student who graduated. Furthermore, the surveys were complemented by a survey addressing graduated students which do not work in the sector, to assess the attraction (and in this case) repulsion factors of working in the sector.

Through the gap assessment, recommendations on courses and curricula can be given, whereas through the attractiveness assessment leads to recommendations on actions to improve the sectors attractiveness.

<u>Sample size</u>

The sample size was calculated. To do so, we relied on stratified sampling. This means that for every group of respondents, we calculate a separate sample by using an existing table, looking at the population size and the precision levels. However, for the educational institutions, we decided to take into account the 3 most important ones of each EU27 country.

Looking at a population of nearly 250 companies and a precision level of 5%, we can see that the sample size of companies is 154.

Both employees and graduating students have such a large population that we take 400 as a sample size.

<u>Questionnaires</u>

The questionnaires are structured into three main parts. All questionnaires start with a general part and conclude with a part for comments and/or remarks. The second part is the core of the questionnaire. It contains several subsections (recruitment, graduating students, current educational offer, competences, cooperation between industry and educational institutes and educational background & career path) which can be compared to one another to identify the gaps.

Figure 5.3: Overview of different surveys in line with the educational gaps

Legend:

----= industry survey addressed to managers of new employees and people recruiting new employees

----= industry survey addressed to employees

In the survey to the companies (industry survey - 1), we want to find out whether the industry is satisfied with the number of courses that are offered (quantitative) as well as their quality concerning the competences that are taught (qualitative)

In the survey to the educational institutions (education survey - 1), we want to find out whether the educational institutions believe that they live up to the expectations of the companies, regarding the courses taught.

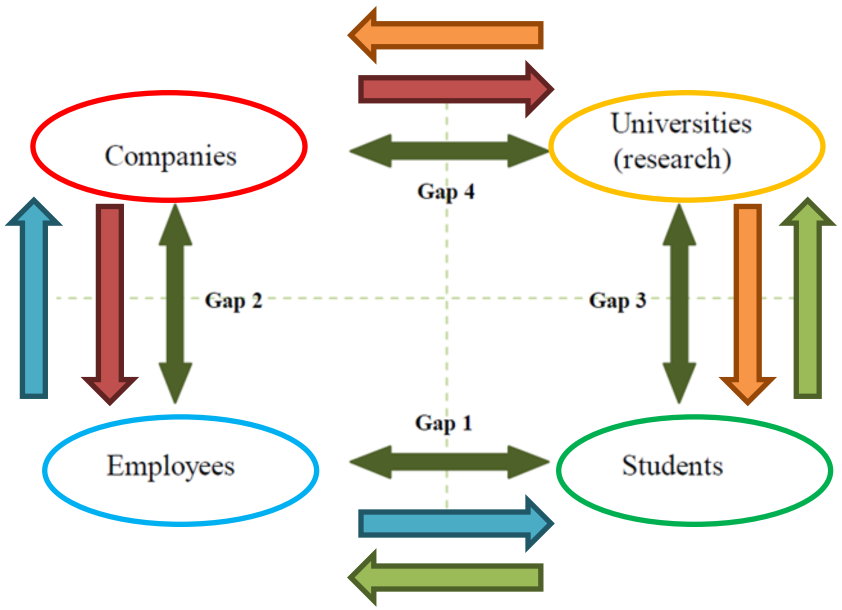
Legend:

----= education survey addressed to heads of departments or full professors

----= education survey addressed to students

In the survey to the companies (industry survey - 1), we want to find out which competences the employees need to have in the eyes of the companies and whether the existing employees, incl. "new" and "old" employees have them or not

In the survey to the employees (industry survey 2-3), we want to find out what career paths the employees have and which competences they have or have acquired for the job.



In the survey to the educational institutions (education survey - 1) we want to find out which competences the students should acquire through their education.

In the survey to the students (education survey - 2) we want to find out which competences the students actually acquired through their education and whether they are satisfied with them.

In the survey to the employees (industry survey - 2-3), we want to find out which competences the employees actually had when starting their work and whether the employees were satisfied with them.

In the survey to the students (education survey - 2), we try to find out which competences students think they have that are needed for their career.

Within the four questionnaires, the competences are listed and judged by the respondents. The competences are derived from the key functions[24] performed in companies covered by the scope. For each of the four types of companies, all key functions are listed. This list, which is printed in table 1 of the Deliverable 3, covers the competences used in the questionnaires. To each respondent, the question to judge the competences is formulated differently to get a view on the possible mismatch between the competences.

For example, to get a view on GAP 1, an analysis is made concerning to what extent the student's competences are useful in their working day activities. So employees are asked what competences they need and what competences they had when they graduated. And in the student questionnaire questions what competences students they think they will need and what competences they actually acquire. By comparing these two blocks, we can get a view on a possible mismatch. The same goes for the other three gaps.

As stated before, next to this gap assessment, also other information can be extracted from the questionnaires. For example, how cooperation between education and industry can reduce such gaps and what the attraction and repulsion factors of studying Aviation or working in the sector are.

A 3-step methodological approach was developed to assess the competence gaps (Macário et al., 2013), as follows:

- **Step 1** – Identification of the Competences and Skills in Aviation industries;
- **Step 2** – Survey to Companies, Employees, Educational and Research Institutions and Students;
- **Step 3** – Assessment of the Competence Gap.

Each step is now briefly presented.

5.2.1 Step 1 –Competences in Aviation industries

The purpose of Step 1 was the identification of the competences in the four domains of activities, being: Airlines, Airports, ANSP and Manufacturers. We used a comprehensive list already prepared

[24] Key functions are functions which require specific skills that cannot be acquired in a general education. For example, in an airline company, there are technicians who are in charge of the maintenance and repair of the airframe. By describing the key functions in such a way, it grasps the competences of those jobs, on an aggregate level.

and validated by Kupfer et al (2012). This list identifies a total of 88 competences, clustered in 19 groups or aggregated-competences, in the four domains of activity, as follows (Table 5.2 to Table 5.5):

Table 5.2 – Airline- related competences

Competence	Constituent	Competence	Constituent
1. Cockpit Crew	1.1. Planning of the flight	3. Technics & Engineering	3.1. Maintenance and reparation of airframe
	1.2. On board instrument control		3.2 Maintenance and reparation of power plant
	1.3. General and radio navigation & communication		3.3 Reparation of on board instruments
	1.4 Understanding air law & operational procedures		3.4 Maintenance and reparation of navigation and radio communications equipment
	1.5 Management of technical aspects		3.5 Maintenance and repair of auxiliary systems
2. Planning & Control	2.1 Coordination of maintenance		
	2.2 Planning and coordination of operations		
	2.3 Flight dispatching		
	2.4 Determination and provision of meteorological circumstances		
	2.5 Ramp planning		
	2.6. Safety management		

Table 5.3 – Airport-related competences

Competence	Constituent	Competence	Constituent
4. Design	4.1. Design of airside infrastructure	9. Maintenance	9.1. Airside maintenance
	4.2. Design of building and terminal		9.2. Terminal maintenance
	4.3. Design of landside access	10. Environmental Control	10.1. Noise control
5. Building & Construction	5.1. Building & construction of airside infrastructure		10.2. Emission control
	5.2. Building & construction of building and terminal		10.3. Waste maintenance
	5.3. Building & construction of landside access		10.4 Wildlife control
6. Planning	6.1. Master planning	11. Security	11.1. Security concerning passengers
	6.2. Land use planning		11.2. Security concerning cargo
7. Handling	7.1. Handling of passengers		11.3. Security concerning employees
	7.2. Handling of freight		11.4. Prevention of intrusion / unauthorized access
	7.3. Handling of air vehicles		
8. Emergency Planning	8.1. Rescue and fire fighting		
	8.2. Obstacles removal		

Table 5.4 – Air Traffic Management-related competences

Competence	Constituent	Competence	Constituent
12. Area Control	12.1. Supervision of Area Control Centre operations	15. Operations	15.1. Provision of flight information to VFR traffic
	12.2. En route aircraft control		15.2. Planning and coordination of network capacity
	12.3. Planning & coordination en route air traffic	16. Air Traffic Management (ATM)	16.1. Design, development and evaluation of ATC procedures
13. Approach Control	13.1. Supervision & planning approach operations		16.2. Design, development and sustainment of ATC systems, product and tools
	13.2. Provision of terminal radar approach control		16.3. Management of safety of ATC operations
14. Tower Control	14.1. Supervision of tower operations		16.4. Management of air traffic capacity and efficiency
	14.2. On the ground aircraft movements control		16.5. Management of interaction of operational controllers with operational environment
	14.3. Aircraft landing & taking-off control		

Table 5.5 – Manufacturers-related competences

Competence	Constituent	Competence	Constituent
17. Research & Development	17.1. Failure assessment and recognition	19. Engineering	19.1. Aircraft operability and design maturity integration
	17.2. Avionics, electronic and electrical systems & EMC		19.2. Design
	17.3. Customer service		19.3. Failure assessment and recognition
	17.4. Fluid mechanics and acoustics		19.4. Stress and structures analysis
	17.5. Propulsion and powerplant		19.5. Materials and processes
	17.6. RAMS, human factors & operability		19.6. Systems engineering and architecture
	17.7. Software design & IT		19.7. Airworthiness and certification
	17.8. Structural design		19.8. Architecture, integration and in-service support
	17.9. Test engineering		19.9. Systems & electronics engineering
	17.10. Services solutions		19.10. Structural & general engineering
	17.11. Quality engineering		19.11. Flight physics
	17.12. Production rigs		19.12. Configuration management
18. Operations	18.1. Airline operations appreciation		19.13 Composites design and stress
	18.2. Components and aircraft architecture		19.14. Supply management
	18.3. Manufacturing engineering		19.15. Lean experts & supply chain quality field engineering
	18.4. Maintenance		19.16. Electrical design/integration
	18.5. RAMS, human factors & operability		
	18.6. Governance		

	18.7. Risk management
	18.8. Composites manufacturing and assembly

In addition to the competences, a set of Skills was also considered in the analysis, being:

- Problem solving;
- Ability to work in multidisciplinary teams;
- Oral and written communications;
- Analytical background;
- Technical background;
- Leadership;
- Theoretical background.

5.2.2 Step 2 – Surveys to Companies, Employees, Educational and Research Institutions and Students

The objective of this step was to evaluate the relevancy of competences in Aviation sector. The survey targeted employees graduated in engineering (1st and 2nd levels of Bologna Process) and working in the Aviation organisations. The surveys were presented in the previous Section.

5.2.3 Step 3 – Gap Assessment

The surveys provided the information for the assessment of the gaps or misalignments in terms of competences and skills. The available literature in competence gap assessment follows a qualitative approach based in simple statistical descriptors (Macário et al., 2013, Reis and Macário, 2012, Lautala, 2007). Literature provides no suggestion on how to formulate the evaluation to the gap. In addition, and considering that the amount of answers is insufficient to deploy a pure quantitative analysis, we adopted a mixed approach based in a qualitative and quantities analysis, based in a lexicographical representation. As already described, in addition to the competences, we also assessed the skill gaps. Figure 5.4 presents the interactions between the surveys that were considered in the assessment of the competence gaps, as follows:

- **Gap 1: Promotion Gap (or Misinterpretation)**
  - **Connection 1.1:** Misalignment on the General Skills' relevancy - gap between the employees' perception on the General Skills' relevancy and students' perception;
  - **Connection 1.2:** Misalignment on the Competences' relevancy - gap between the employees' perception on the Competences' relevancy and students' relevancy.

- **Gap 2: Misreading or Misinterpretation of Expectations**
  - **Connection 2.1:** Misalignment on the General Skills' relevancy - gap between the employees' perception on the General Skills' relevancy and employers' perception;
  - **Connection 2.2:** Misalignment on the Competences' relevancy - gap between the employees' perception on the Competences' relevancy and employers' perception.

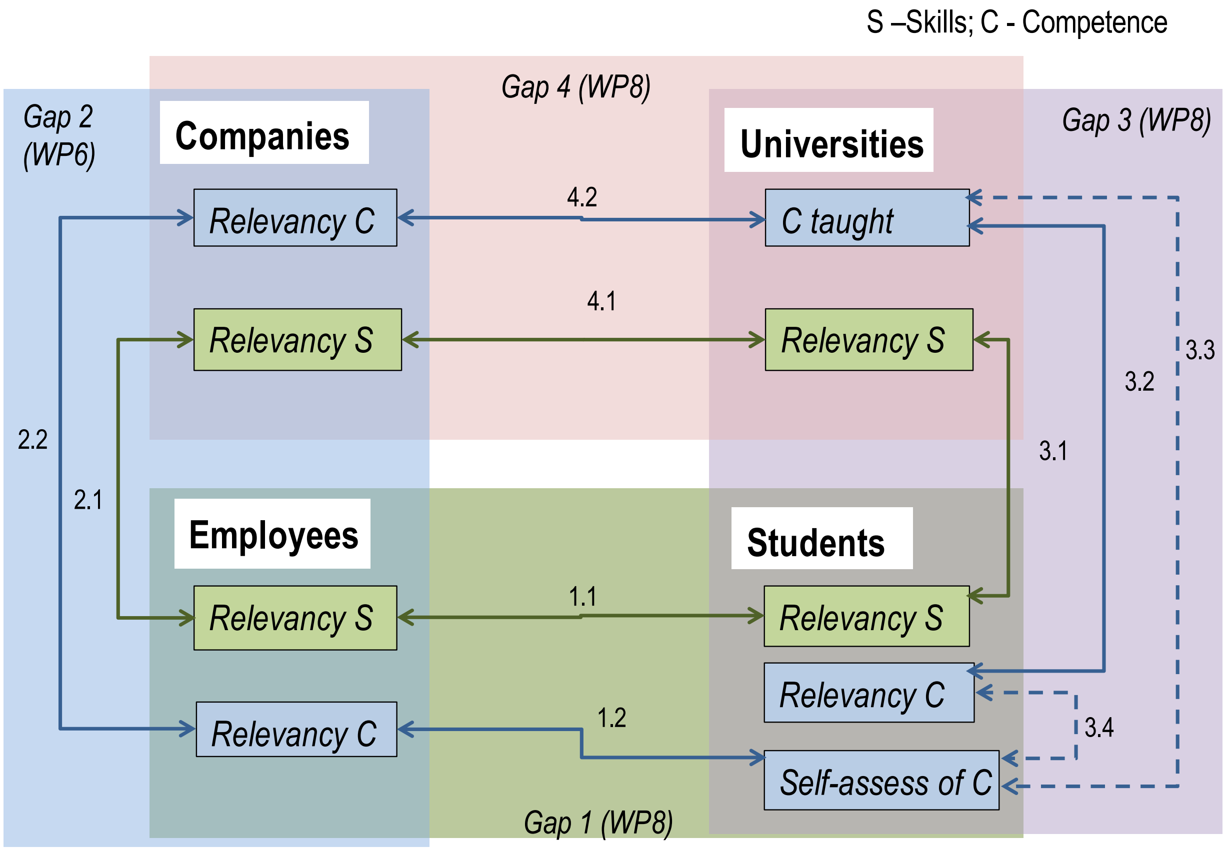


Figure 5.4 – Surveys' connection in the Gap Assessment Framework

- **Gap 3: Educational or Communication Gap (or Misinterpretation)**
  - **Connection 3.1:** Misalignment on the General Skills' relevancy - gap between the educational institutions' perception on the General Skills' relevancy and students' perception;
  - **Competence 3.2:** Misalignment on the Competences' relevancy - gap between the students' perception on the Competences' relevancy and those actually taught/acquired at Educational institutions/Research Centres.
  - **Connection 3.3:** Misalignment on the education of Competences - gap between the relevancy of the Competences and the students' self-assessment on their own level.

- **Connection 3.4:** Misalignment on the education of Competences, from the students' perspective - gap between the students' relevancy of the Competences and their self-assessment on their own level.

- **Gap 4: Market Misreading or Misinterpretation**

  - **Connection 4.1:** Misalignment on the General Skills' relevancy - gap between the companies' perception on the GS's relevancy and educational institutions' perception.
  - **Connection 4.2:** Misalignment on the Competences' relevancy - gap between the companies' perception on the Competences' relevancy and those taught/learnt at Educational institution/Research Centre.

In Figure 5.4, competences are represented at blue and skills at green.

The formulation adopted in the identification of the gaps, either competence or skills, was tailored with respect to the nature of information collected with the surveys. As already explained, the surveyees were asked to valuate the relevancy (in a 4 level Likert scale) of competences or skills. The single exception concerned the competences taught at the Education Institutions. In this case, we used a binary variable to record whether a given competences was taught or not. Consequently, we had to develop two formulations for the assessment of the gap, as follows:

1. Formulation 1: concerning every gap related with the competences taught at the Educational Institutions (that is, 3.4, 3.5, 3.6 and 4.2).
2. Formulation 2: concerning all other gaps (this formulation was already deployed in Macário et al., 2013).

Starting with Formulation 1, we adopted a lexicographical representation to assess the respective gaps. Figure 5.5 displays the theoretical range of results that could be obtained from the surveys to both the Educational Institutions, and Students or Companies in a two dimensions graph. On the horizontal axis (X-axis), we display the results from the survey to the students or companies in a 1 to 4 scale, with 1 denoting low relevancy, 4 denoting high relevancy and 2.5 denoting medium relevancy. On the vertical axis (Y-axis), we display the results from the survey to the students or companies in a 0% to 100% scale, with 0% denoting that none of the surveyed Educational Institutions is teaching a given competence and 100% denoting that all surveyed Educational Institutions are teaching a given competence.

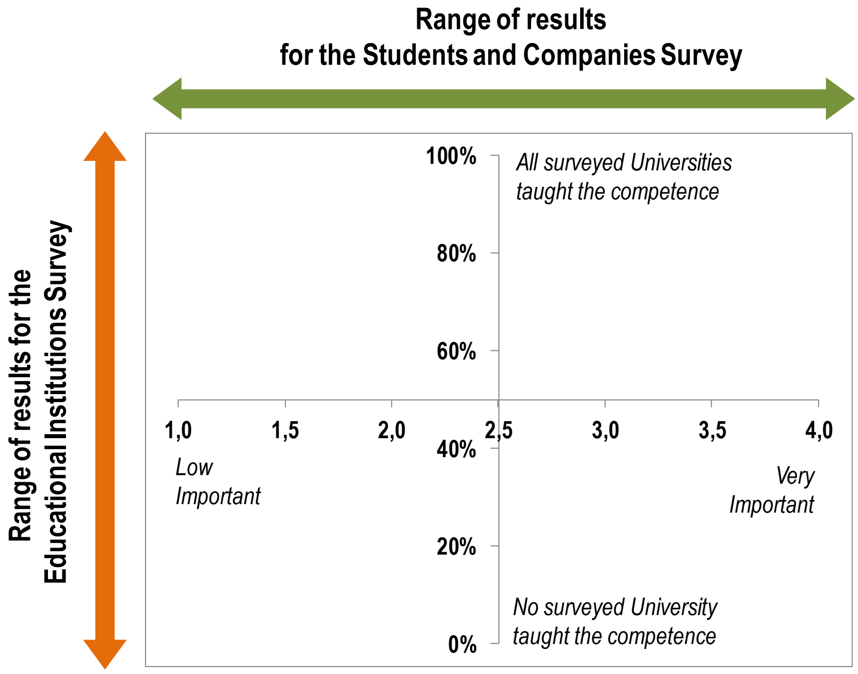


Figure 5.5 - Lexicographical representation of the competences gaps focussed on the competences taught at the Educational Institutions

The four resultant quadrants were used to infer about the eventual existence of competence gap, as sketched in Figure 5.6. So, we considered the likely non-existence of a Competence Gap in the odd quadrants and the likely existence of Gap in the even quadrants. In Quadrant 1 (top-right) we have a situation in which respondents (either companies or students) ranked a given competence as relevant and, in parallel, that very competence is taught in a large community of Educational Institutions. In Quadrant 3 (bottom-left) we have an opposite situation in which a given competence was ranked as having low relevancy and, in parallel, few Educational Institutions reported teaching it. In both these quadrant there is a similitude between respondents' perspectives (companies or students) and Educational Institutions' teaching behaviour. As an example, we may expect that every Educational Institutions offers a set of propaedeutical disciplines aimed to established that fundamental competences, which in turn are recognised by companies or students as relevant (since they are great usefulness). On the other hand, a very specific competence (only necessary in few special cases of projects) is likely to be taught only is specific schools. Likewise that very competences is likely not-recognised by many companies or students as being relevant, since few have felt its need.

Looking now into the even quadrants, we have the following situations. In Quadrant 2, we have a situation in which respondents (either companies or students) ranked a given competence as relevant but that few Educational Institutions reported teaching it. In Quadrant 4, we have again a symmetrical situation in which a given competence was ranked as having low relevancy but that it is taught in a large community of Educational Institutions. The rational behind the likely existence of gap results from a mismatch between the companies or students' perspective and the supply of education.

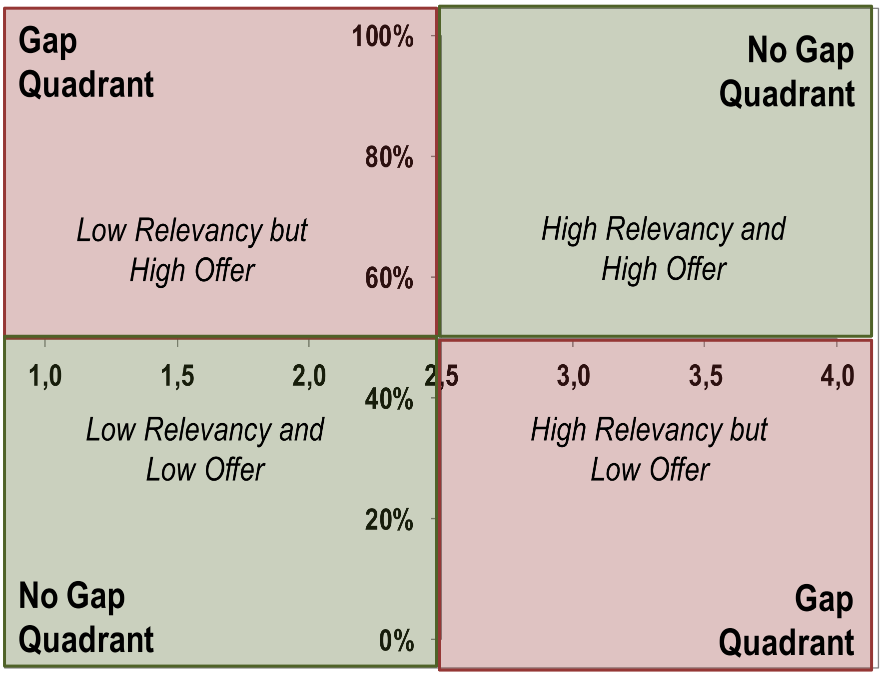


Figure 5.6 – Identification of the Competence Gaps

Formulation 2 was adopted in those gaps where both sides were evaluated in a similar manner (that is, from a 1 to 4 scale). In these situations, a direct comparison can be established. We considered the likely existence of a gap when the deviation of valuations between each pair or agents (companies, employees, educational institutions or students) was above half of one level (out of four in the Likert scale). In mathematical notation we have:

$$Competence\ Gap\ if\ |V_{1i} - V_{2i}| \geq 0.5$$

$$V_{Ei} - valuation\ of\ competence\ i\ given\ by\ Agents\ 1;$$

$$V_{Si} - valuation\ of\ competence\ i\ given\ by\ Agents\ 2$$

5.3 Skills Gaps

The assessment of the Skill Gaps is supported on the graphs presented in Annex III (Section 10). Annex III is structured accordingly with Figure 5.4 in four sub-sections, each one dedicated to a specific gap, as follows:

1. Skill Gap between Employees and Students – listed from Figure 10.1 to Figure 10.20;
2. Skill Gap between Companies and Employees – listed from Figure 10.21 to Figure 10.25;
3. Skill Gap between Educational Institutions and Students – listed from Figure 10.26 to Figure 10.29;
4. Skill Gap between Companies and Educational Institutions – listed from Figure 10.29 to Figure 10.40.

In theoretical terms, gaps may reveal different perceptions of relevancy, which in turn may eventually lead to some distress among agents. The point is that agents tend to naturally focus their efforts in mastering the most relevant Skills or Competences. If two agents have different perceptions about the relevancy of Skills and Competences, they will naturally concentrate their efforts in different Skills and Competences. Consequently, each one may perceive that the other is not concentrating on the fundamentals, or each one may perceive that the other is not proficient on the most relevant Skill or Competence, which may then result in some sort of stress or underperformance.

The labels adopted in the graphs are for a matter of better readability. Each number represents a Skill, as follows:

- Problem Solving
- Analytical Background
- Technical Background
- Theoretical Background
- Oral and Written Communication
- Leadership
- Ability to work in a multidisciplinary team

As discussed in the previous section, the green shade area represents the no-gap area, while the outer-zone may denote the presence of some misalignment between the agents' perceived relevancy.

Skill 1 – Problem Solving is consistently ranked higher than the other Skills. Conversely, *Skill 4 – Theoretical Background* is consistently ranked lower than the other Skills. If the positioning of Skill 1 is natural, the same does not happen with Skill 4 since a strong theoretical background would be seen as relevant. The results show a mixed behaviour concerning the relative positioning of the remaining Skills, with no apparent pattern emerging among the different group of respondents. In addition to the analysis of the relative valuation, an analysis to the absolution valuation of Skills also offers interesting insights. Foremost, there is a wide recognition about the relevancy of all Skills in a professional carrier in Aviation sector. The results show that Skills were valuated above 2.5 and often above 3.5, in the vast majority of the cases[25]. Also, the results denote a consistency and similitude of perspectives among groups of respondents since there is a visible alignment in the valuation of the Skills.

Starting with the analysis to the Gap between Employees and Students (Figure 10.1 to Figure 10.20), we a made a break down per educational background along five groups, as follows:

- Aerospace and Aeronautical Engineering (A&A Eng);
- Mechanical Engineering (Mec Eng);
- Civil Engineering (Civ Eng);
- Other Engineering (Oth Eng);
- Non Engineering (non-Eng).

The comparison is always between Employees and Students in the educational stream. We identified the following gaps:

- A&A Eng. educational background - minor gap[26] in *Skill 4* with the Airlines and Manufacturers Employees, and in *Skill* 7 with ANSPs Employees;
- Civ. Eng. educational background – minor gap in *Skill 2* and *Skill 3* with ANSPs Employees and *Skill 6* and *Skill 7* with Other Companies Employees;
- Oth. Eng. educational background – minor gap in *Skill 4* and *Skill 7* with Airlines Employees and *Skill 6* with Airport Employees;

With the exception of Gap in *Skill 4* with the Airlines Employees and A&A Eng students, the remaining gaps results from an overvaluation of the students versus employees. The remaining situations exhibit no gap.

Looking now to the Gap between Companies and Employees, the assessment was made at domain of activity level, regardless the educational background. This case also reveals some minor gaps and one gap, in the following situations:ç

- Airport domain – minor gap in *Skill 3* and *Skill 4*;

[25] The single exceptions are: Airlines Employees (Figure 10.1, Figure 10.16, Figure 10.21), Airline Employers (Figure 10.21, Figure 10.30, Figure 10.31), ANSPs Employers (Figure 10.23, Figure 10.34), Educational Institutions (Figure 10.28)

[26] A Gap is considered minor if the difference between valuations is below 0.75; otherwise is considered a relevant Gap.

- ANSP domain – minor gap in *Skill 3, Skill4* and *Skill 7,* and gap in *Skill 6*;
- Manufacturer – minor gap in *Skill 4*;
- Other Companies domain – minor gap in *Skill 3* and *Skill 4*;

In the Airport, ANSP and Manufacturer domains the gaps result from a overvaluation of employees vis-à-vis companies, while in the Other Companies we observed the opposite.

A single important Gap that matters tackling was found concerning *Skill 6 – Leadership* in the ANSP domain. Yet, the results must be interpreted with caution since the amount of answers was low.

The third type of Gaps concerns the Educational Institutions and the Students. Like the first type of Gaps, the analysis was done by educational background. The following gaps were found:

- A&E Eng. – minor gap in *Skill 7*;
- Mec. Eng. – minor gap in *Skill 7* and gap in *Skill 6*;
- Oth. Eng. – minor gap in *Skill 2, Skill 3* and *Skill 6* and gap in *Skill 7.*

In this case, the amount and significance of the Gaps is considerable. The deviation between educational institutions and students, in particular in the Mec. Eng., may be relevant, since students develop a significant part of their basic Skills and Competences at this stage. Among the Skills generating Gaps, *Skill 7 - Ability to work in a multidisciplinary team* is the only one appearing in all situations. This is somewhat surprising since more and more working in teams is fundamental in current working environments, even in in Engineering related domains. And increasingly students are required to work in teams. The point now is if the gap results from an excessive overvaluation by the students or an effective undervaluation by the educational institutions. The results do not allow concluding on this, but further analysis should be undertaken to understand the roots of this situation. In any case, if the problem arises from an overvaluation form the students then it is relatively innocuous. On the other hand, if the problem arises from an undervaluation by the educational institutions, then the situation can be worrisome since it may signal that students are graduating lacking an important Skill.

In what concerns the gap between Companies and Educational Institution, we made a distinction between Engineering and Non-Engineering Educational Institutions. The reason is based on the assumption that aviation sector is strongly related with engineering teaching and therefore there are significant differences between engineering and other educational domains in the perception of the needs of the aviation sector. Additionally, in the manufacturing domain, we considered a further division between aeronautical and aerospace engineering and the other engineering programmes. The reason is similar: we believe there is a strong demand for aerospace or aeronautical engineers in this professional domain.

The results show gaps in all five domains, as follows:

- Skill Gaps concerning Airlines Companies:
  - Engineering Educational Institutions – minor gap in *Skill 4 and Skill 7*
  - Non Engineering Educational Institutions – gap in *Skill 4 and* minor gap in *Skill 6*
- Skill Gaps concerning Airport Companies:
  - Engineering Educational Institutions – minor gap in *Skill 6 and Skill 7*
  - Non Engineering Educational Institutions – minor gap *Skill 2 and Skill 4*
- Skill Gaps concerning ANSPs Companies:
  - Engineering Educational Institutions – gap in *Skill 4 and* minor gap in *Skill 6*
  - Non Engineering Educational Institutions – *Skill 3, Skill 6, Skill 6 and Skill 7*
- Skill Gaps concerning Manufacturing Companies:
  - A&A Eng. Educational Institutions – minor gap in *Skill 7*
  - Engineering Educational Institutions – minor gap in *Skill 7*
  - Non Engineering Educational Institutions – minor gap in *Skill 4 and Skill 6*
- Skill Gaps concerning Other Companies:
  - Engineering Educational Institutions – minor gap in *Skill 7*
  - Non Engineering Educational Institutions – minor gap in *Skill 2, Skill 4 and Skill 6*

In overall terms, Non Engineering Educational Institutions tend to exhibit more and more significant Skill Gaps, which can be explained by a lower knowledge about the reality and needs of the aviation sector. In any case, such outcome must be considered since non-engineering graduates are also potential employees in the aviation sector. Also, *Skill 4 – Theoretical Background* exhibits a Gap in all domains and always with a overvaluation by the educational institutions. Such result, transversal to all non-engineering educational institutions may either reveal again a lack of knowledge from these institutions concerning the aviation sector, or a likely a companies' lower perception about the relevancy on the technical background. In any case, further investigations should be undertaken, although we cannot see major problems from the fact of non-engineering students having excessive theoretical background. *Skill 6 – Leadership* is another situation with gaps in 4 out of 5 domains. Similar conclusions may be made to those already made for *Skill 4*. Two other skills exhibit minor gaps in few domains, being: *Skill 2 - Analytical Background* and *Skill 3 - Technical Background*.

Looking now into the engineering education institutions, we may have a worrisome situation concerning *Skill 7 - Ability to work in a multidisciplinary team*, as all domains, with the exception of ANSPs companies, exhibit a Gap. Also, all Gaps result from an undervaluation by the Educational Institutions. This is precisely the root of the concern, since we may face a situation in which educational institutions do not perceive the relevancy of the skill in the same way as companies. As a result, we may have graduate students with not enough skills in a likely relevant area. This is more relevant when we see that the total amount of gaps is relatively reduced. So, the gap is likely not random but actual. Along with *Skill 7*, we could also identify gaps in *Skill 4* and *Skill 6*, in two domains. *Skill 6* exhibits a mixed behaviour in terms of overvaluation (educational institutions or companies), so no further conclusions may be made. On the other hand, the gap in *Skill 4* results from an overvaluation by the educational institutions. This situation may be related with the one already discussed in the case of non-engineering educational institutions, in which, such gap cannot be considered problematic.

Corrective measures depend on the location and significance of the Skill Gap. The results reveals multiple gaps, but although the vast majority exhibits minor relevancy. Considering that deviations between agents' perceptions is natural and results from different perceptions and roles, we consider not having need for any special corrective measures. In any case, we could identify three skills that may require further studies and eventually tailored actions, being:

- Skill 4 – Theoretical Background;
- Skill 6 – Leadership;
- Skill 7 – Ability to work in multidisciplinary teams.

Skill 4 and Skill 6 exhibit a similar behaviour with a high valuation by educational institutions and students, and a lower valuation by companies and employees. This can be interpreted as a more academic, and thus theoretical, perspective by the former group versus a more practical perspective of the latter group. Also, we cannot state that excess of theoretical knowledge is negative. In worst case, graduate students simply do not make use of the skill. What could be relevant is to understand the reasons leading companies and employees' to have a low perception about these Skills. This could provide insights on actions to improve and to better explain these agents the relevancy of a good theoretical background.

Concerning Skill 7, the situation is worrisome since we repeatedly have a situation in which companies overvalue above educational institutions and, to great extent, students. The results are consistent and may evidence that educational institutions may not be giving enough attention in the development of these skills by the students, which can eventually lead to underperformance. This results requires further investigation and, if proved accurate, intervention mainly by incentivising educational institutions to have propaedeutic disciplines on this matter and the promote working groups.

5.4 Competences Gaps

The assessment of the Competence Gaps is supported on the graphs presented in Annex IV (Section 10). Annex IV is structured accordingly with Figure 5.4 in four sub-sections, each one dedicated to a specific gap, as follows:

1. Competence Gap between Employees and Students – listed from Figure 11.1 to Figure 11.7;
2. Competence Gap between Companies and Employees – listed from Figure 11.8 to Figure 11.11;
3. Competence Gap between Educational Institutions and Students – listed from Figure 11.12 to Figure 11.17;
4. Competence Gap between Companies and Educational Institutions – listed from Figure 11.24 to Figure 11.27.

The labels adopted in the graphs are for a matter of better readability. Each number represents a Competence (that are divided by Domain of Activity), as follows:

- Airline Related Competences:
  - ✓ A1 - Cockpit Crew
  - ✓ A2 - Technics & Engineering
  - ✓ A3 - Planning & Control
- Airport Related Competences:
  - ✓ B1 - Design
  - ✓ B2 - Building & Construction
  - ✓ B3 - Planning
  - ✓ B4 - Handling
  - ✓ B5 - Emergency Planning
  - ✓ B6 - Maintenance
  - ✓ B7 - Environmental Control
  - ✓ B8 – Security
- ANSP Related Competences
  - ✓ C1 - Area Control
  - ✓ C2 - Approach Control
  - ✓ C3 - Tower Control
  - ✓ C4 - Other ATC Operations
  - ✓ C5 – ATM
- Manufacturer Related Competences
  - ✓ Research & Development Competences:

    A1. Failure assessment and recognition
    A2. Avionics, electronic and electrical systems & EMC

A3. Customer service
A4. Fluid mechanics and acoustics
A5. Propulsion and powerplant
A6. RAMS, human factors & operability
A7. Software design & IT
A8. Structural design
A9. Test engineering
A10. Services solutions
A11. Quality engineering
A12. Production rigs

- ✓ Operations Competences

B1. Airline operations appreciation
B2. Components and aircraft architecture
B3. Manufacturing engineering
B4. Maintenance
B5. RAMS, human factors & operability
B6. Governance
B7. Risk management
B8. Composites manufacturing and assembly

- ✓ Engineering Competences

C1. Aircraft operability and design maturity integration
C2. Design
C3. Failure assessment and recognition
C4. Stress and structures analysis
C5. Materials and processes
C6. Systems engineering and architecture
C7. Airworthiness and certification
C8. Architecture, integration and in-service support
C9. Systems & electronics engineering
C10. Structural & general engineering
C11. Flight physics
C12. Configuration management
C13. Composites design and stress
C14. Supply management
C15. Lean experts & supply chain quality field engineering
C16. Electrical design/integration

The green shade area of the graphs represents the no-gap area, while the outer-zone may denote the presence of some misalignment between the agents' perceived relevancy.

It is important to emphasise that the actual nature of the analyses was strongly conditioned by the amount of answers. Indeed, despite our best efforts, the amount of answers greatly varied amount domains and educational backgrounds. Consequently, the data used on the assessment of each Gap changed accordingly with its availability. The single exception concerned the Manufacturing domain and the Aerospace and Aeronautical Engineering program. In which, we were able to gather all required information. The results are presented in Section 11.6.

The type of analyses undertaken in each Gap Assessment were the following ones:

- Employees and Students Gap:
  - Aerospace & Aeronautical Engineers Employees and Students in Aerospace & Aeronautical Engineering (1st and 2nd Level of Bologna) – analyses done at level of aggregated competences on Airline, Airport and ANSPs domains, and competences on Manufacturer domain;
- Companies and Employees Gap:
  - Airline Companies with Employees working in Airlines – analyses done at level of aggregated competences;
  - Airport Companies with Employees working in Airport – analyses done at level of aggregated competences;
  - ANSPs Companies with Employees working in ANSPs – analyses done at level of aggregated competences;
  - Manufacturer Companies with Employees working in Manufacturers – analyses done at level of competences;
- Educational Competences and Students Gap:
  - Aerospace & Aeronautical Programs with Students in Aerospace & Aeronautical Engineering (1st and 2nd Level of Bologna) – analysis done at level of aggregated competences on Airline, Airport and ANSPs domains, and competences on Manufacturer domain;
  - Other Engineering Programs with Students in Other Engineering Courses (includes all Engineering programs – 1st and 2nd Level of Bologna – with the exception of Aerospace & Aeronautical) – analysis done at level of aggregated competences on Airline, Airport and ANSPs domains, and competences on Manufacturer domain;
  - Non-Engineering Programs with Students in Non-Engineering Course (includes all non-Engineering programs – 3rd Level of Bologna – with the exception of Aerospace & Aeronautical) – analysis done at level of aggregated competences on Airline, Airport and ANSPs domains, and competences on Manufacturer domain;
- Companies and Educational Institutions Gap:
  - Engineering Programs (includes all Engineering programs – 1st and 2nd Level of Bologna) with Companies – analysis done at level of aggregated competences on Airline, Airport and ANSPs domains, and competences on Manufacturer domain;
  - Non-Engineering Programs (includes all Engineering programs – 3rd Level of Bolgna) with Companies – analysis done at level of aggregated competences on Airline, Airport and ANSPs domains, and competences on Manufacturer domain;

As already discussed, the main purpose of the Gap Assessment exercise was used to shed light on the current potential Gaps in the Aviation Sector (more than pinpoint or isolate specific situations, in specific member states, educational institutions or companies). As such, the proposed corrective measures are necessarily broad in nature meant to point out directions of change and improvement. Further analysis, following the same rational, would have to be conducted to reach tailored solutions on specific cases.

In theoretical terms, a competence gap or misalignment results from a difference in the agents' perceptions on the relevancy of a given competence for performing a given task. Gaps may occur from asymmetric information between agents, in which one agent may feel some need earlier than other just because it has privileged access to some information. Other situation that may generate Gaps results from agents' different positioning in the value chain. That is, each agent has its own strategies, objectives, limitations and background experience. Therefore, we may expect differences of perception towards a given competence (for example: students may prefer practical experience in detriment of theoretical one, while educational institutions may prefer the opposite. While the second source of gaps does not require corrective measures, the former source does require.

Starting the analysis with the Employees and Students gap assessment, the results show a wide Gap in all educational backgrounds and domains. Yet, the situation is likely of no major concern, since the gap results from an overvaluation of students vis-à-vis employees. Employees have already a good understanding about the relevancy of the competences, whereas students are still acquiring them and do not have yet time to grasp their actual relevancy. This assumption is supported by the students' survey. The results show a high concentration of answers in all situations, that is, all competences were similarly valuated (the valuation is 3 or 4). The fact of all 81 competences having similar relevancy is highly unlikely. Indeed, looking to the employees' answers the same does not happen whose valuations range in the full spectrum of choices. So, the wide gap is in our understanding of minor concern and does not require corrective actions. Even so, if required, corrective actions should increase the contact of Students with Companies, preferably in the Company's premises, if not, by bringing the Companies into the Education Institution (Open Days or Fairs).

The second Assessment corresponds to the Competence Gap between Companies and Employees. Gaps are visible in all domains of activity for a considerable number of Competences (around half of them). The majority of the Gaps are however minor and only a fraction are significant[27].

The situation is of concerns as the Gaps invariantly[28] result from an overvaluation of the companies versus the employees. It may evidence a lack of knowledge by the Employees about their Company's real needs. As a consequence, the Company may be feeling needs for some given Competences that Employees are not aware of and, consequently, may be not mastering. The Gap should therefore be addressed. In any case, we must proceed with cautions since the amount of answers by the Companies is reduced, which undermines the validity of the conclusions. In this case, we recommend conducting further analysis to the Gap and, if proved accurate them corrective measures should be implemented. Naturally, the measures will depend on the actual dimension of the Gap in each company, but it may include improvements in the internal communication (e.g.: strategic and management objectives, new projects or new challenges) and promotion of long life educational courses.

The third and fourth Gaps have the Educational Institutions as focal points. The method of analysis is different since we have not asked Educational Institutions about the relevancy of the competences but we measure the frequency of teaching of each competence. The underlying idea is that relevancy of a competence must be linked with the frequency of teaching, that is: the more relevant is a competence, more often it should be taught (conversely, the less relevant is a competence, less often it can be taught).

In overall terms, the results to the Educational Institutions reveal two important features. Foremost, all competences are taught which means that European Educational Institutions are able to provide every required competence. Secondly, results show a wide dispersion about the frequency of teaching of the competences, albeit some patterns are recognisable. In our sample, the competences related with the domain of Airlines, Airports and ANSP are always taught is less than half of the Educational Institutions. The same does not happen with the Manufacturer related competences, in which a significant part (around half) is taught in more than half of the sample.

In what concerns the Educational Institution – Students Gap assessment, the results reveal Gaps in the majority of the cases. The Gaps invariantly result from the students' high valuation and the relatively frequency of teaching competences, leading the results to locate in the third quadrant. The Aerospace & Aeronautics Competences are the single notable exception with some result in the

[27] See Footnote26.
[28] There is one single gap that occurs from na overvaluation of the Companies.

second quadrant, resulting from high frequencies of teaching. The Gaps must be analysed having in mind the discussion already undertaken in the Employees – Students Gap. Students have highly valuated every single Gap, which may indicate that students still lack knowledge on the actual importance of each gap (and, in doubt, ranked them all very high). Therefore, the Gaps between Educational Institutions and Students do not appear worrisome. In any case, corrective actions can be deployed. Indeed, the corrective action already proposed to the Employees – Student Gap can also provide help in this situation. An increased contact with Companies will lead to a more mature valuation. Other corrective actions may include improved explanations and demonstration of the validity and relevancy of the curricula, so that students could understand it and therefore adjust their expectations.

Finally, in what concerns the Educational Institutions – Companies Gap Assessment, the results are similar with Gaps in all domains (Airlines, Aiports, ANSPs and Manufactures) and all Educational Programs (Engineering and Non-Engineering), although with less intensity than with Students. Gaps in both quadrant 1 (low relevancy and high frequency) and quadrant 3 (high relevancy and low frequency) are visible. The Gaps in quadrant 1 are less relevant since it denotes a case in which students may have competences that may not be relevant. The main problem is an eventual problem in the allocation of resources. As both teachers and students may be investing time and other resources with few return. On the other hand, Gaps in quadrant 3 are worrisome, since they may evidence cases of misalignment between Educational Institutions' curricula and Companies' needs, which in turn may lead students to graduate with an incomplete set of competences. We must not forget that the competences may result from temporary misalignments and not corresponding to structural Gaps. The point is that market dynamics may result in rapid changes in Companies' relevant competences. Educational Institutions' curricula however tends to be stable over time (not only because changing curricula requires lengthy process as well as often accreditation process is based on a given set disciplines). These different rhythms may create momentary misalignments, in which Companies have changes but Educational Institutions are still changing. Finally, we must be aware that the amount of answers by the Companies is reduced, so the conclusions must be interpreted with cautions.

Corrective actions include increasing the information exchange between Companies and Educational Institutions aiming to reduce the natural asymmetry. This can be done by the development of info days, seminars or participation in students' works. Another corrective action is to increase the flexibility of the Educational offer. Many of the competences analysed can easily be provided through short to medium-term courses. These courses can be held in parallel with existent disciplines (of the main stream programs) to external students (as lifelong learning programs) or given as extra credits. This type of courses have typically less restrictions in terms of accreditation and preparation, therefore they can be given almost on an ad-hoc basis and tailored to the Companies' actual requirements.

Students were also asked to self-assess their level of proficiency with respect to the competences. Such information revealed some important insights. The results are available in Section 11.5. Firstly, comparing students' perception of relevancy with students' perception of proficiency, we concluded for a significant deviation with perception of proficiency always ranking below perception of relevancy. Such results were somewhat unexpected as we were expecting mixed results with cases of competences in which the perception of proficiency ranked above perception of relevancy. The results could indicate that students may perceive their level of competency bellow requirements, which can in turn negatively impact their level of confidence. It is widely recognised that successful professionals combined robust knowledge and competency with self-confidence and self–assurance, and what the results show is that the second part of the equation may be missing and this is worth of study. To conclude it is important to clarify that we are not stating that students lack competences, simply that they may be not recognising them.

Another analysis to be done is comparing the students and educational institutions' results. The results show a strong linear and direct correlation between the students' perception of proficiency and educational institutions' frequency of teaching. This is, the more often you teach, the higher students' perceive their level of proficiency. These results are natural (and obvious), since if we have more institutions teaching a given competence, then students' will naturally report high levels of perceived proficiency. The results evidence the robustness of the data.

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6 Conclusions

6.1 Introduction

Studying the past trend in the Air Transport Sector, one can conclude that the market grew and will continue to grow in the future. Due to urbanisation and liberalisation, the demand and connectivity between cities increased and will continue to do so. This influenced and will influence in the future the development of the sector and thus affect the number or aircraft needed. Furthermore, the industry will keep on innovating.

To get a view on the future market developments, forecasts were analysed. Manufacturers such as Airbus and Boeing are closely in touch with the market and therefore can provide the most accurate forecasts. However, as they are also companies with marketing strategies, their forecasts might be biased. Therefore, the look into the future as predicted by manufacturers needs to be (and was) complemented with more general forecasts of e.g. international institutions such as the International Transport Forum. By doing so, a more complete picture can be painted and this resulted in a forecast.

The overarching objective of EDUCAIR project was to improve the match between needs in human resources, and the educational and training offer of engineers and researchers within the Europe Union for the horizon of 2020 in the Aviation Sector. Such objective results from an assumption that a misalignment or gap between the Competences (& Skill) required by the Industry the assumption and those provided by the Educational Institutions and Students could exist. Also, if such Gap was left unattended, it could result in underperformance of employees, with the negative consequences for the EU's Aviation Sector.

EDUCAIR project included other important objectives. A second objective of the project was to identify the key attractiveness and repulsion factors for studying and working in the Aviation Sector. These factors could be pivotal to understand how to attract more students into educational programmes in Aviation and consequently more graduates into the Aviation Industry. A third objective was to forecast the amount of jobs in the EU Aviation Sector for the year 2020. This will provide relevant information on the short term needs of graduated students. A final objective was to review and characterise the current educational offer on Aviation (and related fields) within the space of the European Union. Indeed, information on this topic is relative scarce and disperse among different institutions.

6.2 Attractiveness and Repulsion Factors in EU Aviation Sector

The analysis to the Attractiveness and Repulsion Factors for studying and working in the Aviation Sector was based on a wide scale online survey to students, employees and graduated students in Aviation domain but working elsewhere. We obtained the following amount of respondents, as follows: 153, 409 and 19. The amount of answers, although relatively reduced particularly in the last group, was sufficient to enable the elaboration of analyses. Unfortunately, the survey to graduated students in Aviation domain but working elsewhere produced an insufficient amount of answer to enable strong conclusions. The same did not occur with the two other groups, whose surveys produced enough responses to allow strong conclusions.

The employees' answers focussed around three main repulsion factors as follows:

E1. *cumbersome regulatory and legal framework*,
E2. *heavy theoretical with unperceived connection with real practice*,
E3. *reduced amount of practical working hours*.

Whereas the students' answers allowed the identification of the following ones:

S1. *above-average difficulty and lengthy of the programme*,
S2. *excessive theoretical contexts*,
S3. *insufficient emphasis on practice*.

There is a clear overlap between employees and students' perception. The first repulsion factors point out by the employees can only be perceived when looking for a job. The other two are related with the current educational paradigm. Since we got answers from multiple EU member states we may conclude that the problem is transversal to the EU Educational institutions.

Looking now into the attraction factors, we could identify an overlap between employees and students' perceptions. Although varying the description among respondents, three key attraction factors emerged from the analysis of the results, as follows:

1. Fascination of Aviation sectors.
2. Challenging carrier and development path;
3. Employment and working benefits.

Interestingly both employees and students agreed on the attraction factors. This denotes that the attraction factors have not been changing over time. From the analysis of the surveys it was evident that, firstly, a key driver for pursuing education in Aviation was the students' enthusiasm and fascination by aviation and aeronautics. Indeed, both employees and students referred often and often that a fundamental reason for ever entering an aviation or aeronautics graduation was the enthusiasm or fascination for this industry, in particular, on airships or spaceships.

Secondly, employees' referred (and students' mentioned a strong belief) in the ever-changing and always-challenging nature of a job in Aviation. This perception was mentioned as an important attraction factor. Indeed, by its very technological nature and owing to the recent dynamics, Aviation offers a very challenging working environment. This is not expected to change in the near future, therefore, this attraction factor is not expected to fade out.

In addition, a job in Aviation still offers respect and admiration by Society and peers, and this is an important factor of attraction. An eventual degradation of the working conditions will erode such positive property, with negative consequences. The sources of respect were not easy to track, but apparently the following reasons are important contributors: difficult education track, denotes that only the most capable students are able to graduate, challenging and demanding working competences, denotes that only the most competence people can work in this environment, above-average salary (and other benefits), aviation and aeronautics' inherent fascination, and the strong technological nature of the industry, that contributes for an image of development and advancement. All of these factors were to some extend brought forward by the respondents.

Thirdly, Aviation companies offer (very) good working conditions and benefits. Again this was indicated by the employees and expressed by the students. The specificities, competence requirements or responsibilities of many tasks in aviation and aeronautics naturally results in job positions offering above average working conditions.

There is a perception in the EU about a steady decline in the level of attractiveness of Aviation industry over the last years. Several factors and trends were already identified as lying at the root of this problem, including:

- P1. Progressive loss of interest in scientific or technical carriers
- P2. Progressive loss of prestige of the Air Transport and Aeronautic Sectors
- P3. Progressive reduction of students' interest for mathematics, physics and other sciences
- P4. Technical carrier is inferior to management carrier
- P5. Educational paradigm has changed favouring the teaching of soft-skills in detriment of hard-skills
- P6. Reduction of systems engineering-related courses

Every and each trend is believed to contribute, to some extent, to the decay of the attractiveness level although the actual contribution (if any) is still to be demonstrated. EUCAIR's surveys cannot provide evidence to support the existence of these trends, instead they can be used to infer about their relevancy and validity.

From the surveys we can infer the following conclusions for each trend:

P1. Both employees and students referred that the technological nature of aviation and aeronautics was a relevant factor in their decision making process (Attractiveness factor 1 and 2);

P2. Attractiveness factor 1 provides strong evidence towards the non-validity of this factor;

P3. It is indirectly supported by the surveys in the sense that some students referred that a reason to choose Aviation education was the emphasis in mathematics and analytical reasoning

P4. It is not supported by the surveys, as any employee mentioned a feeling of inferior by having a more technical job.

P5. Surveys do not provide definitive answer, but many students complain about the too heavy lectures on mathematics, physics and other analytical disciplines (repulsion factor E2). This repulsion factor may denote that the teaching of these disciplines has not been softened.

P6. The surveys cannot conclude anything towards this factor.

6.3 Availability of Jobs in the Aviation Sector in 2020

The forecasting exercise about the job availability in the Aviation Sector in 2010 results mainly from disaggregate estimations for the demand for employment at airports, airlines, at ANSPs and the (civil) aeronautics sector. As basis the share of engineering jobs in aeronautics was estimated to be between 30% and 35%, at airport operators between 15% and 25% and in airlines between 5% and 10%. The amount of direct engineering related jobs in 2010 was around [103,200; 120,400] in civil Aeronautics, around [20,500; 34,100] in Airports, and around [21,200; 42,400] in Airlines. The number of jobs in Aviation is calculated to evolve, in 2020, to about [121,000; 141,200] jobs in Aeronautics, around [34,200; 57,000] jobs in Airports, and [26,667; 53,300] in Airlines. The number of jobs for Air Traffic Control Officers are estimated to grow from between 13,236 and 13,857 in 2010 to between 16,839 and 17,628 in 2020.

Before arriving at the estimations concerning the availability of jobs in the Aviation sector in 2020, different approaches were carried out, with not always reliable results. The main difficulty with the estimations proved to be the lack of long reliable time-series data. Especially Europe-wide information about the historic development of employment in the overall Aviation sector was scarce. Also in the separate sectors of airlines, airports, ANSPs and civil aeronautics sector data was difficult to find. Even sector organizations such as ACI were found to have only have limited data concerning the employment of their members. Some studies could be found analyzing the number of jobs in particular countries (see for example CAA, 2004) and others that give the number of jobs in Aviation at a specific point in time (see e.g. Air Transport Action Group, 2005, 2012a,b, booz&co, 2009 and ACI Europe and York Aviation, 2004), but without giving comparable data for a longer time period. If data series could be found they often showed gaps for specific years or countries, so that they could not be used for the estimation or, in order to use them, the gaps also had to be estimated.

6.4 Review of the Educational Offer in Aviation

The culmination of the Bologna process needed a basic line establishing two pillars of the knowledge based society: "European Higher Education Area (EHEA) and European Research Area (ERA)", in order to promote the key role of doctoral programmes and research training in the context of increasing the competitiveness of the European region. A dominant observation stemming from the analysis of the reviewed 1st and 2nd cycle programmes is that engineering education varies considerably with the different educational systems. The engineering profession itself and particularly the "Engineer" interpretation differs across the various European countries and worldwide. Some harmonization of the educational studies across Europe has been achieved with the Bologna scheme known as 3-5-8 according to the Bologna Declaration and its subsequent refinements. Although there is substantial progress made towards the Bologna Declaration aims and many Educational institutions have adapted their programme structures to the proposed new scheme, the harmonization process has still some way to go in terms of harmonization and standardization of the educational offering.

Despite some country or educational system-specific differences, there is an evident pattern and common features in the educational curriculum and course structure/content of engineering programmes (particularly full 5-year and 3+2 programmes) in Aviation. The first two years are mostly focused on courses related to fundamental sciences or basic/general engineering content; some aerospace engineering topics are typically introduced during the second year. The third year introduces more course modules on aerospace engineering complemented by general engineering courses. The last two years offer specialized and advanced topics on aerospace engineering along with opportunities for undertaking more research-oriented topics complemented by general management/business or other specialized courses (e.g., law).

Based on the review of engineering programmes of the 1st and 2nd cycle, it was clearly concluded that fundamental sciences and general engineering courses represent by far the dominant category in 1st cycle engineering and MEng programmes. Specialized aerospace/aeronautical engineering courses are also similarly weighted in all cycles of engineering programmes. It is, however, important to underline the fact that airport, airline, and ATM/ATC-related courses are hardly available (at least on a stand-alone basis) in engineering programmes. On the contrary, the aforementioned categories represent almost half of the educational offering of 2nd cycle EU Management Aviation programmes. This observation reveals the strong complementarity between relevant engineering and management programmes in Aviation and justifies the study path of several engineers pursuing a "complementary" management degree after completing their 1st cycle engineering degree.

Most of the reviewed Aviation programmes of the 1st and 2nd cycle provided - to varying degrees though - the option to their students to freely select a certain number of courses (or ECTS) from the entire course catalogue of the programme, the Educational institution or even other cooperating Educational institutions (e.g., PEGASUS partner). This provides ample opportunities for students to shape their own, customized / individual profile and build their own portfolio of competences especially through the selection of elective courses at home or other foreign partner Educational institution. The diversity of student profiles contributes to increasing the flexibility and mobility of students and to a more spherical coverage of specialized industry needs. On the other hand, it makes difficult to assess and compare the educational offering of programmes or Educational institutions since their educational "output" (various student profiles) is already highly customized and hence not easily comparable.

Although professional accreditation / licensing is common, academic (programme) accreditation is sparsely offered. Therefore, there seems to be a need for a European-wide academic accreditation system that should build on recent initiatives undertaken by the PEGASUS Partnership towards the establishment of a voluntary accreditation system for Aerospace Engineering education in Europe. In addition, it should pursue synergies with other accreditation bodies / associations with special emphasis on: i) the European Network for Accreditation of Engineering Education (ENAEE) offering the EUR-ACE framework for engineering degree programmes at 1st/2nd cycle and ii) the European Association for Quality Assurance in Higher Education offering accreditation models and quality assurance best practices for higher education.

Looking now into the 3rd cycle of Bologna Process, it became apparent as there was a need to promote closer links between the EHEA and the ERA in a Europe of Knowledge, and of the importance of research as an integral part of higher education across Europe. Therefore, Ministers considered it necessary to go beyond the focus on two main cycles of higher education to include the doctoral level as the third cycle in the Bologna Process. They emphasised the importance of research and research training and the promotion of interdisciplinary in maintaining and improving the quality of higher education and in enhancing the competitiveness of European higher education more generally. Ministers call for increased mobility at the doctoral and postdoctoral levels and encourage the institutions concerned to increase their cooperation in doctoral studies and the training of young researchers.

Research training and research career development - and the need to increase the number of highly qualified graduates and well trained researchers – are also becoming increasingly important in the debate on strengthening Europe's research capacity.

From the discussions in Salzburg a consensus emerged on a set of ten basic principles, so a summary of the doctoral programmes analysed is being undertaken following the structure of these principles:

1) The core component of doctoral training is the advancement of knowledge through original research. At the same time it is recognised that doctoral training must increasingly meet the needs of an employment market that is wider than academia.
   - ✓ ***This principle is mostly achieved.***
2) Embedding in institutional strategies and policies: educational institutions as institutions need to assume responsibility for ensuring that the doctoral programmes and research training they offer are designed to meet new challenges and include appropriate professional career development opportunities.
   - ✓ ***This principle is also mostly achieved but here we recommend in a major involvement of the industry in order to develop collaborative doctoral programmes.***
3) The importance of diversity: the rich diversity of doctoral programmes in Europe - including joint doctorates - is a strength which has to be underpinned by quality and sound practice.
   - ✓ ***Here, we consider that there is enough room to improve. There is a need to start joint programmes. However it is highlighted that there is a real informal cooperation between the different existing programmes in Europe.***
4) Doctoral candidates as early stage researchers: should be recognized as professionals – with commensurate rights - who make a key contribution to the creation of new knowledge.
   - ✓ ***This principle is basically achieved but there is also a need to have a more common framework within the EU.***
5) The crucial role of supervision and assessment: in respect of individual doctoral candidates, arrangements supervision and assessment should be based on a transparent contractual

framework of shared responsibilities between doctoral candidates, supervisors and the institution (and where appropriate including other partners).

- ✓ ***This principle is also partly achieved and it is highly recommended to work in a common code of conduct at the European level.***

6) Achieving critical mass: Doctoral programmes should seek to achieve critical mass and should draw on different types of innovative practice being introduced in educational institutions across Europe, bearing in mind that different solutions may be appropriate to different contexts and in particular across larger and smaller European countries. These range from graduate schools in major educational institutions to international, national and regional collaboration between educational institutions.
   - ✓ ***This principle has been partly achieved with the creation of Doctoral Schools in some countries. However in our opinion, it will be advisable to move into the direction of joint programs within the field as a better way to get a critical mass with the main stakeholders of the industry at the European level.***
7) Duration: doctoral programmes should operate within an appropriate time duration (three to four years full-time as a rule).
   - ✓ ***This principle is basically achieved.***
8) The promotion of innovative structures: to meet the challenge of interdisciplinary training and the development of transferable skills.
   - ✓ ***There is no evidence about the performance of this principle, but it is highly advisable to work into the direction of creating joint programmes including several educational institutions and different stakeholders of the industry.***
9) Increasing mobility: Doctoral programmes should seek to offer geographical as well as interdisciplinary and intersectoral mobility and international collaboration within an integrated framework of cooperation between educational institutions and other partners.
   - ✓ ***There is enough room to improve the performance of this principle.***
10) Ensuring appropriate funding: the development of quality doctoral programmes and the successful completion by doctoral candidates requires appropriate and sustainable funding.
   - ✓ ***This principle is mostly achieved.***

6.5 Skills and Competence Gaps

Figure 6.1 presents the framework used to assess the Skills & Competences Gap in the Aviation Sector. This framework identifies four gaps, being:

- **Gap 1** - Competence Gap - Gap between the competences that the employees need and the actual competences of the students (i.e. to what extend are the student's competences actually useful in their working daily activities?);
- **Gap 2** - Gap between the knowledge that the companies need and the actual competences of the employees (i.e. to what extend do the employees' competences actually fit in their companies' competences requirements?)
- **Gap** 3 - Gap between the knowledge the educational institutions generate and the actual competences of the students (i.e. is the knowledge generated in the research transferred in the courses?)
- **Gap 4** - Gap between the knowledge the companies need and the knowledge the educational institutions have (i.e. is the educational institutions' research and teaching activities of relevance for the companies?)

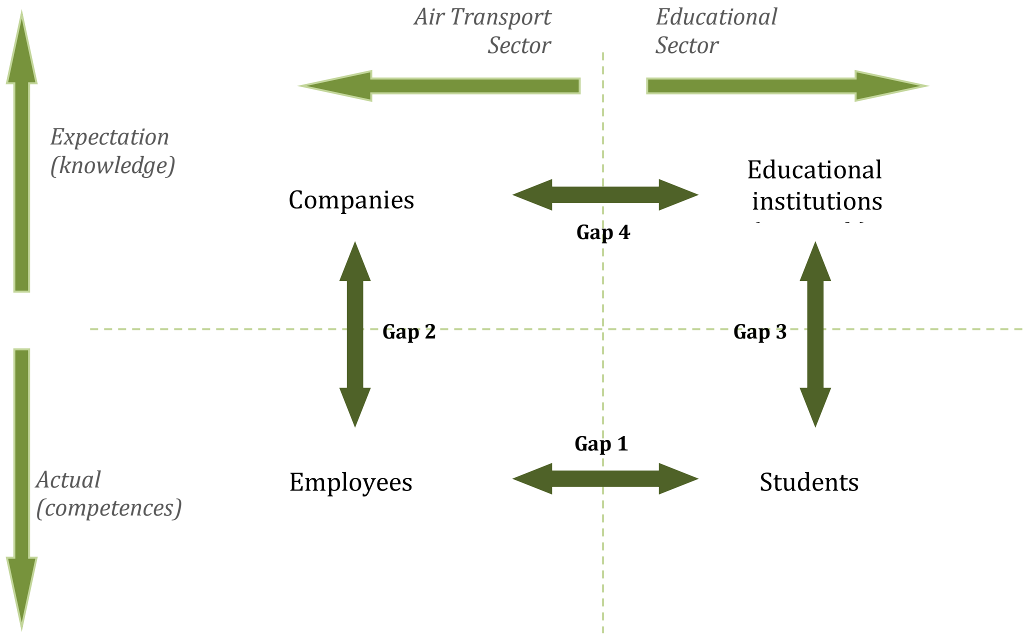

Figure 6.1 - The four gaps framework

In theoretical terms, gaps may reveal different perceptions of relevancy, which in turn may eventually lead to some distress among agents. The point is that agents tend to naturally focus their efforts in mastering the most relevant Skills or Competences. If two agents have different perceptions about the relevancy of Skills and Competences, they will naturally concentrate their efforts in different Skills and Competences. Consequently, each one may perceive that the other is not concentrating on the fundamentals, or each one may perceive that the other is not proficient on the most relevant Skill or Competence, which may then result in some sort of stress or underperformance.

6.5.1 Skill Gaps

A total of seven skills were considered in the analysis, being:

1. Problem Solving
2. Analytical Background
3. Technical Background
4. Theoretical Background
5. Oral and Written Communication
6. Leadership
7. Ability to work in a multidisciplinary team

Starting with the analysis to the Skills, *Skill 1 – Problem Solving* was consistently ranked higher than the other Skills. Conversely, *Skill 4 – Theoretical Background* is consistently ranked lower than the other Skills. If the positioning of Skill 1 is natural, the same does not happen with *Skill 4 – Theoretical Background* since a strong theoretical background should be seen as relevant. The results show a mixed behaviour concerning the relative positioning of the remaining Skills, with no apparent pattern emerging among the different group of respondents. In addition to the analysis of the relative valuation, an analysis to the absolution valuation of Skills also offers interesting insights. Foremost, there is a wide recognition about the relevancy of all Skills in a professional carrier in Aviation sector. The results show that Skills were valuated above 2.5 and often above 3.5 (in a scale of 1 to 4), in the vast majority of the cases. Also, the results denote a consistency and similitude of perspectives among groups of respondents since there is a visible alignment in the valuation of the Skills.

Starting with the analysis to the Gap between Employees and Students, we could not identify gaps that require corrective actions. Minor gaps in the Aerospace and Aeronautics, Civil and Other Engineering Programmes were indeed identified, but without significance.

Looking now to the Gap between Companies and Employees, we found multiple minor gaps without significance in all domains concerning Skill 3, Skill 4 and Skill 7. Skill 6 on the other hand exhibited a relevant Gap that could require corrective actions, although the relative amount of answers does not allow to reach solid conclusions. As such, we recommend to conduct further analysis.

The third type of Gaps concerns the Educational Institutions and the Students. Gaps were found in the Aeronautics and Aerospace, Mechanical and Other Engineering Programmes, in Skill 2, Skill 3, Skill 6 and Skill 7. Among the Skills generating Gaps, *Skill 7 - Ability to work in a multidisciplinary team* is the only one appearing in all situations. This is somewhat surprising since more and more working in teams is fundamental in current working environments, even in in Engineering relates domains. And increasingly students are required to work in teams. The analysis undertaken does not allow concluding whether the gap results from an excessive overvaluation by the students or an effective undervaluation by the educational institutions. If the problem arises from an overvaluation form the students then it is relatively innocuous. On the other hand, if the problem arises from an undervaluation by the educational institutions, then the situation can be worrisome since it may signal that students are graduating lacking an important Skill.

In what concerns the gap between Companies and Educational Institution, the results show gaps in all domains in Skill 2, Skill 3, Skill 4, Skill 6, Skill 7. The analysis made a distinction between Engineering and Non-Engineering Educational Institutions. In overall terms, Non Engineering Educational Institutions tend to exhibit more and more significant Skill Gaps, which can be explained by a lower knowledge about the reality and needs of the aviation sector. In any case, such outcome must be considered since non-engineering graduates are also potential employees in the aviation sector. Also of relevance, *Skill 4 – Theoretical Background* exhibits a Gap in all domains and always with a overvaluation by the educational institutions. Such result, transversal to all non-engineering educational institutions may either reveal again a lack of knowledge from these institutions concerning the aviation sector, or a likely a companies' lower perception about the relevancy on the technical background. In any case, further investigations should be undertaken, although we cannot see major problems from the fact of non-engineering students having excessive theoretical background. The engineering education institutions exhibit a worrisome situation concerning *Skill 7 - Ability to work in a multidisciplinary team*, as all domains, with the exception of ANSPs companies, exhibit a Gap. Also, all Gaps result from an undervaluation by the Educational Institutions. This is precisely the root of the concern, since we may face a situation in which educational institutions do not perceive the relevancy of the skill in the same way as companies. As a result, we may have graduate students with not enough skills in a likely relevant area. This is more relevant when we see that the total amount of gaps is relatively reduced. So, the gap is likely not random but actual.

Corrective measures depend on the location and significance of the Skill Gap. The results reveals multiple gaps, but although the vast majority exhibits minor relevancy. Considering that deviations between agents' perceptions is natural and results from different perceptions and roles, we consider not having need for any special corrective measures. In any case, we could identify three skills that may require further studies and eventually tailored actions, being:

- Skill 4 – Theoretical Background;
- Skill 6 – Leadership;
- Skill 7 – Ability to work in multidisciplinary teams.

Skill 4 and Skill 6 exhibit a similar behaviour with a high valuation by educational institutions and students, and a lower valuation by companies and employees. This can be interpreted as a more academic, and thus theoretical, perspective by the former group versus a more practical perspective of the latter group. Also, we cannot state that excess of theoretical knowledge is negative. In worst case, graduate students simply do not make use of the skill. What could be relevant is to understand the reasons leading companies and employees' to have a low perception about these Skills. This could provide insights on actions to improve and to better explain these agents the relevancy of a good theoretical background.

Concerning Skill 7, the situation is worrisome since we repeatedly have a situation in which companies overvalue above educational institutions and, to great extent, students. The results are consistent and may evidence that educational institutions may not be giving enough attention in the development of these skills by the students, which can eventually lead to underperformance. This results requires further investigation and, if proved accurate, intervention mainly by incentivising educational institutions to have propaedeutic disciplines on this matter and the promote working groups.

6.5.2 Competences Gaps

A total of 88 competences were analysed in EDUCAIR project, divided in 19 aggregated competences along 4 domains (Airlines, Airport, ANSPs and Manufacturers). Likewise the Skills Gaps, the Competences Gap assessment followed the rational laid down in Figure 5.4. It was done on a pair basis between Companies, Employees, Students and Educational Institutions. The students were asked to value the relevancy of the competences (perceived relevancy) and asked to rank their level of proficiency on every competence, so additional analysis were undertaken. It is important to emphasise that the amount of answers greatly vary among domains and agents, which conditioned the nature of the analyses. Indeed, the analyses were defined in function of the available data. Although not being optimal, this option increases the reliability and accuracy of the results.

In theoretical terms, a competence gap or misalignment results from a difference in the agents' perceptions on the relevancy of a given competence for performing a given task. Gaps may occur from asymmetric information between agents, in which one agent may feel some need earlier than other just because it has privileged access to some information. Other situation that may generate Gaps results from agents' different positioning in the value chain. That is, each agent has its own strategies, objectives, limitations and background experience. Therefore, we may expect differences of perception towards a given competence (for example: students may prefer practical experience in detriment of theoretical one, while educational institutions may prefer the opposite. While the second source of gaps does not require corrective measures, the former source does require.

Starting the analysis with the Employees and Students gap assessment, the results show a wide Gap in all educational backgrounds and domains. Yet, the situation is likely of no major concern, since the gap results from an overvaluation of students vis-à-vis employees. Likely, Students are still lacking a good understanding about the actual needs and consequently valued very high all Competences. So, the wide Gaps are in our understanding of minor concern and does not require corrective actions. Even so, if required, corrective actions should increase the contact of Students with Companies, preferably in the Company's premises, if not, by bringing the Companies into the Education Institution (Open Days or Fairs).

The second Assessment corresponds to the Competence Gap between Companies and Employees. Gaps are visible in all domains of activity for a considerable number of Competences (around half of them). The majority of the Gaps are however minor and only a fraction are significant. The situation is of concerns as the Gaps invariantly[29] result from an overvaluation of the companies versus the employees. It may evidence a lack of knowledge by the Employees about their Company's real needs. As a consequence, the Company may be feeling needs for some given Competences that Employees are not aware of and, consequently, may be not mastering. The Gap should therefore be addressed. In this case, we recommend conducting further analysis to the Gap and, if proved accurate them corrective measures should be implemented. Naturally, the measures will depend on the actual dimension of the Gap in each company, but it may include improvements in the internal communication (e.g.: strategic and management objectives, new projects or new challenges) and promotion of long life educational courses.

The third and fourth Gaps have the Educational Institutions as focal points. In overall terms, the results to the Educational Institutions reveal two important features. Foremost, all competences are taught which means that European Educational Institutions are able to provide every required competence. Secondly, results show a wide dispersion about the frequency of teaching of the competences, albeit some patterns are recognisable.

[29] There is one single gap that occurs from na overvaluation of the Companies.

In what concerns the Educational Institution – Students Gap assessment, the results reveal Gaps in the majority of the cases. The Gaps invariantly result from the students' high valuation and the relatively frequency of teaching competences, leading the results to locate in the third quadrant. The Aerospace & Aeronautics Competences are the single notable exception with some result in the second quadrant, resulting from high frequencies of teaching. The Gaps must be analysed having in mind the discussion already undertaken in the Employees – Students Gap. Students have highly valuated every single Gap, which may indicate that students still lack knowledge on the actual importance of each gap (and, in doubt, ranked them all very high). Therefore, the Gaps between Educational Institutions and Students do not appear worrisome. In any case, corrective actions can be deployed. Indeed, the corrective action already proposed to the Employees – Student Gap can also provide help in this situation. An increased contact with Companies will lead to a more mature valuation. Other corrective actions may include improved explanations and demonstration of the validity and relevancy of the curricula, so that students could understand it and therefore adjust their expectations.

Finally, in what concerns the Educational Institutions – Companies Gap Assessment, the results are similar with Gaps in all domains (Airlines, Aiports, ANSPs and Manufactures) and all Educational Programs (Engineering and Non-Engineering), although with less intensity than with Students.

We must not forget that the competences may result from temporary misalignments and not corresponding to structural Gaps. The point is that market dynamics may result in rapid changes in Companies' relevant competences. Educational Institutions' curricula however tends to be stable over time (not only because changing curricula requires lengthy process as well as often accreditation process is based on a given set disciplines). These different rhythms may create momentary misalignments, in which Companies have changes but Educational Institutions are still changing.

Corrective actions include increasing the information exchange between Companies and Educational Institutions aiming to reduce the natural asymmetry. This can be done by the development of info days, seminars or participation in students' works. Another corrective action is to increase the flexibility of the Educational offer. Many of the competences analysed can easily be provided through short to medium-term courses. These courses can be held in parallel with existent disciplines (of the main stream programs) to external students (as lifelong learning programs) or given as extra credits. These type of courses have typically less restrictions in terms of accreditation and preparation, therefore they can be given almost on an ad-hoc basis and tailored to the Companies' actual requirements.

6.6 European Observatory for Education and Employment in Civil Aviation

The research works of EDUCAIR project revealed a relevant flaw in the European Civil Aviation Sector: the absence of accurate and reliable data sources concerning Education and Employment. Indeed, a key problem felt during the execution of the works was the difficulty in gathering the required information. Such difficulties brought problems in the analysis to the job availability, review of educational offer and execution of the surveys.

Considering Employment, the available statistics are scarce, incomplete and only available at aggregate level. Several problems were identified: i) statistics about the aviation sector merged with other sectors[30], ii) partial statistics about specific sectors (e.g.: pilots, manufacturers), or iii) different designations for the same concept in different countries. Also, the available information differs from member state to member state, from Eurostat[31] (and other international boards, such as: International Labour Organisation) and from aviation sector's organisations (such as: IATA or ICAO). Finally, long time series are practically inexistent. All of these factors prevent the development of robust statistical about the state and development of the EU Aviation Sector.

The situation concerning Education is somewhat better but still far from satisfactory. Data about students and/or graduates of engineering programmes in aviation are not available at central EU level, while these are only sparsely available (and in some cases for engineering graduates as a whole) at national statistical agencies. At member state the situation varies considerably, with few countries with relatively detailed statistical information about courses and programs (e.g.: Netherlands or Germany) and many without any available information.

Another problem is related with the absence of data about the educational background of employees working in the aviation Sector. The very interdisciplinary nature of aviation sector is the main responsible for this situation. There are many courses or programs, not related with aviation, but that provide valuable graduates to this sector. This is particularly relevant in the 1st level of Bologna and includes courses as Civil Engineering (for working at Airports and Aerodromes), Computer Engineering (for working in all areas) and even non-Engineering programs as economics

[30] More specifically, Eurostat collects and reports graduate statistics for the 1st and 2nd Bologna cycles through the following ISCED97 fields (Andersson and Olsson, 1999): ED5AD1, ED5AD2, ED5BQ1, and ED5BQ2. As far as engineering graduates are concerned, the reported statistical data go as deep as ISCED EF52 ("Engineering and engineering trades"). Aeronautical/aerospace engineering graduates are part of the ISCED EF525 (a more detailed level on the EF52 "tree" titled "Motor vehicles, ships and aircraft"), which reports together data with graduates of Aerospace engineering, Automotive engineering, Coachwork, Motorcycle engineering, Shipbuilding, Vehicle building and repairing and other relevant domains. Following certain rounds of queries with the Eurostat's Production Unit, it was concluded that Eurostat does not collect data on the ISCED EF525 level and therefore cannot report statistics about aeronautical/aerospace engineering graduates in particular (as a subset of EF525 level).

[31] *ibidem*

or management. In higher education levels (2nd level and mainly the 3rd level of Bologna) this situation is not so worrisome, as the scope of the courses tends to be narrower and therefore closer to aviation topics.

The problem is nevertheless mitigated by the existence of multiples sectorial association or societies of educational institutions (e.g.: PEGASUS[32]), students (e.g.: EURAVIA[33]) or professionals (e.g.: Royal Aeronautical Society[34]). These groups typically have robust, long-term series about their members and, therefore, they are a reliable source of information. However, only have information about their members or affiliates which is naturally a tiny fraction of the overall universe of students and graduates. Also, often the information is confidential.

Finally, most educational institutions have Alumni Offices that track the professional development of their graduate students. However, the data is typically confidential and often incomplete as over time the ties with the educational institution are lost.

Based on the above, we recommend the establishment of an European Observatory for Education and Employment in Civil Aviation. The Observatory would be responsible for collecting standardised data about relevant Educational offer and Employment figures of the aviation sector at EU level. The Observatory would enable the development of robust and valuable statistical analysis about the state of development of EU Aviation Sector.

[32] www.pegasus-europe.org (accessed on the 20th May 2013)
[33] www.euroavia.net (accessed on the 20th May 2013)
[34] aerosociety.com/ (accessed on the 20th May 2013)

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8 Annex I – Characterisation of Surveys

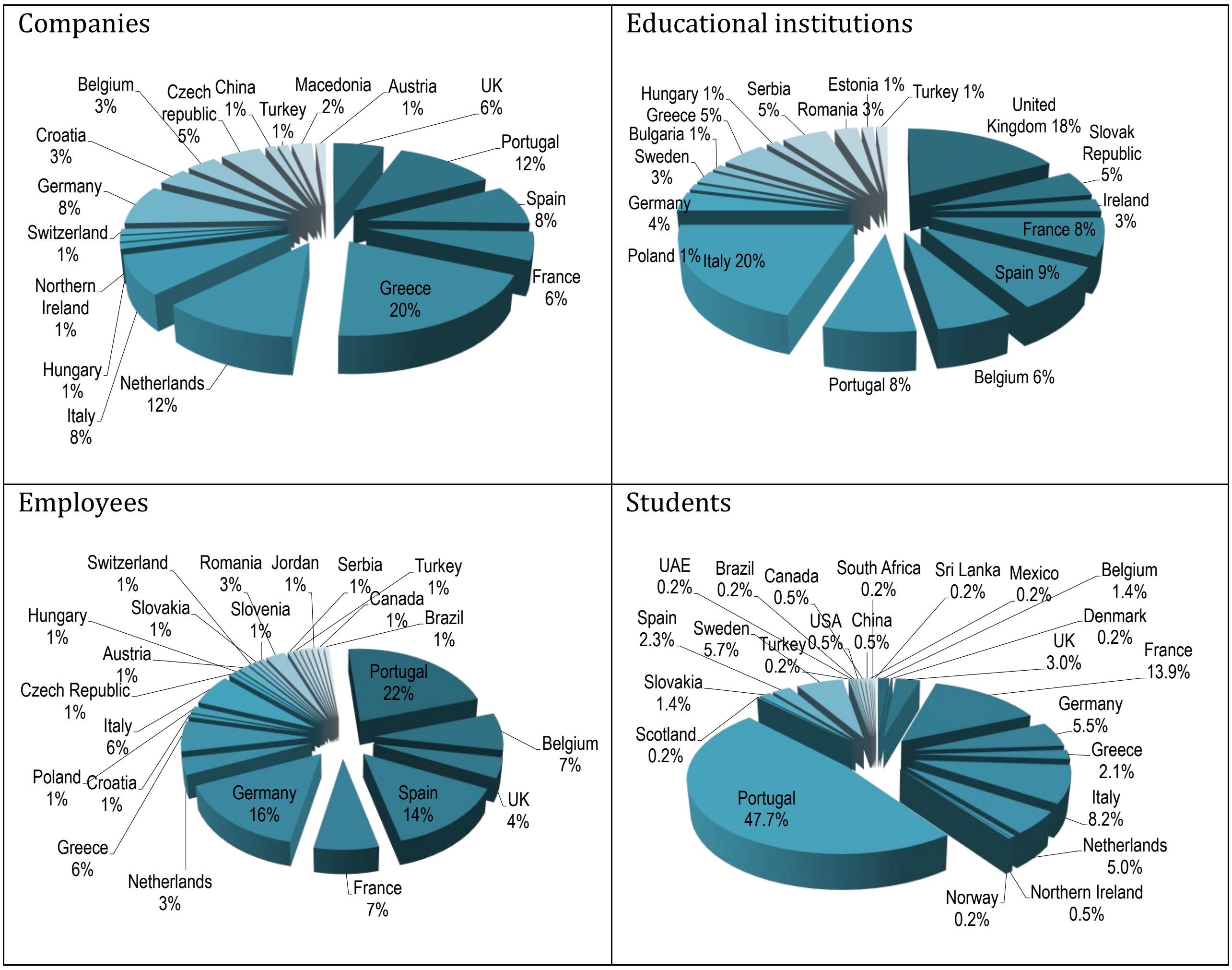


Figure 8.1 – Percentage (%) of countries' representation in the four surveys

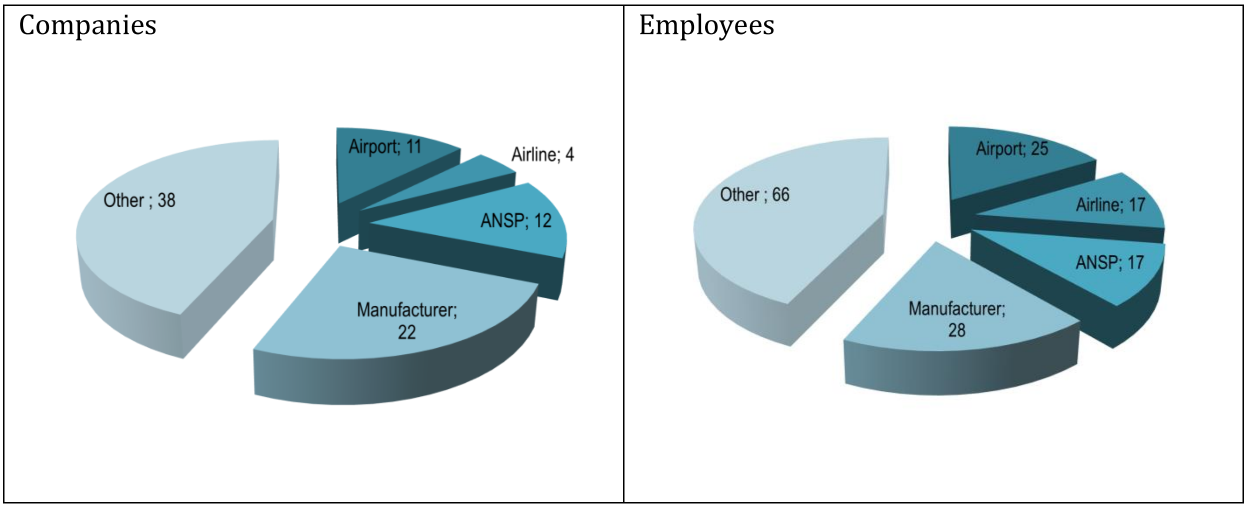


Figure 8.2 - Commercial activity of the companies

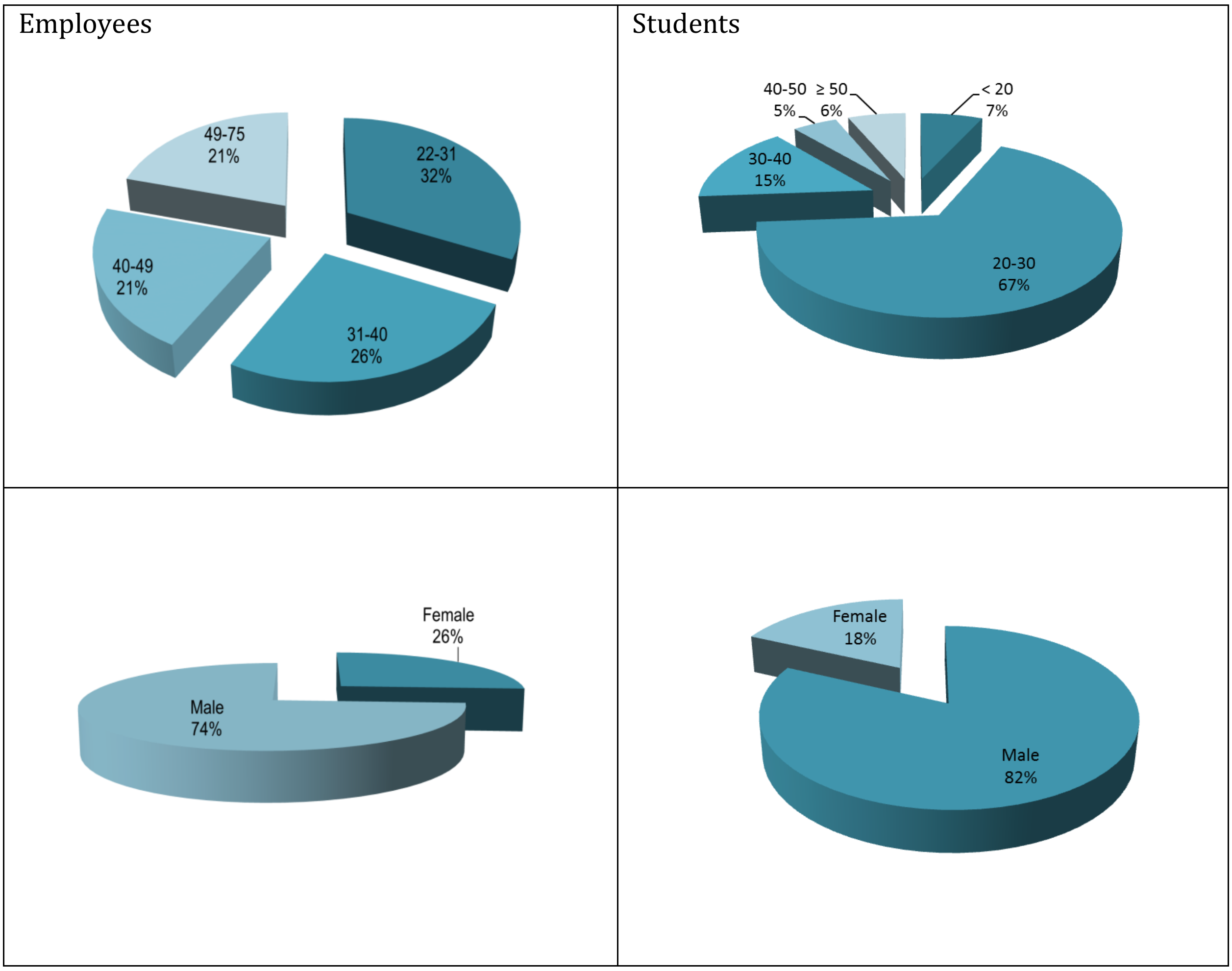


Figure 8.3 – Age and Gender of respondents

9 Annex II –Results of the Surveys about the relevancy of Skills and Competences

This Annex contains the table with data source used in the assessment of the Skills and Competence Gaps. There are three levels of organisations: Type (Skills or Competences), Domain (Airlines, Airport, ANSP and Manufacturer), Agents (Company, Employee, Educational Institution and Student). All tables are identically formatted for a better reading. For each domain, we present the average value and the amount of valid answers. Cells shaded at grey are not relevant for the specific case.

9.1 Skills

Table 9.1 – Companies' evaluation of the Skills relevancy

COMPANIES	Airline		Airport		ANSP		Manufacturer		Other	
	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	3,67	3	3,75	4	3,75	4	3,75	12	3,52	23
Analytical Background	3,33	3	3,25	4	3,25	4	3,50	12	3,26	23
Technical Background	3,00	3	3,00	4	2,75	4	3,50	12	3,13	23
Theoretical Background	2,33	3	2,75	4	2,00	4	2,73	11	2,82	22
Oral and Written Communication	3,33	3	3,75	4	3,75	4	3,42	12	3,54	24
Leadership	3,00	3	3,75	4	2,00	4	3,00	11	2,87	23
Ability to work in a multidisciplinary team	3,67	3	3,50	4	2,50	4	3,83	12	3,65	23

Table 9.2 – Educational Institutes' evaluation of the Skills relevancy

UNIVERSITIES	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
relevancy	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	3,48	48	4	2	3	1	3,69	13	3,71	7
Analytical Background	3,25	48	3,5	2	2	1	3,06	14	3,85	7
Technical Background	3,09	49	3	2	4	1	3,00	14	3,28	7
Theoretical Background	3,26	46	3	2	1	1	2,99	14	3,42	7
Oral and Written Communication	3,41	47	3,5	2	3	1	3,38	14	3,57	7
Leadership	3,02	47	2,5	2	2	1	2,35	14	3,57	7
Ability to work in a multidisciplinary team	2,83	49	3	2	4	1	2,42	14	3,57	7

UNIVERSITIES	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
evaluation to students' actual level	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	2,47	48	3	1	3	1	2,46	13	1,14	7
Analytical Background	3,69	37	3,5	2	3	1	3,08	12	1,5	4
Technical Background	2,41	49	4	1	4	1	2,64	14	1,57	7
Theoretical Background	2,50	47	3	2	3	1	1,85	14	1,28	7
Oral and Written Communication	2,35	48	3,5	2	3	1	2,68	13	1	7
Leadership	1,87	48	2,5	2	2	1	1,92	14	1	7
Ability to work in a multidisciplinary team	2,42	49	3	2	3	1	2,64	14	1,42	7

Table 9.3 - Students' evaluation of the Skills relevancy

STUDENTS (1st and 2nd Level of Bologna)	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	3,76	88	3,71	7	3,7	10	4,16	37	4,09	32
Analytical Background	3,43	86	3,14	7	3,9	10	3,78	37	3,58	31
Technical Background	3,56	85	3,57	7	4,1	10	3,66	38	3,63	30
Theoretical Background	3,06	86	3,14	7	3	10	3,42	38	3,13	30
Oral and Written Communication	3,35	88	3,29	7	3,8	10	3,59	39	3,52	31
Leadership	3,15	88	3,57	7	3,6	10	3,18	38	3,35	31
Ability to work in a multidisciplinary team	3,69	88	3,86	7	3,9	10	3,92	38	3,97	31

Table 9.4 - Employees' evaluation of the Skills relevancy

AIRLINES EMPLOYEES	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	3,67	9					4,00	2	4,00	1
Analytical Background	3,11	9					4,00	2	2,00	1
Technical Background	3,44	9					3,50	2	4,00	1
Theoretical Background	2,44	9					2,50	2	2,00	1
Oral and Written Communication	3,11	9					3,50	2	4,00	1
Leadership	3,33	9					3,00	2	4,00	1
Ability to work in a multidisciplinary team	3,67	9					3,00	2	4,00	1

AIRPORT EMPLOYEES	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	4,00	5			4,00	5	4,00	3	4,00	3
Analytical Background	3,60	5			3,60	5	4,00	3	3,67	3
Technical Background	3,60	5			4,00	5	3,33	3	4,00	3
Theoretical Background	3,40	5			3,20	5	3,33	3	3,33	3
Oral and Written Communication	3,60	5			3,60	5	4,00	3	4,00	3
Leadership	3,60	5			3,00	5	4,00	3	4,00	2
Ability to work in a multidisciplinary team	4,00	4			3,60	5	4,00	3	4,00	3

ANSP EMPLOYEES	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	3,57	7			4,00	1	3,50	4	3,50	2
Analytical Background	3,43	7			3,00	1	3,75	4	3,50	2
Technical Background	3,43	7			3,00	1	3,50	4	3,00	2
Theoretical Background	2,57	7			3,00	1	3,00	4	2,50	2
Oral and Written Communication	3,43	7			4,00	1	3,25	4	3,50	2
Leadership	2,86	7					3,25	4	3,50	2
Ability to work in a multidisciplinary team	3,14	7			4,00	1	3,50	4	3,50	2

MANUFACTURER EMPLOYEES	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	4,00	7	3,50	6			4,00	5	4,00	2
Analytical Background	3,71	7	3,50	6			3,60	5	4,00	2
Technical Background	4,00	7	3,50	6			3,80	5	3,50	2
Theoretical Background	3,57	7	3,33	6			3,40	5	3,00	2
Oral and Written Communication	3,29	7	3,50	6			3,60	5	4,00	2
Leadership	3,43	7	3,33	6			3,20	5	3,00	2
Ability to work in a multidisciplinary team	3,86	7	3,83	6			3,80	5	3,50	2

OTHER EMPLOYEES	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Problem Solving	3,80	25	3,63	8	4,00	3	3,75	12	4,00	4
Analytical Background	3,48	25	3,50	8	4,00	3	3,73	11	3,00	4
Technical Background	3,36	25	3,38	8	3,67	3	2,82	11	3,25	4
Theoretical Background	3,16	25	3,00	8	3,00	3	2,91	11	2,75	4
Oral and Written Communication	3,58	24	3,50	8	4,00	3	3,33	12	3,75	4
Leadership	3,04	25	3,14	8	3,00	3	3,00	12	3,50	4
Ability to work in a multidisciplinary team	3,56	25	3,50	8	3,33	3	3,58	12	3,75	4

9.2 Competences

9.2.1 Airline-related Competences

Table 9.5 – Evaluation of Airline related competences by Companies

COMPANIES		Airline		Airport		ANSP		Manufacturer	
		Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
Cockpit Crew	Planning of the flight	1,00	3						
	On board instrument control	1,25	4						
	General and radio navigation & communication	2,00	3						
	Understanding air law & operational procedures	2,00	3						
	Management of technical aspects	2,00	3						
Technics & Engineering	Maintenance and reparation of airframe	3,00	3						
	Maintenance and reparation of power plant	3,00	3						
	Reparation of on board instruments	2,67	3						
	Maintenance and reparation of navigation and radio communications equipment	2,67	3						
	Maintenance and repair of auxiliary systems	2,67	3						
Planning & Control	Coordination of maintenance	2,00	2						
	Planning and coordination of operations	2,00	2						
	Safety management	4,00	2						
	Flight dispatching	2,00	2						
	Determination and provision of meteorological circumstances	1,00	2						
	Ramp planning	3,00	2						

Table 9.6 - Evaluation of Airline related competences by Employees

		EMPLOYEES relevancy	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRLINE-related Competences	Cockpit Crew	Planning of the flight	1,88	8					1,00	2		
		On board instrument control	2,25	8					2,00	2		
		General and radio navigation & communication	2,25	8					2,00	2		
		Understanding air law & operational procedures	2,38	8					2,50	2		
		Management of technical aspects	2,63	8					2,50	2		
	Technics & Engineering	Maintenance and reparation of airframe	2,00	8					2,50	2		
		Maintenance and reparation of power plant	2,00	8					2,50	2		
		Reparation of on board instruments	1,83	6					2,00	2		
		Maintenance and reparation of navigation and radio communications equipment	1,80	5					2,50	2		
		Maintenance and repair of auxiliary systems	1,83	6					2,50	2		
	Planning & Control	Coordination of maintenance	2,25	8					4,00	2		
		Planning and coordination of operations	2,75	8					2,50	2		
		Safety management	2,63	8					1,50	2		
		Flight dispatching	1,86	7					1,50	2		
		Determination and provision of meteorological circumstances	1,71	7					1,00	1		
		Ramp planning	2,00	6					3,00	1		

		EMPLOYEES self assessment while students	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRLINE-related Competences	Cockpit Crew	Planning of the flight	1,00	6					3,00	1		
		On board instrument control	1,00	6					3,00	1		
		General and radio navigation & communication	1,00	6					3,00	1		
		Understanding air law & operational procedures	1,33	6					4,00	1		
		Management of technical aspects	1,57	7					4,00	1		
	Technics & Engineering	Maintenance and reparation of airframe	1,29	7					1,00	1		
		Maintenance and reparation of power plant	1,14	7					1,00	1		
		Reparation of on board instruments	1,40	5					1,00	1		
		Maintenance and reparation of navigation and radio communications equipment	1,40	5					1,00	1		
		Maintenance and repair of auxiliary systems	1,40	5					1,00	1		
	Planning & Control	Coordination of maintenance	1,29	7					3,00	1		
		Planning and coordination of operations	1,29	7					3,00	1		
		Safety management	1,71	7					2,00	1		
		Flight dispatching	1,17	6					4,00	1		
		Determination and provision of meteorological circumstances	1,29	7					4,00	1		
		Ramp planning	1,00	5					3,00	1		

Table 9.7 Evaluation of Airline related competences by Educational Institutions

UNIVERSITIES (1st and 2nd Level of Bologna)		competences taught	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRLINE-related Competences	Cockpit Crew	Planning of the flight	0,41	51	0	2	0	1	0,05	18	0,14	7
		On board instrument control	0,35	51	0	2	0	1	0,16	18	0,14	7
		General and radio navigation & communication	0,49	51	0	2	0	1	0,16	18	0,29	7
		Understanding air law & operational procedures	0,47	51	0	2	0	1	0,11	18	0,57	7
		Management of technical aspects	0,41	51	0	2	1	1	0,26	18	0,29	7
	Technics & Engineering	Maintenance and reparation of airframe	0,45	51	0	2	1	1	0,16	18	0,14	7
		Maintenance and reparation of power plant	0,37	51	0	2	0	1	0,16	18	0,00	7
		Reparation of on board instruments	0,16	51	0	2	0	1	0,11	18	0,00	7
		Maintenance and reparation of navigation and radio communications equipment	0,18	51	0	2	0	1	0,16	18	0,00	7
		Maintenance and repair of auxiliary systems	0,18	51	0	2	0	1	0,05	18	0,00	7
	Planning & Control	Coordination of maintenance	0,39	51	0	2	0	1	0,16	18	0,14	7
		Planning and coordination of operations	0,45	51	0	2	0	1	0,11	18	0,14	7
		Safety management	0,49	51	0	2	0	1	0,11	18	0,57	7
		Flight dispatching	0,35	51	0	2	0	1	0,05	18	0,14	7
		Determination and provision of meteorological circumstances	0,22	51	0	2	0	1	0,11	18	0,29	7
		Ramp planning	0,22	51	0	2	0	1	0,05	18	0,14	7

Table 9.8 - Evaluation of Airline related competences by Students

STUDENTS (1nd and 2nd level of bologna)		relevancy	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRLINE-related Competences	Cockpit Crew	Planning of the flight	3,35	46	3,50	2	3,5	8	3,41	17	3	14
		On board instrument control	3,23	47	4,00	2	3,88	8	3,56	16	2,79	14
		General and radio navigation & communication	3,26	47	4,00	2	3,88	8	3,44	16	2,85	13
		Understanding air law & operational procedures	3,34	47	3,50	2	3,75	8	3,56	16	2,93	14
		Management of technical aspects	3,34	47	3,50	2	3,13	8	3,31	16	2,87	15
	Technics & Engineering	Maintenance and reparation of airframe	3,32	47	4,00	1	3,71	7	3,6	15	3,36	11
		Maintenance and reparation of power plant	3,26	46	3,00	1	3,86	7	3,53	15	3,36	11
		Reparation of on board instruments	3,27	45	3,00	1	3,71	7	3,73	15	3,36	11
		Maintenance and reparation of navigation and radio communications equipment	3,17	46	3,00	1	3,71	7	3,67	15	3,27	11
		Maintenance and repair of auxiliary systems	3,29	35	2,50	2	3,5	6	3,47	17	3,1	20
	Planning & Control	Coordination of maintenance	3,44	36	1,00	1	3,8	5	3,31	16	3,26	23
		Planning and coordination of operations	3,58	36	1,00	1	4	6	3,44	16	3,5	24
		Safety management	3,79	38	1,00	1	4	6	3,81	16	3,5	24
		Flight dispatching	3,46	35	1,00	1	3,5	6	3,53	15	3,24	25
		Determination and provision of meteorological circumstances	3,19	36	1,00	1	4	6	3,56	16	3,09	23
		Ramp planning	3,34	35	1,00	1	3,67	6	3,47	15	3,32	22

STUDENTS (1st and 2nd level of bologna)		self assessment	Aerospace		Aeronautical		Civil		Mechanical		Electrical/Electronics	
			Average Y	#Resp.	Average Y	#Resp.	Average Y	#Resp.	Average Y	#Resp.	Average Y	#Resp.
AIRLINE-related Competences	Cockpit Crew	Planning of the flight	1,78	41	3	1	1,29	7	1,82	11	1,75	12
		On board instrument control	2,05	42	2	1	1	7	1,64	11	1,36	11
		General and radio navigation & communication	2,02	42	2	1	1,29	7	1,92	13	1,64	11
		Understanding air law & operational procedures	1,98	41	2	1	1,86	7	1,58	12	1,73	11
		Management of technical aspects	2	38	4	1	1,29	7	1,69	13	1,36	11
	Technics & Engineering	Maintenance and reparation of airframe	1,73	41	-	0	1	6	1,3	10	1,18	11
		Maintenance and reparation of power plant	1,63	41	-	0	1	6	1,3	10	1,1	10
		Reparation of on board instruments	1,54	41	-	0	1	6	1,33	9	1,09	11
		Maintenance and reparation of navigation and radio communications equipment	1,5	36	-	0	1	6	1,46	13	1,43	14
		Maintenance and repair of auxiliary systems	1,55	31	-	0	1	5	1,5	12	1,39	18
	Planning & Control	Coordination of maintenance	1,72	32	-	0	1,5	6	1,45	11	1,53	19
		Planning and coordination of operations	1,84	32	-	0	1,67	6	1,45	11	1,95	22
		Safety management	2	35	-	0	2	6	1,91	11	1,9	21
		Flight dispatching	1,74	31	-	0	1,5	6	1,5	10	1,67	21
		Determination and provision of meteorological circumstances	1,78	32	-	0	1,5	6	1,64	11	1,33	18
		Ramp planning	1,6	30	-	0	1,83	6	1,5	10	1,53	19

9.2.2 Airport-related Competences

Table 9.9 - Evaluation of Airport related competences by Companies

COMPANIES			Airline		Airport		ANSP		Manufacturer	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRPORT-related Competences	Design	Design of airside infrastructure			2,50	4				
		Design of building and terminal			2,50	4				
		Design of landside access			2,25	4				
	Building & Construction	Building & construction of airside infrastructure			2,75	4				
		Building & construction of building and terminal			2,75	4				
		Building & construction of landside access			2,00	3				
	Planning	Master planning			2,75	4				
		Land use planning			2,50	4				
	Handling	Handling of passengers			2,00	4				
		Handling of freight			2,33	3				
		Handling of air vehicles			3,33	3				
	Emergency Planning	Rescue and fire fighting			3,00	4				
		Obstacles removal			3,67	3				
	Maintenance	Airside maintenance			3,33	3				
		Terminal maintenance			3,33	3				
	Environmental Control	Noise control			3,33	3				
		Emission control			3,33	3				
		Waste maintenance			3,33	3				
		Wildlife control			3,00	2				
	Security	Security concerning passengers			3,67	3				
		Security concerning cargo			3,67	3				
		Security concerning employees			3,33	3				
		Prevention of intrusion / unauthorized access			3,33	3				

Table 9.10 - Evaluation of Airport related competences by Educational Institutions

UNIVERSITIES (1st and 2nd Level of Bologna) competences taught			Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRPORT-related Competences	Design	Design of airside infrastructure	0,35	51	0,00	2	0	1	0,21	18	0,43	7
		Design of building and terminal	0,37	51	0,00	2	0	1	0,10	18	0,29	7
		Design of landside access	0,22	51	0,00	2	0	1	0,10	18	0,14	7
	Building & Construction	Building & construction of airside infrastructure	0,24	51	0,00	2	0	1	0,10	18	0,00	7
		Building & construction of building and terminal	0,22	51	0,00	2	0	1	0,10	18	0,00	7
		Building & construction of landside access	0,16	51	0,00	2	0	1	0,16	18	0,00	7
	Planning	Master planning	0,33	51	0,00	2	0	1	0,26	18	0,14	7
		Land use planning	0,29	51	0,00	2	0	1	0,21	18	0,00	7
	Handling	Handling of passengers	0,41	51	0,00	2	0	1	0,16	18	0,43	7
		Handling of freight	0,35	51	0,00	2	0	1	0,10	18	0,14	7
		Handling of air vehicles	0,43	51	0,00	2	0	1	0,10	18	0,14	7
	Emergency Planning	Rescue and fire fighting	0,25	51	0,00	2	0	1	0,05	18	0,14	7
		Obstacles removal	0,18	51	0,00	2	0	1	0,00	18	0,14	7
	Maintenance	Airside maintenance	0,25	51	0,00	2	0	1	0,05	18	0,14	7
		Terminal maintenance	0,20	51	0,00	2	0	1	0,11	18	0,14	7
	Environmental Control	Noise control	0,53	51	0,00	2	0	1	0,27	18	0,14	7
		Emission control	0,47	51	0,00	2	0	1	0,26	18	0,29	7
		Waste maintenance	0,14	51	0,00	2	0	1	0,16	18	0,14	7
		Wildlife control	0,20	51	0,00	2	0	1	0,05	18	0,14	7
	Security	Security concerning passengers	0,31	51	0,00	2	0	1	0,10	18	0,14	7
		Security concerning cargo	0,31	51	0,00	2	0	1	0,00	18	0,14	7
		Security concerning employees	0,22	51	0,00	2	0	1	0,05	18	0,14	7
		Prevention of intrusion / unauthorized a	0,22	51	0,00	2	0	1	0,05	18	0,14	7

Table 9.11 - Evaluation of Airport related competences by Employees

EMPLOYEES relevancy			Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRPORT-related Competences	Design	Design of airside infrastructure	2,00	6			2,33	3	4,00	2	4,00	2
		Design of building and terminal	1,83	6			2,33	3	4,00	2	3,50	2
		Design of landside access	1,80	5			2,67	3	3,50	2	3,50	2
	Building & Construction	Building & construction of airside infrastructure	1,80	5			2,00	3	1,50	2	3,50	2
		Building & construction of building and terminal	2,00	5			2,00	3	1,50	2	3,50	2
		Building & construction of landside access	2,00	5			2,00	3	1,50	2	3,50	2
	Planning	Master planning	1,83	6			2,67	3	4,00	2	4,00	2
		Land use planning	2,20	5			2,33	3	3,50	2	4,00	2
	Handling	Handling of passengers	2,60	5			1,33	3	4,00	2	4,00	2
		Handling of freight	2,60	5			1,33	3	3,00	2	4,00	2
		Handling of air vehicles	2,60	5			1,33	3	3,50	2	2,50	2
	Emergency Planning	Rescue and fire fighting	2,33	6			1,00	3	3,00	2	4,00	2
		Obstacles removal	2,17	6			1,00	3	3,00	2	4,00	2
	Maintenance	Airside maintenance	1,80	5			2,00	3	1,50	2	4,00	2
		Terminal maintenance	1,80	5			2,00	3	1,50	2	4,00	2
	Environmental Control	Noise control	2,17	6			1,33	3	3,50	2	3,50	2
		Emission control	2,00	5			1,33	3	3,00	2	3,50	2
		Waste maintenance	2,50	4			1,33	3	3,50	2	3,50	2
		Wildlife control	2,20	5			1,33	3	3,00	2	3,50	2
	Security	Security concerning passengers	1,83	6			1,67	3	3,50	2	3,50	2
		Security concerning cargo	2,00	5			1,00	3	2,50	2	3,50	2
		Security concerning employees	1,80	5			2,00	3	3,50	2	3,50	2
		Prevention of intrusion / unauthorize	1,80	5			1,67	3	3,50	2	3,50	2

EMPLOYEES self assessment while students			Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRPORT-related Competences	Design	Design of airside infrastructure	1,17	6			2,00	3	3,00	2	2,00	2
		Design of building and terminal	1,00	5			2,00	3	2,00	2	2,00	2
		Design of landside access	1,00	5			2,00	3	1,50	2	2,00	2
	Building & Construction	Building & construction of airside infrastructure	1,00	5			1,33	3	1,50	2	2,00	2
		Building & construction of building and terminal	1,00	5			1,33	3	1,50	2	2,00	2
		Building & construction of landside access	1,20	5			1,33	3	1,50	2	2,00	2
	Planning	Master planning	1,17	6			2,33	3	1,50	2	2,50	2
		Land use planning	1,20	5			2,00	3	1,50	2	2,50	2
	Handling	Handling of passengers	1,20	5			1,67	3	2,50	2	2,00	2
		Handling of freight	1,40	5			1,67	3	1,50	2	1,00	1
		Handling of air vehicles	1,40	5			1,67	3	2,00	2	2,00	2
	Emergency Planning	Rescue and fire fighting	1,20	5			2,00	3	1,50	2	2,00	2
		Obstacles removal	1,40	5			2,00	3	1,00	2	2,00	2
	Maintenance	Airside maintenance	1,40	5			1,33	3	1,00	2	2,00	2
		Terminal maintenance	1,40	5			1,33	3	1,00	2	2,00	2
	Environmental Control	Noise control	1,17	6			2,00	3	2,50	2	2,00	2
		Emission control	1,50	4			2,00	3	2,00	2	2,00	2
		Waste maintenance	1,50	4			2,00	3	1,50	2	2,00	2
		Wildlife control	2,00	4			2,00	3	1,50	2	2,00	2
	Security	Security concerning passengers	1,00	5			1,67	3	1,50	2	2,00	2
		Security concerning cargo	1,00	5			1,67	3	1,50	2	2,00	2
		Security concerning employees	1,00	5			1,67	3	1,50	2	2,00	2
		Prevention of intrusion / unauthorize	1,20	5			1,67	3	1,50	2	2,00	2

Table 9.12 - Evaluation of Airport related competences by Students

STUDENTS (1nd and 2nd level of bologna)			Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
relevancy			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRPORT-related Competences	Design	Design of airside infrastructure	3,57	35	4	1	3,83	6	3,33	15	3,38	24
		Design of building and terminal	3,41	34	2	1	3,57	7	3,27	15	3,25	24
		Design of landside access	3,47	36	4	1	3,83	6	3,27	15	3,21	24
	Building & Construction	Building & construction of airside infrastructure	3,46	35	4	1	3,83	6	3,21	14	2,9	21
		Building & construction of building and terminal	3,32	34	4	1	3,5	6	3,14	14	2,86	21
		Building & construction of landside access	3,37	35	4	1	3,67	6	3,14	14	2,81	21
	Planning	Master planning	3,41	34	4	1	4	6	3,5	16	3,24	21
		Land use planning	3,47	34	4	1	3,5	6	3,38	16	3	21
	Handling	Handling of passengers	3,4	35	-	0	3,86	7	3,47	15	3,29	24
		Handling of freight	3,32	34	-	0	3,83	6	3,4	15	3,13	24
		Handling of air vehicles	3,59	34	-	0	3,83	6	3,67	15	3,21	24
	Emergency Planning	Rescue and fire fighting	3,53	34	3	1	4	6	3,8	15	2,96	23
		Obstacles removal	3,32	34	3	1	4	6	3,47	15	2,83	23
	Maintenance	Airside maintenance	3,43	35	4	1	4	6	3,71	14	3,08	24
		Terminal maintenance	3,29	35	4	1	3,67	6	3,43	14	3	24
	Environmental Control	Noise control	3,44	32	3	1	4	6	3,6	15	3,22	23
		Emission control	3,56	32	4	1	4	6	3,53	15	3,26	23
		Waste maintenance	3,42	33	4	1	3,83	6	3,4	15	3,04	23
		Wildlife control	3,35	34	4	1	3,83	6	3,4	15	3,09	23
	Security	Security concerning passengers	3,58	33	1	1	4	7	3,79	14	3,61	23
		Security concerning cargo	3,39	33	1	1	3,83	6	3,64	14	3,35	23
		Security concerning employees	3,48	33	1	1	3,83	6	3,79	14	3,39	23
		Prevention of intrusion / unauthorized a	3,55	33	1	1	3,83	6	3,57	14	3,35	23

STUDENTS (1st and 2nd level of bologna)			Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
self assessment			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
AIRPORT-related Competences	Design	Design of airside infrastructure	1,87	31	2	1	2,33	6	1,3	10	1,81	21
		Design of building and terminal	1,77	31	2	1	2,29	7	1,3	10	1,76	21
		Design of landside access	1,74	31	2	1	2,33	6	1,3	10	1,71	21
	Building & Construction	Building & construction of airside infrastructure	1,43	30	1	1	2,5	6	1,3	10	1,26	19
		Building & construction of building and terminal	1,43	30	1	1	2,33	6	1,2	10	1,21	19
		Building & construction of landside access	1,4	30	1	1	2,33	6	1,3	10	1,21	19
	Planning	Master planning	1,68	31	1	1	2,33	6	1,55	11	1,63	19
		Land use planning	1,69	32	1	1	2,17	6	1,55	11	1,42	19
	Handling	Handling of passengers	1,84	31	-	0	2	7	1,5	10	1,91	23
		Handling of freight	1,67	30	-	0	2	6	1,4	10	1,74	23
		Handling of air vehicles	1,8	30	-	0	1,83	6	1,6	10	1,74	23
	Emergency Planning	Rescue and fire fighting	1,74	31	1	1	2	6	1,82	11	1,44	18
		Obstacles removal	1,68	31	2	1	2	6	1,73	11	1,33	18
	Maintenance	Airside maintenance	1,67	30	-	0	1,4	5	1,5	10	1,33	18
		Terminal maintenance	1,6	30	-	0	1,6	5	1,3	10	1,33	18
	Environmental Control	Noise control	2,03	29	1	1	1,67	6	1,73	11	1,9	21
		Emission control	2,03	30	1	1	1,67	6	1,7	10	1,9	21
		Waste maintenance	1,83	29	1	1	1,5	6	1,3	10	1,47	19
		Wildlife control	1,54	28	1	1	1,5	6	1,3	10	1,42	19
	Security	Security concerning passengers	1,93	27	1	1	2	7	1,67	9	1,71	21
		Security concerning cargo	1,74	27	1	1	2,17	6	1,44	9	1,45	20
		Security concerning employees	1,89	27	1	1	2	6	1,44	9	1,26	19
		Prevention of intrusion / unauthorized a	1,89	27	1	1	2	6	1,4	10	1,26	19

9.2.3 ANSP-related Competences

Table 9.13 - Evaluation of ANSP related competences by Companies

		COMPANIES	Airline		Airport		ANSP		Manufacturer	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
ANSP-related Competences	Area Control	Supervision of Area Control Centre operations					4,00	2		
		En route aircraft control					4,00	2		
		Planning & coordination en route air traffic					4,00	2		
	Approach Control	Supervision & planning approach operations					4,00	3		
		Provision of terminal radar approach control					2,33	3		
	Tower Control	Supervision of tower operations					2,75	4		
		On the ground aircraft movements control					2,25	4		
		Aircraft landing & taking-off control					2,25	4		
	Other ATC Operations	Provision of flight information to VFR traffic					2,50	4		
		Planning and coordination of network capacity					3,00	4		
	ATM	Design, development and evaluation of ATC procedures					1,67	3		
		Design, development and sustainment of ATC systems, product and tools					1,67	3		
		Management of safety of ATC operations					2,33	3		
		Management of air traffic capacity and efficiency					2,00	2		
		Management of interaction of operational controllers with operational environment					2,00	2		

Table 9.14 - Evaluation of ANSP related competences by Employees

		EMPLOYEES relevancy	Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
ANSP-related Competences	Area Control	Supervision of Area Control Centre operations	2,43	7			1,00	1	2,00	3	2,50	2
		En route aircraft control	2,57	7			1,00	1	2,00	3	2,50	2
		Planning & coordination en route air traffic	2,57	7			2,00	1	2,00	3	2,50	2
	Approach Control	Supervision & planning approach operations	2,43	7			1,00	1	2,50	4	2,50	2
		Provision of terminal radar approach control	2,29	7			1,00	1	2,50	4	2,50	2
	Tower Control	Supervision of tower operations	2,43	7			1,00	1	2,50	4	2,50	2
		On the ground aircraft movements control	2,57	7			1,00	1	2,50	4	2,50	2
		Aircraft landing & taking-off control	2,43	7			1,00	1	2,00	3	2,50	2
	Operations	Provision of flight information to VFR traffic	2,00	7			1,00	1	2,50	4	2,50	2
		Planning and coordination of network capacity	2,29	7			1,00	1	2,50	4	2,50	2
	ATM	Design, development and evaluation of ATC procedures	2,29	7			3,00	1	2,50	4	2,50	2
		Design, development and sustainment of ATC systems, product and tools	2,57	7			3,00	1	2,50	4	2,50	2
		Management of safety of ATC operations	2,57	7			2,00	1	2,50	4	2,50	2
		Management of air traffic capacity and efficiency	2,57	7			2,00	1	2,50	4	2,50	2
		Management of interaction of operational controllers with operational environment	2,57	7			1,00	1	2,50	4	2,50	2

		EMPLOYEES self assessment while students	Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
ANSP-related Competences	Area Control	Supervision of Area Control Centre operations	1,67	6			1,00	1	1,00	3	2,00	2
		En route aircraft control	1,83	6			1,00	1	1,00	3	2,00	2
		Planning & coordination en route air traffic	1,71	7			1,00	1	1,00	3	2,00	2
	Approach Control	Supervision & planning approach operations	1,71	7			1,00	1	1,50	4	3,00	1
		Provision of terminal radar approach control	1,80	5			1,00	1	1,50	4	3,00	1
	Tower Control	Supervision of tower operations	1,67	6			1,00	1	1,50	4	3,00	1
		On the ground aircraft movements control	1,83	6			1,00	1	1,50	4	3,00	1
		Aircraft landing & taking-off control	1,83	6			1,00	1	1,50	4	3,00	1
	Operations	Provision of flight information to VFR traffic	1,71	7			1,00	1	1,50	4	3,00	1
		Planning and coordination of network capacity	1,71	7			1,00	1	1,50	4	3,00	1
	ATM	Design, development and evaluation of ATC procedures	1,86	7			1,00	1	1,60	5	3,00	1
		Design, development and sustainment of ATC systems, product and tools	1,86	7			1,00	1	1,60	5	3,00	1
		Management of safety of ATC operations	1,83	6			1,00	1	1,60	5	3,00	1
		Management of air traffic capacity and efficiency	1,71	7			1,00	1	1,60	5	3,00	1
		Management of interaction of operational controllers with operational environment	1,71	7			1,00	1	1,60	5	3,00	1

Table 9.15 - Evaluation of ANSP related competences by Educational Institutions

		UNIVERSITIES (1st and 2nd Level of Bologna) competences taught	Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
ANSP-related Competences	Area Control	Supervision of Area Control Centre operations	0,33	48	0	2	0	1	0,05	18	0,14	7
		En route aircraft control	0,47	48	0	2	0	1	0,05	18	0,14	7
		Planning & coordination en route air traffic	0,41	48	0	2	0	1	0,16	18	0,14	7
	Approach Control	Supervision & planning approach operations	0,45	48	0	2	0	1	0,16	18	0,14	7
		Provision of terminal radar approach control	0,35	48	0	2	0	1	0,05	18	0,14	7
	Tower Control	Supervision of tower operations	0,29	48	0	2	0	1	0,00	18	0,14	7
		On the ground aircraft movements control	0,31	48	0	2	0	1	0,05	18	0,14	7
		Aircraft landing & taking-off control	0,33	48	0	2	0	1	0,16	18	0,14	7
	Other ATC Operations	Provision of flight information to VFR traffic	0,33	48	0	2	0	1	0,05	18	0,14	7
		Planning and coordination of network capacity	0,33	48	0	2	0	1	0,16	18	0,14	7
	ATM	Design, development and evaluation of ATC procedures	0,43	48	0	2	0	1	0,10	18	0,14	7
		Design, development and sustainment of ATC systems, product and tools	0,37	48	0	2	0	1	0,10	18	0,14	7
		Management of safety of ATC operations	0,43	48	0	2	0	1	0,00	18	0,14	7
		Management of air traffic capacity and efficiency	0,45	48	0	2	0	1	0,16	18	0,14	7
		Management of interaction of operational controllers with operational environment	0,25	48	0	2	0	1	0,05	18	0,14	7

Table 9.16 - Evaluation of ANSP related competences by Students

		STUDENTS (1nd and 2nd level of bologna) relevancy	Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
ANSP-related Competences	Area Control	Supervision of Area Control Centre operations	3,34	35	-	0	4	7	3,6	15	3,24	21
		En route aircraft control	3,43	35	-	0	4	7	3,6	15	3,24	21
		Planning & coordination en route air traffic	3,4	35	-	0	3,86	7	3,6	15	3,38	21
	Approach Control	Supervision & planning approach operations	3,56	34	4	1	3,86	7	3,8	15	3,33	21
		Provision of terminal radar approach control	3,53	34	4	1	3,71	7	3,87	15	3,24	21
	Tower Control	Supervision of tower operations	3,38	34	-	0	4	6	3,73	15	3,2	20
		On the ground aircraft movements control	3,47	34	-	0	3,4	5	3,67	15	3,1	20
		Aircraft landing & taking-off control	3,56	34	-	0	4	6	3,67	15	3,3	20
	Operations	Provision of flight information to VFR traffic	3,38	34	-	0	3,86	7	3,69	13	2,89	18
		Planning and coordination of network capacity	3,3	33	-	0	3,86	7	3,58	12	3,17	18
	ATM	Design, development and evaluation of ATC procedures	3,33	33	4	1	3,71	7	3,56	16	3,05	19
		Design, development and sustainment of ATC systems, product and tools	3,36	33	4	1	3,71	7	3,5	16	2,89	19
		Management of safety of ATC operations	3,38	34	4	1	3,71	7	3,75	16	3,05	19
		Management of air traffic capacity and efficiency	3,5	34	4	1	3,86	7	3,56	16	3,21	19
		Management of interaction of operational controllers with operational environment	3,38	34	4	1	3,67	6	3,56	16	2,94	18

		STUDENTS (1st and 2nd level of bologna) self assessment	Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
ANSP-related Competences	Area Control	Supervision of Area Control Centre operations	1,46	28	-	0	1,14	7	1,3	10	1,58	19
		En route aircraft control	1,54	28	-	0	1,14	7	1,5	10	1,67	18
		Planning & coordination en route air traffic	1,61	28	-	0	1,14	7	1,3	10	1,61	18
	Approach Control	Supervision & planning approach operations	1,63	30	1	1	1,14	7	1,4	10	1,65	17
		Provision of terminal radar approach control	1,6	30	1	1	1,14	7	1,4	10	1,78	18
	Tower Control	Supervision of tower operations	1,59	29	-	0	1,33	6	1,3	10	1,67	18
		On the ground aircraft movements control	1,62	29	-	0	1,33	6	1,3	10	1,72	18
		Aircraft landing & taking-off control	1,69	29	-	0	1,33	6	1,3	10	1,67	18
	Operations	Provision of flight information to VFR traffic	1,48	27	-	0	1,33	6	1,5	10	1,75	16
		Planning and coordination of network capacity	1,52	27	-	0	1,67	6	1,5	10	1,94	16
	ATM	Design, development and evaluation of ATC procedures	1,5	28	1	1	1,33	6	1,4	10	1,58	19
		Design, development and sustainment of ATC systems, product and tools	1,64	28	1	1	1,33	6	1,5	10	1,58	19
		Management of safety of ATC operations	1,62	29	1	1	1,4	5	1,5	10	1,63	19
		Management of air traffic capacity and efficiency	1,72	29	1	1	1,6	5	1,58	12	1,94	18
		Management of interaction of operational controllers with operational environment	1,52	29	1	1	1,2	5	1,75	12	1,56	18

9.2.4 Manufacturer-related Competences

Table 9.17 - Evaluation of Manufacturer related competences by Companies

COMPANIES			Airline		Airport		ANSP		Manufacturer	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
MANUFACTURER-related Competences	Research & Development	Failure assessment and recognition							2,78	9
		Avionics, electronic and electrical systems & EMC							3,13	8
		Customer service							2,56	9
		Fluid mechanics and acoustics							2,11	9
		Propulsion and powerplant							2,11	9
		RAMS, human factors & operability							3,00	7
		Software design & IT							3,63	8
		Structural design							2,33	9
		Test engineering							2,89	9
		Services solutions							2,71	7
		Quality engineering							2,67	9
		Production rigs							2,17	6
	Operations	Airline operations appreciation							2,67	6
		Components and aircraft architecture							3,17	6
		Manufacturing engineering							2,43	7
		Maintenance							2,20	5
		RAMS, human factors & operability							2,80	5
		Governance							2,25	4
		Risk management							3,17	6
		Composites manufacturing and assembly							1,83	6
	Engineering	Aircraft operability and design maturity integration							2,80	5
		Design							3,00	7
		Failure assessment and recognition							2,86	7
		Stress and structures analysis							2,38	8
		Materials and processes							2,57	7
		Systems engineering and architecture							3,43	7
		Airworthiness and certification							3,14	7
		Architecture, integration and in-service support							3,20	5
		Systems & electronics engineering							3,50	6
		Structural & general engineering							2,50	6
		Flight physics							2,20	5
		Configuration management							2,83	6
		Composites design and stress							2,14	7
		Supply management							2,33	6
		Lean experts & supply chain quality field engineering							2,40	5
		Electrical design/integration							3,17	6

Table 9.18 - Evaluation of Manufacturer related competences by Educational Institutions

UNIVERSITIES (1st and 2nd Level of Bologna)			Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
competences taught			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
MANUFACTURER-related Competences	Research & Development	Failure assessment and recognition	0,39	48	0	2	1	1	0,26	18	0,14	7
		Avionics, electronic and electrical systems & EMC	0,53	48	0	2	1	1	0,37	18	0,14	7
		Customer service	0,16	48	0	2	0	1	0,00	18	0,00	7
		Fluid mechanics and acoustics	0,75	48	0,5	2	1	1	0,37	18	0,14	7
		Propulsion and powerplant	0,65	48	0,5	2	1	1	0,48	18	0,14	7
		RAMS, human factors & operability	0,39	48	0	2	0	1	0,16	18	0,00	7
		Software design & IT	0,49	48	0	2	0	1	0,16	18	0,00	7
		Structural design	0,57	48	0,5	2	1	1	0,48	18	0,00	7
		Test engineering	0,47	48	0	2	1	1	0,26	18	0,00	7
		Services solutions	0,14	48	0	2	0	1	0,10	18	0,00	7
		Quality engineering	0,37	48	0	2	0	1	0,16	18	0,14	7
		Production rigs	0,14	48	0,5	2	0	1	0,21	18	0,00	7
	Operations	Airline operations appreciation	0,31	48	0	2	0	1	0,05	18	0,14	7
		Components and aircraft architecture	0,53	48	0	2	1	1	0,37	18	0,29	7
		Manufacturing engineering	0,55	48	0	2	1	1	0,37	18	0,29	7
		Maintenance	0,45	48	0	2	0	1	0,26	18	0,14	7
		RAMS, human factors & operability	0,29	48	0	2	0	1	0,16	18	0,00	7
		Governance	0,16	48	0	2	0	1	0,00	18	0,00	7
		Risk management	0,33	48	0	2	1	1	0,27	18	0,00	7
		Composites manufacturing and assembly	0,51	48	0	2	1	1	0,31	18	0,29	7
	Engineering	Aircraft operability and design maturity integration	0,43	48	0	2	0	1	0,16	18	0,14	7
		Design	0,65	48	0	2	1	1	0,26	18	0,29	7
		Failure assessment and recognition	0,45	48	0	2	1	1	0,27	18	0,14	7
		Stress and structures analysis	0,65	48	0,5	2	1	1	0,48	18	0,14	7
		Materials and processes	0,71	48	0,5	2	1	1	0,48	18	0,29	7
		Systems engineering and architecture	0,63	48	0	2	1	1	0,42	18	0,14	7
		Airworthiness and certification	0,51	48	0	2	1	1	0,11	18	0,14	7
		Architecture, integration and in-service support	0,37	48	0	2	0	1	0,05	18	0,14	7
		Systems & electronics engineering	0,53	48	0	2	1	1	0,48	18	0,14	7
		Structural & general engineering	0,59	48	0	2	1	1	0,32	18	0,14	7
		Flight physics	0,76	48	0	2	1	1	0,37	18	0,14	7
		Configuration management	0,31	48	0	2	1	1	0,16	18	0,00	7
		Composites design and stress	0,61	48	0	2	1	1	0,21	18	0,14	7
		Supply management	0,35	48	0	2	0	1	0,05	18	0,14	7
		Lean experts & supply chain quality field engineering	0,27	48	0	2	0	1	0,05	18	0,00	7
		Electrical design/integration	0,45	48	0	2	1	1	0,21	18	0,14	7

Table 9.19 - Evaluation of Manufacturer related competences by Employees

	EMPLOYEES relevancy		Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
MANUFACTURER-related Competences	Research & Development	Failure assessment and recognition	2,83	6	2,29	7			2,33	3		
		Avionics, electronic and electrical systems & EMC	2,00	4	2,17	6			3,00	3		
		Customer service	1,25	4	2,00	7			2,33	3		
		Fluid mechanics and acoustics	2,33	6	2,67	6			2,50	4		
		Propulsion and powerplant	2,17	6	2,43	7			2,25	4		
		RAMS, human factors & operability	1,50	4	2,43	7			2,50	4		
		Software design & IT	2,50	4	1,67	6			2,60	5		
		Structural design	3,00	6	2,33	6			2,40	5		
		Test engineering	3,00	6	2,67	6			2,80	5		
		Services solutions	1,75	4	1,86	7			2,00	5		
		Quality engineering	2,25	4	2,17	6			2,80	5		
		Production rigs	2,25	4	1,67	6			1,50	4		
	Operations	Airline operations appreciation	2,00	2	1,83	6			1,00	4		
		Components and aircraft architecture	4,00	2	2,83	6			2,40	5		
		Manufacturing engineering	3,50	2	2,60	5			3,00	4		
		Maintenance	3,50	2	2,33	6			1,00	4		
		RAMS, human factors & operability	2,00	2	2,17	6			1,75	4		
		Governance	2,00	2	1,83	6			1,25	4		
		Risk management	3,00	2	2,40	5			1,80	5		
		Composites manufacturing and assembly	3,00	2	1,80	5			2,00	5		
	Engineering	Aircraft operability and design maturity integration	2,33	6	2,00	4			1,33	6		
		Design	2,88	8	2,50	4			2,67	6		
		Failure assessment and recognition	2,75	8	3,00	5			2,20	5		
		Stress and structures analysis	2,71	7	2,50	4			2,40	5		
		Materials and processes	2,71	7	2,50	4			2,80	5		
		Systems engineering and architecture	2,50	8	3,00	5			2,80	5		
		Airworthiness and certification	2,50	6	2,00	4			1,60	5		
		Architecture, integration and in-service support	2,50	4	2,20	5			1,83	6		
		Systems & electronics engineering	2,75	4	2,20	5			1,60	5		
		Structural & general engineering	3,00	6	3,00	3			1,83	6		
		Flight physics	2,50	4	2,00	5			1,80	5		
		Configuration management	2,50	6	3,20	5			1,80	5		
		Composites design and stress	2,83	6	2,00	4			2,00	6		
		Supply management	1,75	4	2,40	5			1,33	6		
		Lean experts & supply chain quality field engineering	1,75	4	1,80	5			1,00	4		
		Electrical design/integration	2,00	4	2,40	5			1,00	5		

	EMPLOYEES self assessment while students		Aerospace/Aeronautica		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
MANUFACTURER-related Competences	Research & Development	Failure assessment and recognition	2,60	5	1,75	4			1,25	4		
		Avionics, electronic and electrical systems & EMC	3,00	3	1,00	5			1,80	5		
		Customer service	1,33	3	1,33	3			1,00	4		
		Fluid mechanics and acoustics	3,20	5	2,71	7			2,20	5		
		Propulsion and powerplant	3,00	5	1,80	5			1,60	5		
		RAMS, human factors & operability	2,00	3	1,25	4			1,50	4		
		Software design & IT	2,75	4	2,00	6			2,20	5		
		Structural design	3,00	5	2,40	5			1,80	5		
		Test engineering	1,80	5	1,57	7			2,00	4		
		Services solutions	1,67	3	1,00	4			1,50	4		
		Quality engineering	1,67	3	1,40	5			1,80	5		
		Production rigs	1,67	3	1,60	5			1,00	4		
	Operations	Airline operations appreciation	3,00	1	1,00	2			1,40	5		
		Components and aircraft architecture	3,50	2	1,50	4			1,80	5		
		Manufacturing engineering	3,00	2	2,17	6			1,80	5		
		Maintenance	3,00	2	1,75	4			1,67	3		
		RAMS, human factors & operability	3,00	1	1,00	2			1,25	4		
		Governance	3,00	1	1,00	2			1,00	4		
		Risk management	2,50	2	1,25	4			1,80	5		
		Composites manufacturing and assembly	3,50	2	1,80	5			1,40	5		
	Engineering	Aircraft operability and design maturity integration	2,00	4	1,33	3			1,33	6		
		Design	2,83	6	2,40	5			2,00	6		
		Failure assessment and recognition	2,50	6	1,75	4			1,00	5		
		Stress and structures analysis	3,14	7	2,40	5			2,00	6		
		Materials and processes	3,00	5	2,20	5			2,00	6		
		Systems engineering and architecture	2,20	5	1,75	4			1,83	6		
		Airworthiness and certification	1,50	4	1,67	3			1,33	6		
		Architecture, integration and in-service support	2,00	3	1,00	2			1,00	5		
		Systems & electronics engineering	2,33	3	1,00	2			1,00	5		
		Structural & general engineering	3,20	5	2,50	4			1,50	6		
		Flight physics	3,00	4	1,33	3			1,40	5		
		Configuration management	2,00	4	1,33	3			1,00	5		
		Composites design and stress	2,80	5	1,80	5			1,67	6		
		Supply management	1,67	3	1,00	2			1,00	5		
		Lean experts & supply chain quality field engineering	1,67	3	1,00	2			1,00	5		
		Electrical design/integration	2,67	3	1,00	2			1,00	5		

Table 9.20 - Evaluation of Manufacturer related competences by Students

STUDENTS (1nd and 2nd level of bologna)		relevancy	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
MANUFACTURER-related Competences	Research & Development	Failure assessment and recognition	3,57	35	4,00	1	3,5	8	3,67	15	3,45	22
		Avionics, electronic and electrical systems & EMC	3,49	35	4,00	1	3,86	7	3,63	16	3,29	24
		Customer service	3,26	35	2,00	1	3,43	7	3,47	15	2,96	23
		Fluid mechanics and acoustics	3,40	35	4,00	1	3,86	7	3,57	14	3,22	23
		Propulsion and powerplant	3,49	35	4,00	1	3,86	7	3,57	14	3,35	23
		RAMS, human factors & operability	3,53	36	4,00	1	3,86	7	3,47	15	3,22	23
		Software design & IT	3,46	35	4,00	1	3,75	8	3,67	15	3,00	24
		Structural design	3,44	34	4,00	1	4	7	3,50	14	3,35	23
		Test engineering	3,54	35	4,00	1	3,86	7	3,87	15	3,30	23
		Services solutions	3,46	35	4,00	1	3,71	7	3,67	15	3,00	23
		Quality engineering	3,59	34	4,00	1	3,71	7	3,60	15	3,38	24
		Production rigs	3,29	35	4,00	1	3,43	7	3,46	13	2,90	20
	Operations	Airline operations appreciation	3,42	33	-	0	3,67	6	3,47	15	3,05	20
		Components and aircraft architecture	3,45	33	4,00	1	3,5	6	3,67	15	3,40	20
		Manufacturing engineering	3,53	34	4,00	1	3,67	6	3,73	15	3,30	20
		Maintenance	3,60	35	4,00	1	4	6	3,80	15	3,32	19
		RAMS, human factors & operability	3,35	34	4,00	1	3,83	6	3,67	15	3,15	20
		Governance	3,18	34	2,00	1	3,67	6	3,29	14	2,95	19
		Risk management	3,54	35	4,00	1	3,83	6	3,67	15	3,36	22
		Composites manufacturing and assembly	3,44	34	4,00	1	3,67	6	3,67	15	3,37	19
	Engineering	Aircraft operability and design maturity integration	3,48	33	4,00	1	3,71	7	3,38	16	3,18	22
		Design	3,37	35	4,00	1	3,57	7	3,31	16	3,14	22
		Failure assessment and recognition	3,46	35	4,00	1	3,86	7	3,59	17	3,29	21
		Stress and structures analysis	3,56	34	4,00	1	4	7	3,75	16	3,36	22
		Materials and processes	3,54	35	4,00	1	3,71	7	3,69	16	3,23	22
		Systems engineering and architecture	3,53	34	4,00	1	3,88	8	3,65	17	3,26	23
		Airworthiness and certification	3,58	31	4,00	1	3,71	7	3,56	16	3,18	22
		Architecture, integration and in-service support	3,27	45	3,00	1	3,43	7	3,71	17	3,17	12
		Systems & electronics engineering	3,43	46	3,00	1	3,86	7	3,81	16	3,27	11
		Structural & general engineering	3,48	46	4,00	1	3,86	7	3,67	15	3,18	11
		Flight physics	3,55	47	3,00	1	3,71	7	3,73	15	3,08	13
		Configuration management	3,28	46	3,00	1	3,43	7	3,43	14	3,00	10
		Composites design and stress	3,51	45	4,00	1	3,57	7	3,40	15	2,91	11
		Supply management	3,22	46	3,00	1	3,57	7	3,53	15	3,18	11
		Lean experts & supply chain quality field engineering	3,17	46	4,00	1	3,71	7	3,43	14	3,18	11
		Electrical design/integration	3,37	46	3,00	1	3,57	7	3,64	14	3,08	12

STUDENTS (1st and 2nd level of bologna)		self assessment	Aerospace/Aeronautical		Mechanical		Civil		Other Engineering		Other non-engineering	
			Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.	Average	#Resp.
MANUFACTURER-related Competences	Research & Development	Failure assessment and recognition	2,07	29	2,00	1	1	7	1,92	12	1,71	21
		Avionics, electronic and electrical systems & EMC	2,30	30	2,00	1	1,17	6	1,85	13	1,78	23
		Customer service	1,62	29	1,00	1	1	6	1,55	11	1,48	21
		Fluid mechanics and acoustics	2,40	30	3,00	1	1,17	6	1,82	11	1,77	22
		Propulsion and powerplant	2,33	30	2,00	1	1,17	6	1,82	11	1,81	21
		RAMS, human factors & operability	2,17	30	1,00	1	1	6	1,55	11	1,71	21
		Software design & IT	2,25	28	2,00	1	1	7	2,07	15	1,52	21
		Structural design	2,41	29	3,00	1	1,83	6	1,82	11	1,82	22
		Test engineering	2,24	29	2,00	1	1,5	6	2,00	12	1,57	23
		Services solutions	1,97	29	1,00	1	1	6	1,75	12	1,52	21
		Quality engineering	2,23	31	2,00	1	1,33	6	2,00	11	1,70	23
		Production rigs	1,66	29	1,00	1	1	6	1,33	9	1,42	19
	Operations	Airline operations appreciation	1,81	27	-	0	1,4	5	1,55	11	1,72	18
		Components and aircraft architecture	2,43	28	1,00	1	1	5	1,60	10	1,83	18
		Manufacturing engineering	2,31	29	2,00	1	1	5	1,64	11	1,63	16
		Maintenance	2,21	29	2,00	1	1,4	5	1,40	10	1,75	16
		RAMS, human factors & operability	2,04	27	2,00	1	1	5	1,30	10	1,59	17
		Governance	1,78	27	1,00	1	1,2	5	1,22	9	1,60	15
		Risk management	1,97	29	1,00	1	1,4	5	1,58	12	1,63	19
		Composites manufacturing and assembly	2,14	29	3,00	1	1	5	1,30	10	1,72	18
	Engineering	Aircraft operability and design maturity integration	2,29	28	1,00	1	1,17	6	1,64	11	1,67	21
		Design	2,30	30	2,00	1	1,67	6	1,55	11	1,67	21
		Failure assessment and recognition	2,27	30	2,00	1	1	6	1,83	12	1,65	20
		Stress and structures analysis	2,48	29	3,00	1	1,83	6	1,82	11	1,75	20
		Materials and processes	2,63	30	2,00	1	1,83	6	1,73	11	1,70	20
		Systems engineering and architecture	2,43	30	1,00	1	1,29	7	2,08	13	1,55	22
		Airworthiness and certification	2,34	29	1,00	1	1,17	6	1,55	11	1,71	21
		Architecture, integration and in-service support	2,10	40	-	0	1,17	6	1,45	11	1,27	11
		Systems & electronics engineering	2,29	41	-	0	1	6	1,85	13	1,27	11
		Structural & general engineering	2,78	41	-	0	1,5	6	1,80	10	1,27	11
		Flight physics	2,84	43	-	0	1,17	6	1,75	12	1,42	12
		Configuration management	2,05	38	-	0	1,17	6	1,44	9	1,10	10
		Composites design and stress	2,44	41	-	0	1,17	6	1,20	10	1,20	10
		Supply management	1,95	39	-	0	1,17	6	1,20	10	1,80	10
		Lean experts & supply chain quality field engineering	2,05	38	-	0	1	5	1,44	9	1,50	10
		Electrical design/integration	2,03	39	-	0	1	6	1,60	10	1,27	11

10 Annex III – Skill Gaps Graphs

10.1 Employees and Students Skill Gap Assessment

10.1.1 Employees and Aerospace/Aeronautical Engineering Students Skill Gap Assessment

AIRLINES

Figure 10.1 – Evaluation of Skills' relevancy by Airlines Employees and Aerospace/Aeronautical Eng. Students

AIRPORTS

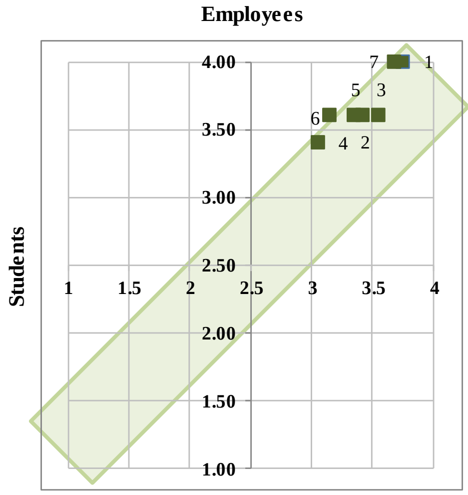


Figure 10.2 - Evaluation of Skills' relevancy by Airport Employees and Aerospace/Aeronautical Eng. Students

ANSPs

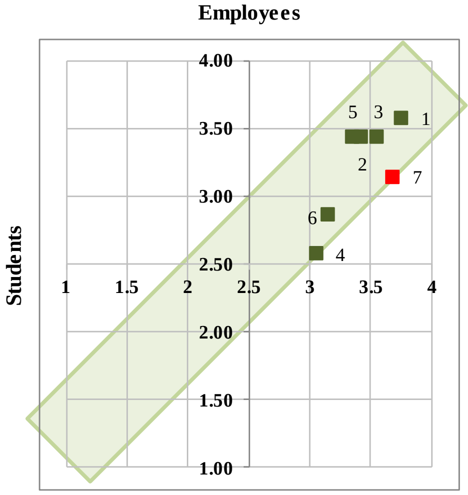


Figure 10.3 - Evaluation of Skills' relevancy by ANSP Employees and Aerospace/Aeronautical Eng. Students

MANUFACTURERS

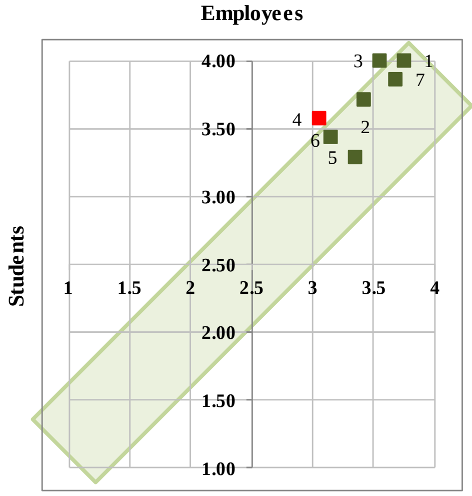


Figure 10.4 - Evaluation of Skills' relevancy by Manufacturing Employees Aerospace/Aeronautical Eng. Students

OTHER COMPANIES

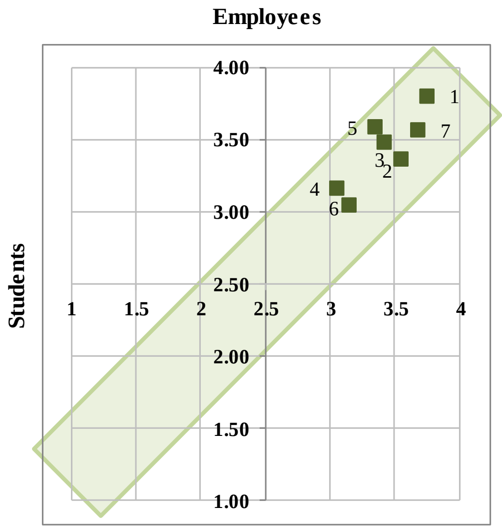


Figure 10.5 - Evaluation of Skills' relevancy by Other Companies Employees and Aerospace/Aeronautical Eng. Students

10.1.2 Employees and Mechanical Engineering Students Skill Gap Assessment

MANUFACTURER

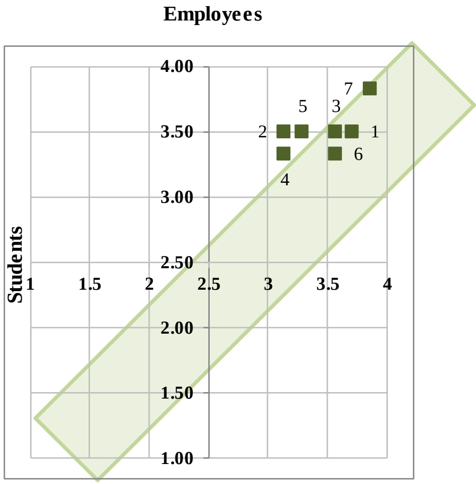


Figure 10.6 – Evaluation of Skills' relevancy by Manufacturer Employees and Mechanical Eng. Students

OTHER COMPANIES

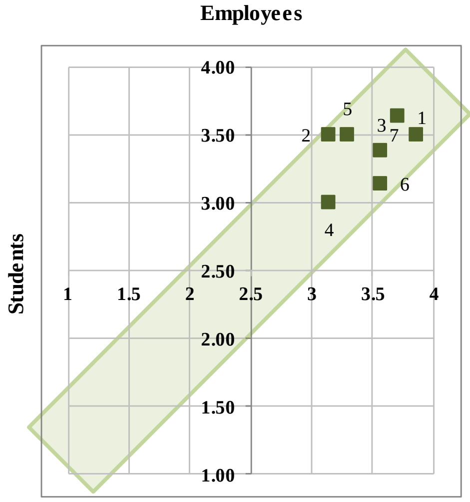


Figure 10.7 - Evaluation of Skills' relevancy by Other Companies and Mechanical Eng. Students

10.1.3 Employees and Civil Engineering Students Skill Gap Assessment

AIRPORT

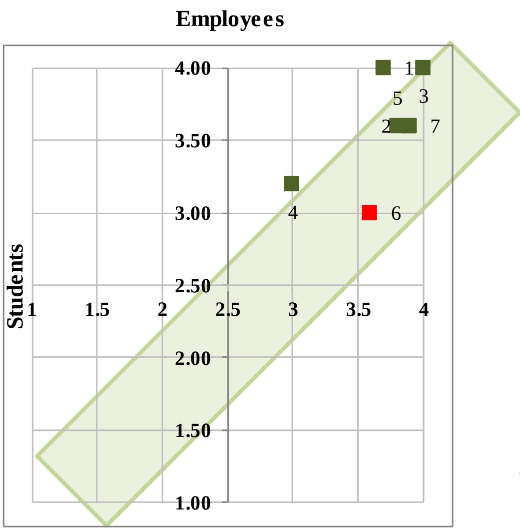


Figure 10.8 – Evaluation of Skills' relevancy by Airport Employees and Civil Eng. Students

ANSP

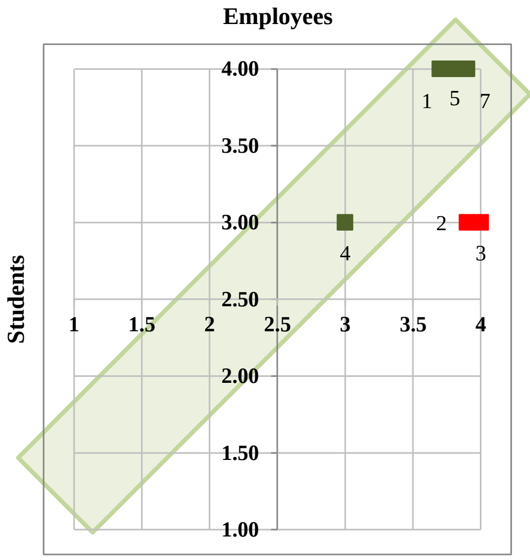


Figure 10.9 - Evaluation of Skills' relevancy by ANSP Employees and Civil Eng. Students

ANSPs

MANUFACTURERS

OTHER COMPANIES

Figure 10.10 - Evaluation of Skills' relevancy by Other Companies Employees and Aerospace/Aeronautical Students

10.1.4 Employees and Other Engineering Students Skill Gap Assessment

AIRLINES

AIRPORTS

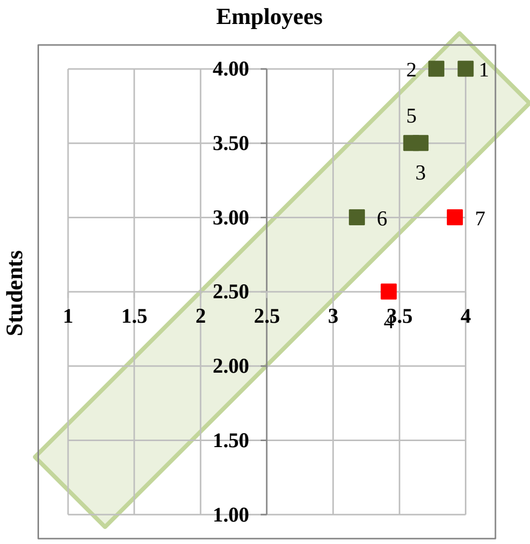


Figure 10.11 – Evaluation of Skills' relevancy by Airlines Employees and Other Eng. Students

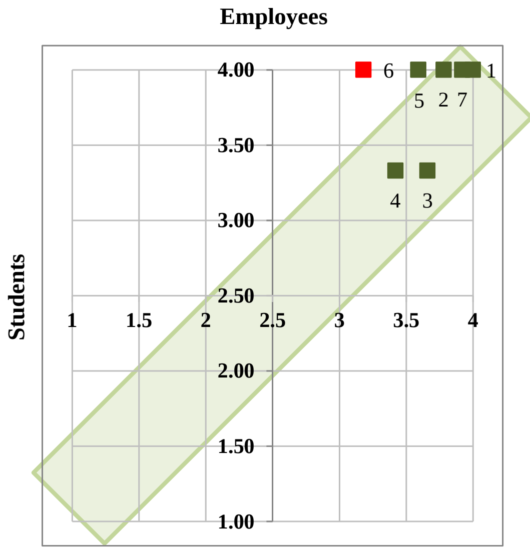


Figure 10.12 - Evaluation of Skills' relevancy by Airport Employees and Other Eng. Students

ANSPs

Figure 10.13 - Evaluation of Skills' relevancy by ANSP Employees and Other Eng. Students

MANUFACTURERS

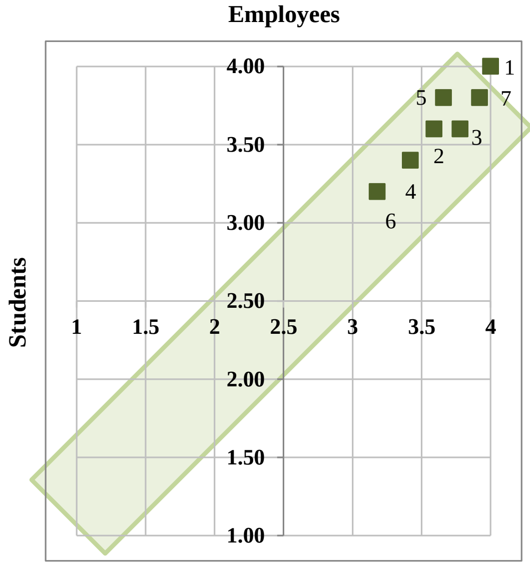


Figure 10.14 - Evaluation of Skills' relevancy by Manufacturing Employees Other Eng. Students

OTHER COMPANIES

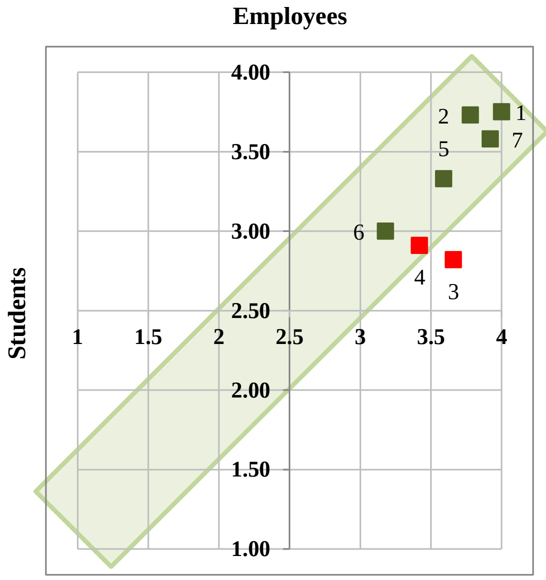


Figure 10.15 - Evaluation of Skills' relevancy by Other Companies Employees and Other Eng. Students

10.1.5 Employees and Other Non-Engineering Students Skill Gap Assessment

AIRLINES

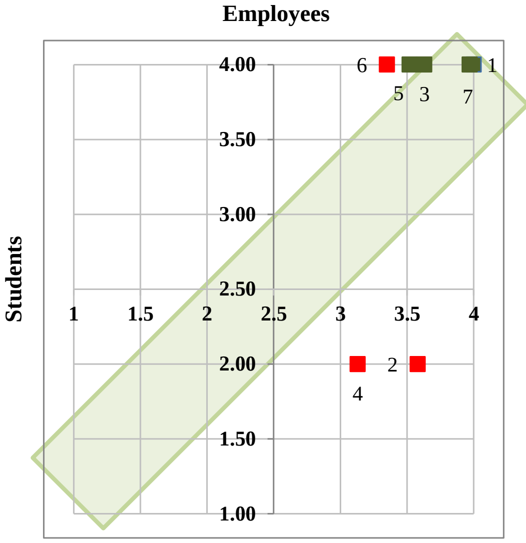


Figure 10.16 – Evaluation of Skills' relevancy by Airlines Employees and Other Non-Eng. Students

AIRPORTS

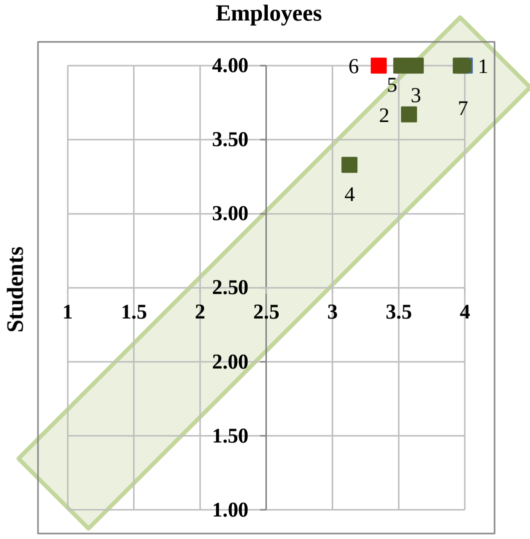


Figure 10.17 - Evaluation of Skills' relevancy by Airport Employees and Other Non-Eng. Students

ANSPs

MANUFACTURERS

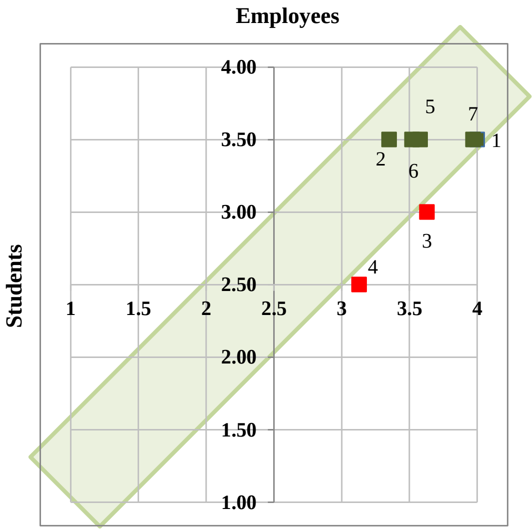


Figure 10.18 - Evaluation of Skills' relevancy by ANSP Employees and Other Non-Eng. Students

Figure 10.19 - Evaluation of Skills' relevancy by Manufacturing Employees Other Non-Eng. Students

OTHER COMPANIES

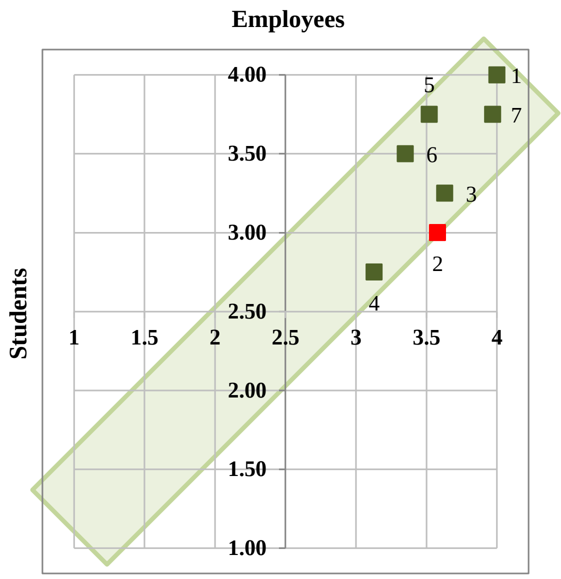


Figure 10.20 - Evaluation of Skills' relevancy by Other Companies Employees and Other Non-Eng. Students

10.2 Companies and Employees Skill Gap Assessment

AIRLINES

AIRPORTS

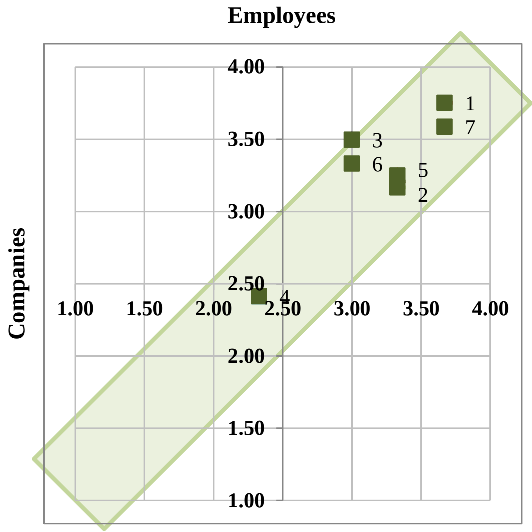


Figure 10.21 – Evaluation of Skills' relevancy by Airlines Companies and Employees

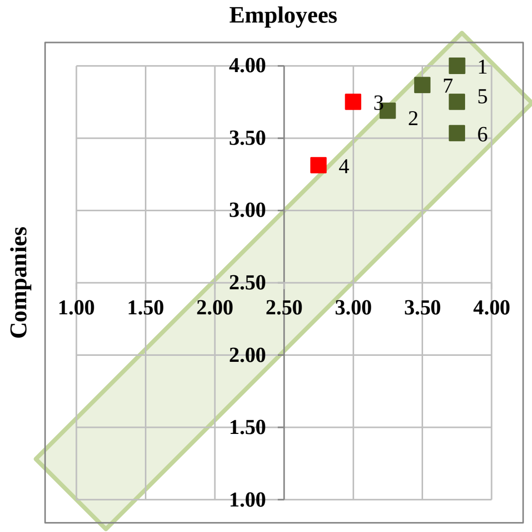


Figure 10.22 - Evaluation of Skills' relevancy by Airport Companies and Employees

ANSPs

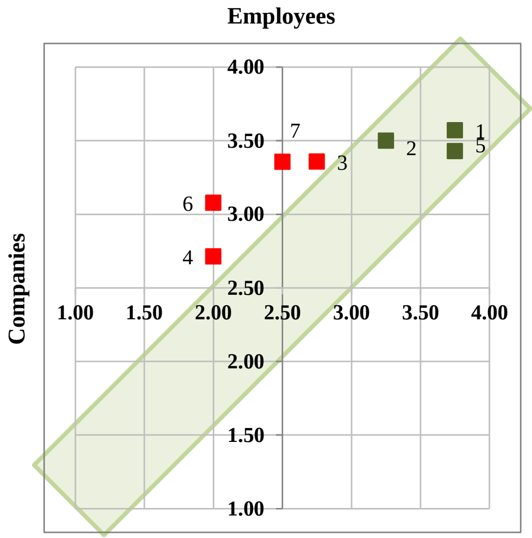


Figure 10.23 - Evaluation of Skills' relevancy by ANSP Companies and Employees

MANUFACTURERS

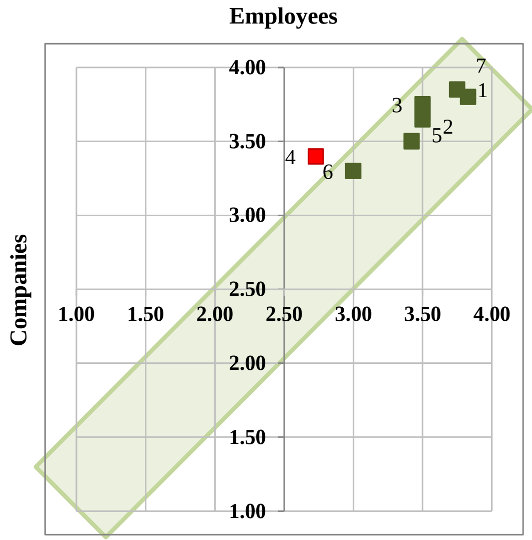


Figure 10.24 - Evaluation of Skills' relevancy by Manufacturing Companies and Employees

ALL

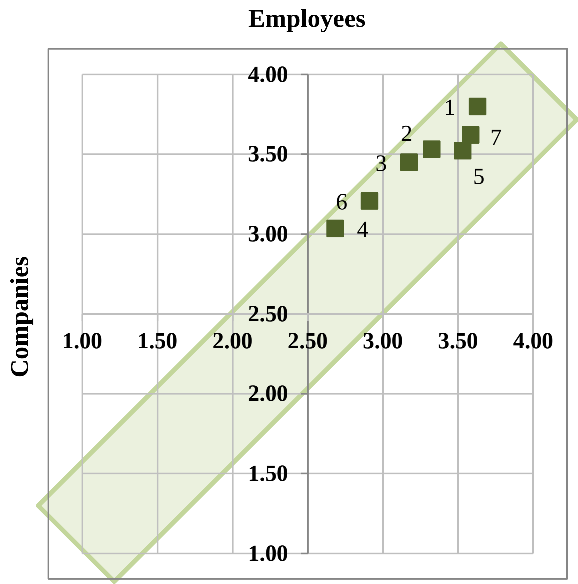


Figure 10.25 - Evaluation of Skills' relevancy by All Companies and Employees

10.3 Educational Institutions and Students Skill Gap Assessment

AEROSPACE & AERONAUTICS

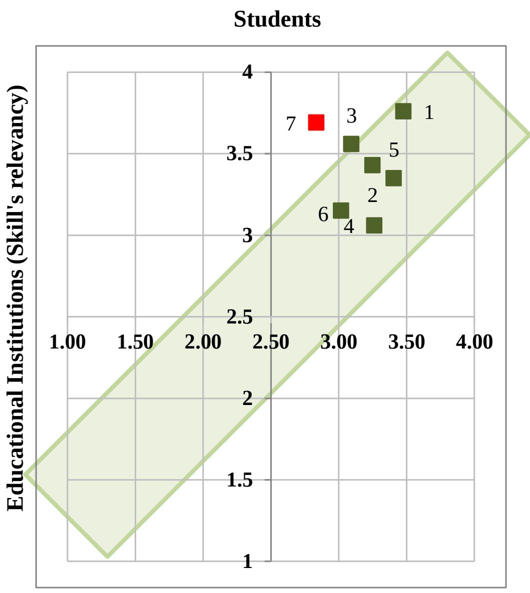


Figure 10.26 – Evaluation of Skills' relevancy by Airlines Employees and Aerospace/Aeronautical Eng. Students

MECHANICAL

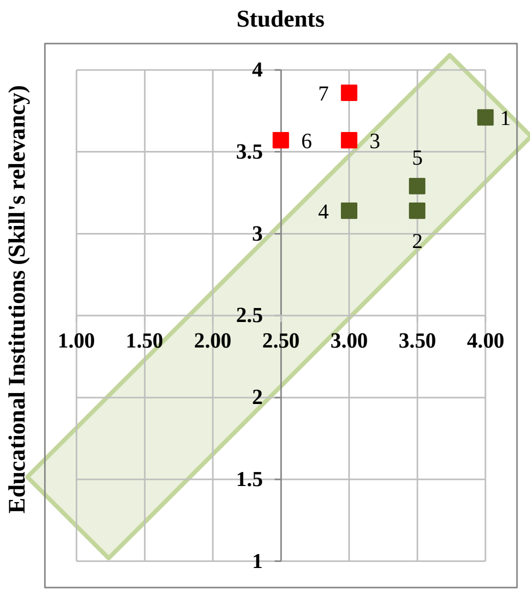


Figure 10.27 - Evaluation of Skills' relevancy by Airport Employees and Aerospace/Aeronautical Eng. Students

OTHER ENGINEERING

NON ENGINEERING

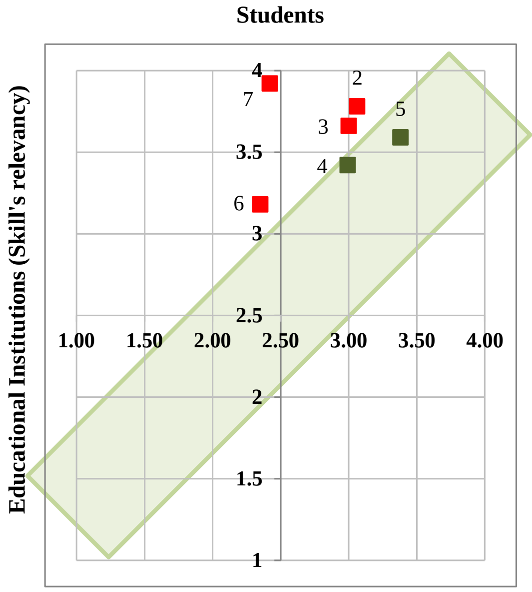


Figure 10.28 - Evaluation of Skills' relevancy by ANSP Employees and Aerospace/Aeronautical Eng. Students

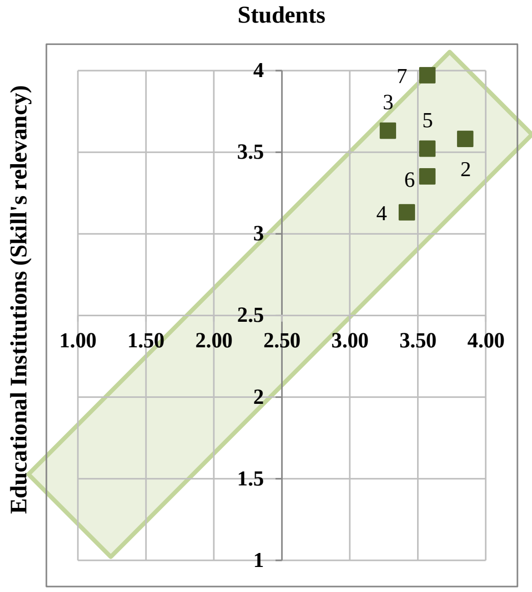


Figure 10.29 - Evaluation of Skills' relevancy by Manufacturing Employees Aerospace/Aeronautical Eng. Students

10.4 Companies and Educational Institutions Skill Gap Assessment

10.4.1 Airlines Companies and Educational Institutions Skill Gap Assessment

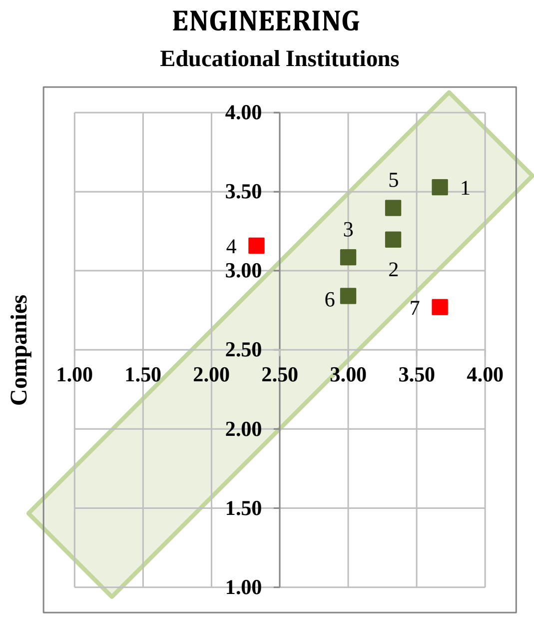


Figure 10.30 – Evaluation of Skills' relevancy by Airlines Companies and Eng. Education Institutions

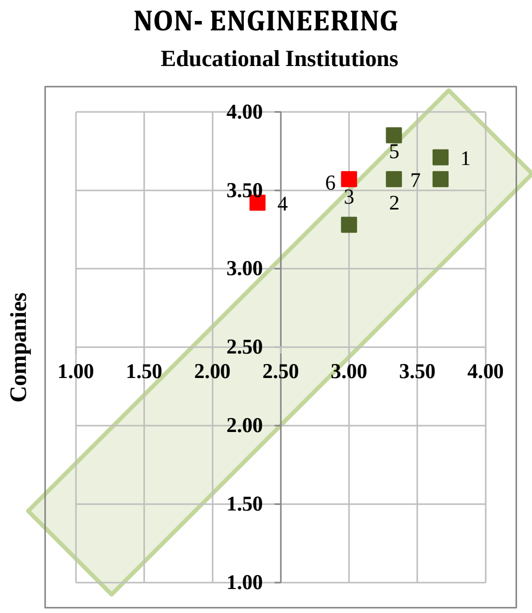


Figure 10.31 - Evaluation of Skills' relevancy by Airlines Companies and Non-Eng. Educational Institutions

10.4.2 Airport Companies and Educational Institutions Skill Gap Assessment

ENGINEERING

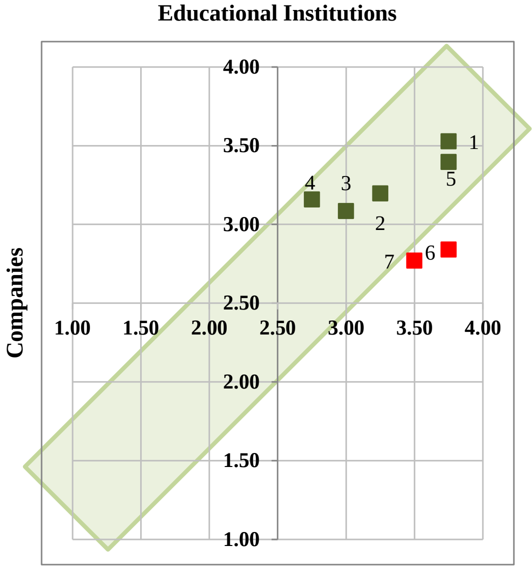


Figure 10.32 – Evaluation of Skills' relevancy by Airport Companies and Eng. Education Institutions

NON- ENGINEERING

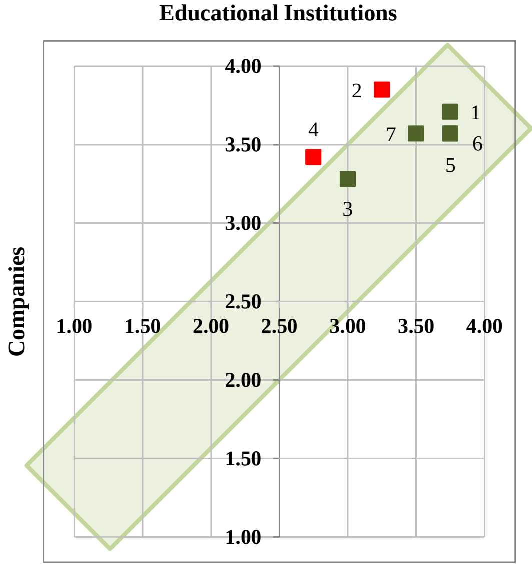


Figure 10.33 - Evaluation of Skills' relevancy by Airport Companies and Non-Eng. Educational Institutions

10.4.3 ANSP Companies and Educational Institutions Skill Gap Assessment

ENGINEERING

NON- ENGINEERING

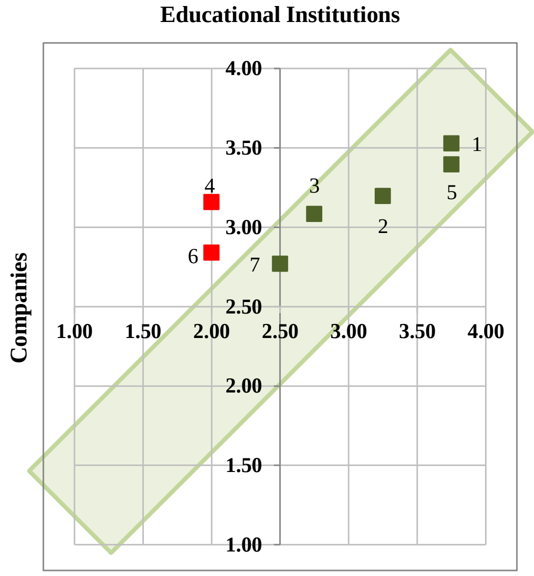


Figure 10.34 – Evaluation of Skills' relevancy by ANSP Companies and Eng. Education Institutions

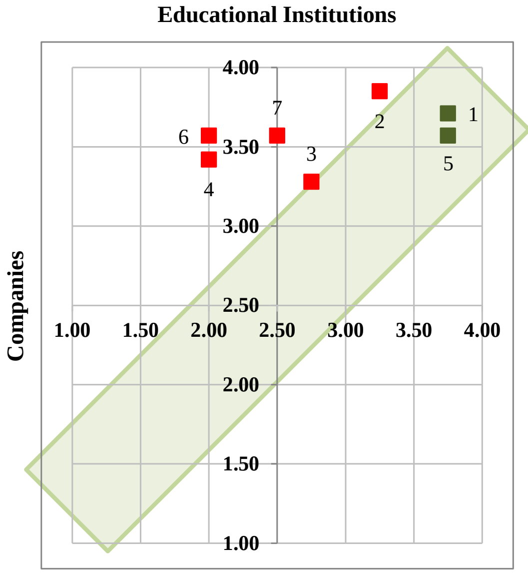


Figure 10.35 - Evaluation of Skills' relevancy by ANSP Companies and Non-Eng. Educational Institutions

10.4.4 Manufacturer Companies and Educational Institutions Skill Gap Assessment

AEROSPACE & AERONAUTICAL ENGINEERING

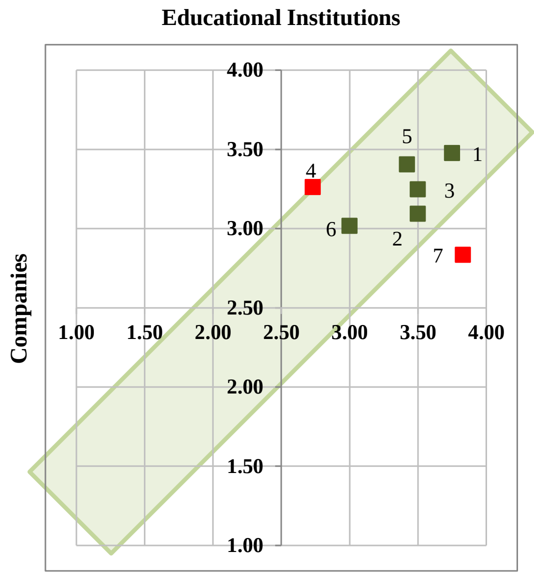


Figure 10.36 – Evaluation of Skills' relevancy by Manufacturer Companies and Aerospace & Aeronautical Eng. Education Institutions

OTHER- ENGINEERING

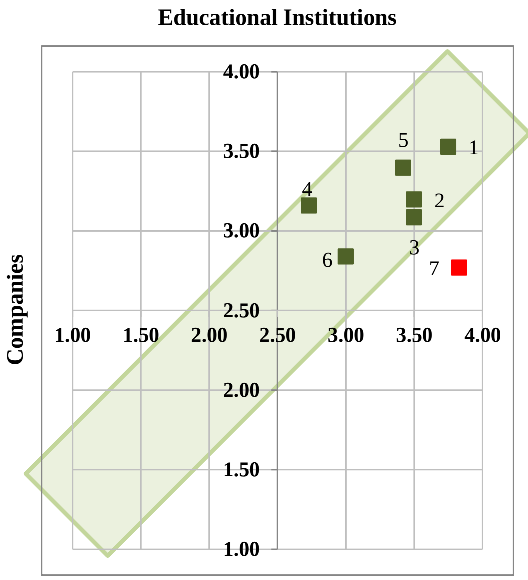


Figure 10.37 - Evaluation of Skills' relevancy by Manufacturer Companies and Eng. Educational Institutions

NON- ENGINEERING

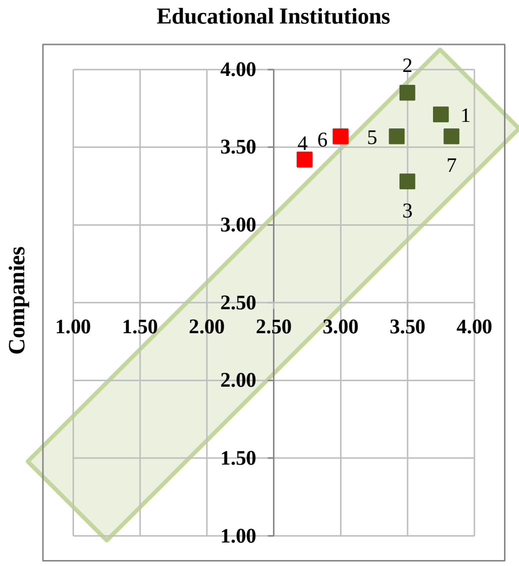


Figure 10.38 - Evaluation of Skills' relevancy by Manufacturer Companies and Non-Eng. Educational Institutions

10.4.5 Other Companies and Educational Institutions Skill Gap Assessment

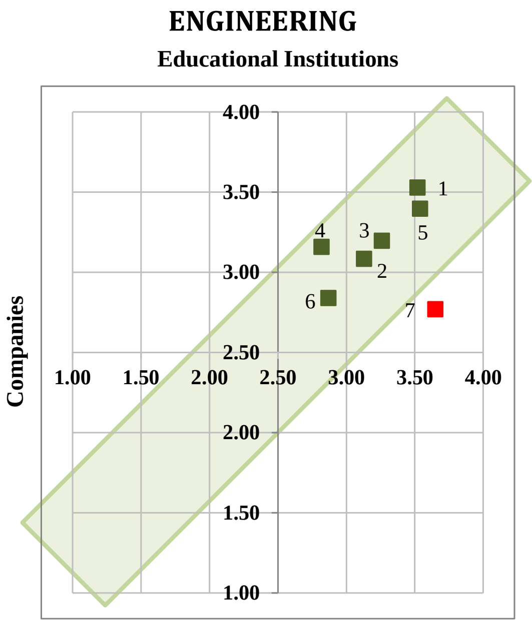


Figure 10.39 – Evaluation of Skills' relevancy by Other Companies and Eng. Education Institutions

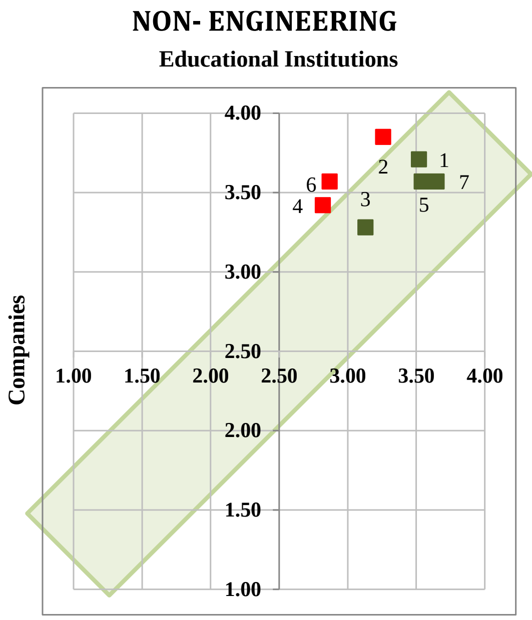
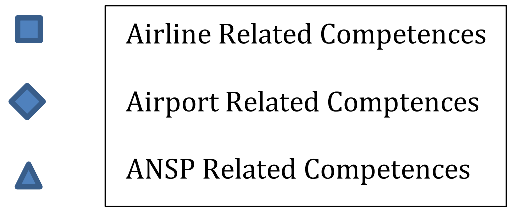


Figure 10.40 - Evaluation of Skills' relevancy by Other Companies and Non-Eng. Educational Institutions

11 Annex IV – Competence Gaps Graphs

11.1 Employees and Students (relevancy) Competences Gap Assessment



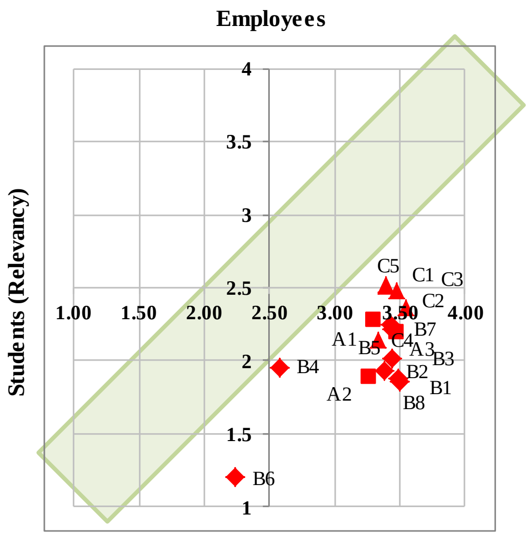


Figure 11.1 - Evaluation of Competences' relevancy by Aerospace/Aeronautical Engineers Employees in Airlines, Airports and ANSP, and Students

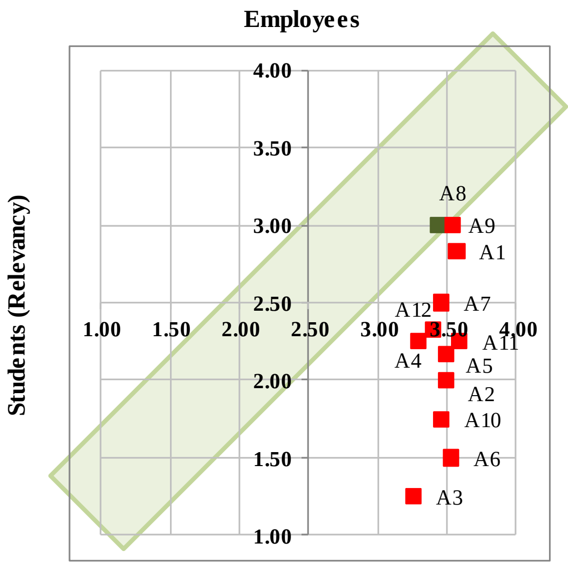


Figure 11.2 - Evaluation of Competences' relevancy by Aerospace/Aeronautical Engineers Employees in Manufacturer Companies (Research & Development) and Students

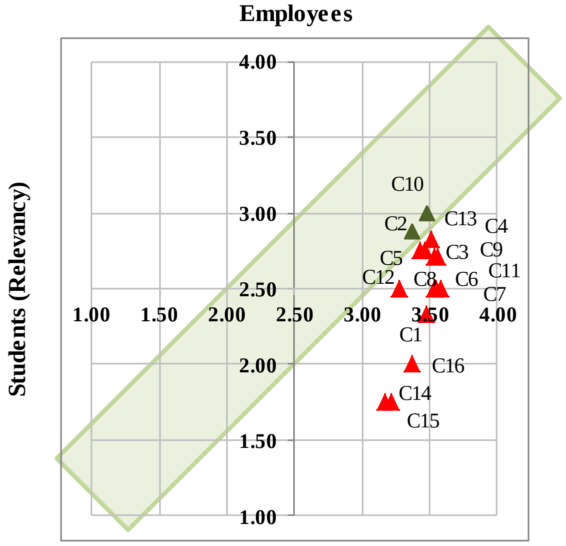


Figure 11.3 - Evaluation of Competences' relevancy by Aerospace/Aeronautical Engineers Employees in Manufacturer Companies (Engineering) and Students

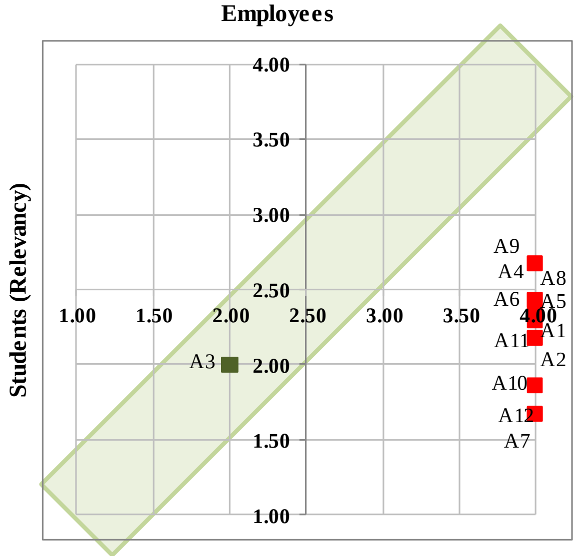


Figure 11.4 - Evaluation of Competences' relevancy by Mechanical Engineers Employees in Manufacturer Companies (Research & Development) and Students

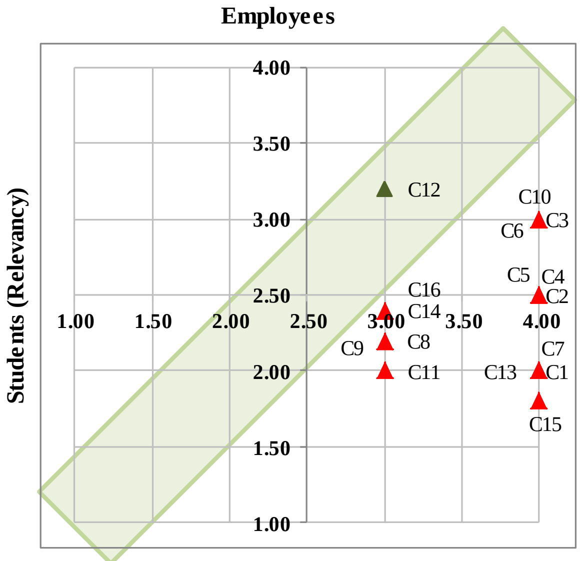


Figure 11.5 - Evaluation of Competences' relevancy by Mechanical Engineers Employees in Manufacturer Companies (Engineering) and Students

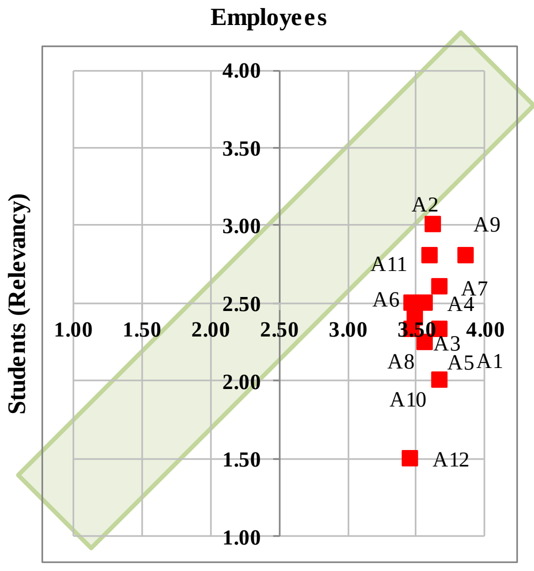


Figure 11.6 - Evaluation of Competences' relevancy by Other Engineers Employees in Manufacturer Companies (Research & Development) and Students

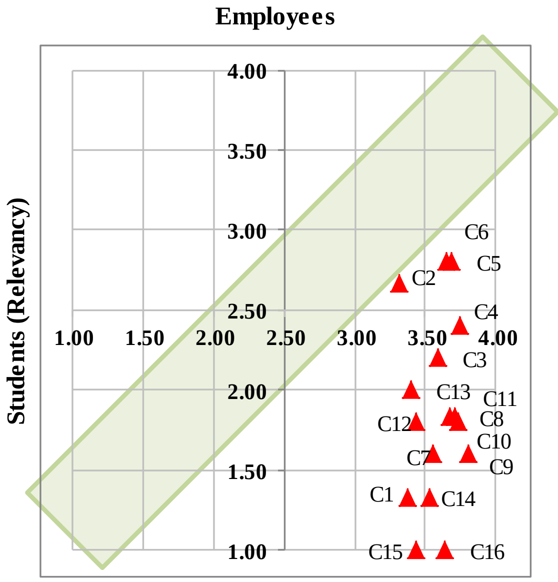


Figure 11.7 - Evaluation of Competences' relevancy by Other Engineers Employees in Manufacturer Companies (Engineering) and Students

11.2 Companies and Employees Competences Gap Assessment

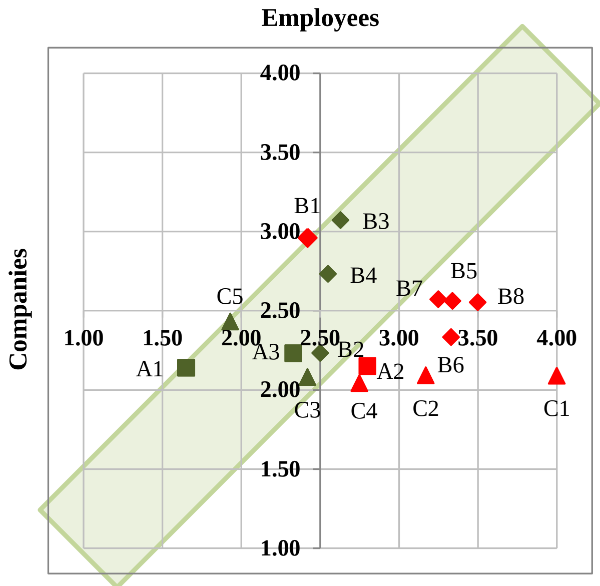


Figure 11.8 - Evaluation of Competences' relevancy by Airlines, Airports and ANSP Companies and Employees

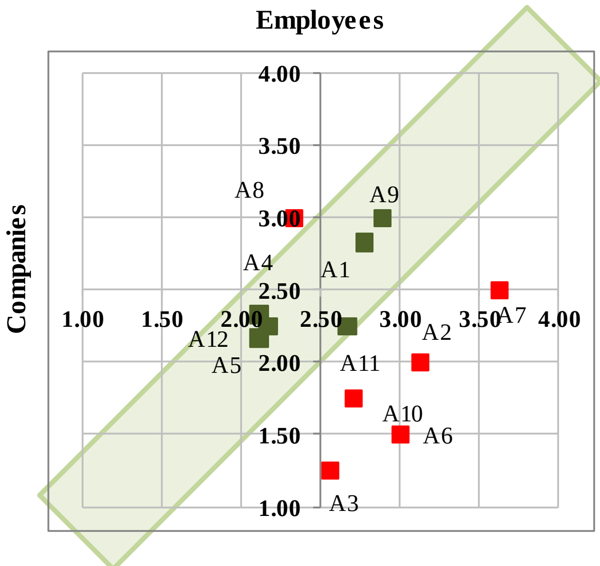


Figure 11.9 - Evaluation of Competences' relevancy by Manufacturers Companies (Research & Development) and Aerospace/Aeronautical Eng. Employees

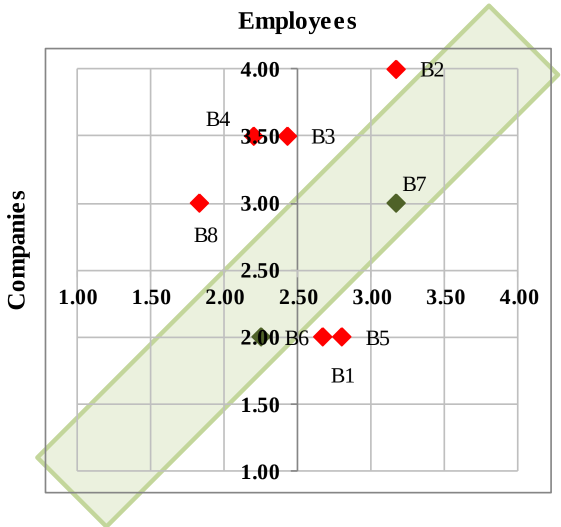


Figure 11.10 - Evaluation of Competences' relevancy by Manufacturers Companies (Operations) and Aerospace/Aeronautical Eng. Employees

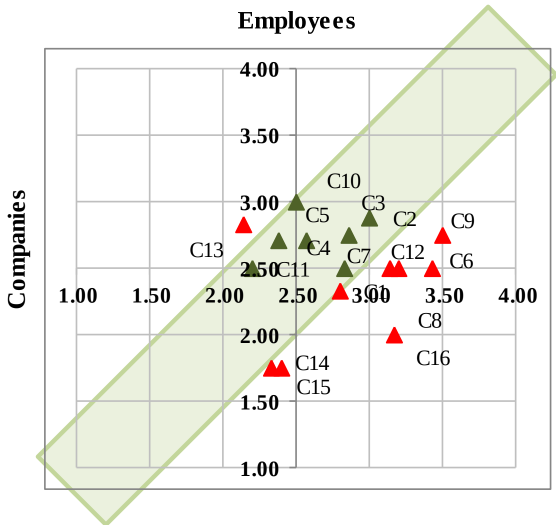


Figure 11.11 - Evaluation of Competences' relevancy by Manufacturers Companies (Engineering) and Aerospace/Aeronautical Eng. Employees

11.3 Educational Institutes and Students (relevancy) Competences Gap Assessment

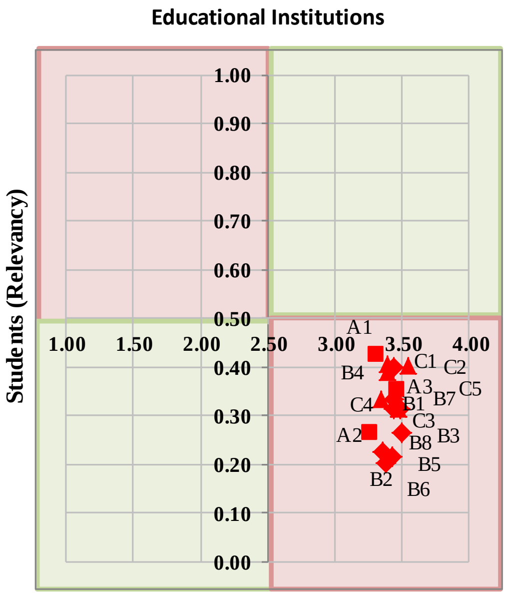


Figure 11.12 - Evaluation of Airlines, Airports and ANSP Competences' relevancy by Aerospace/Aeronautical Eng Students and the competences taught in Education Institutions

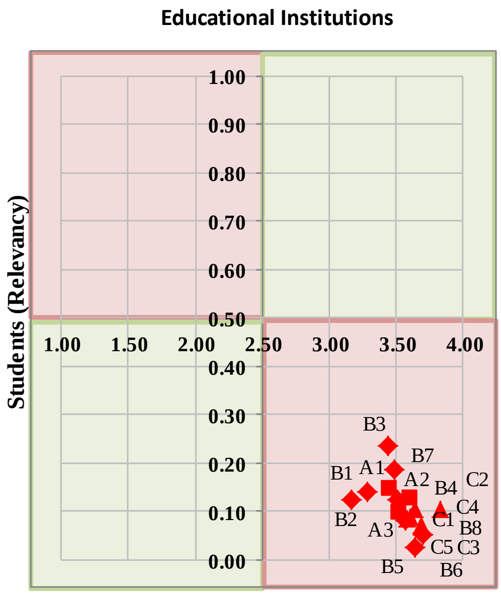


Figure 11.13 – Evaluation of Airlines, Airports and ANSP Competences' relevancy by Other Eng Students and the competences taught in Education Institutions

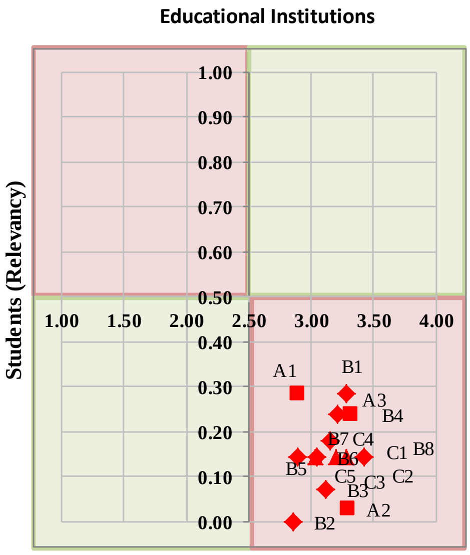


Figure 11.14 - Evaluation of Airlines, Airports and ANSP Competences' relevancy by Non-Eng Students and the competences taught in Education Institutions

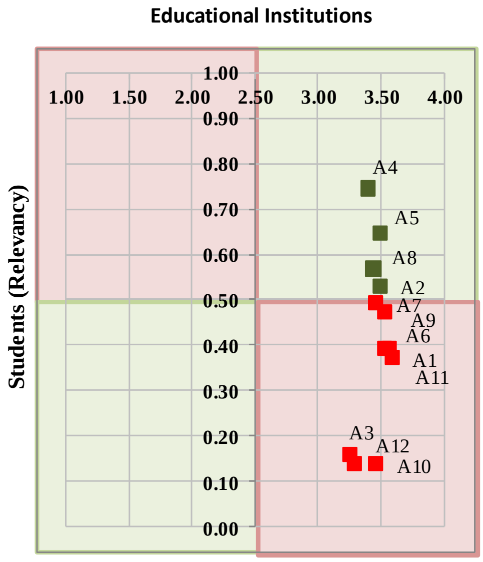


Figure 11.15 - Evaluation of Research & Development Competences' relevancy by Aerospace/Aeronautical Eng Students and the competences taught in Education Institutions

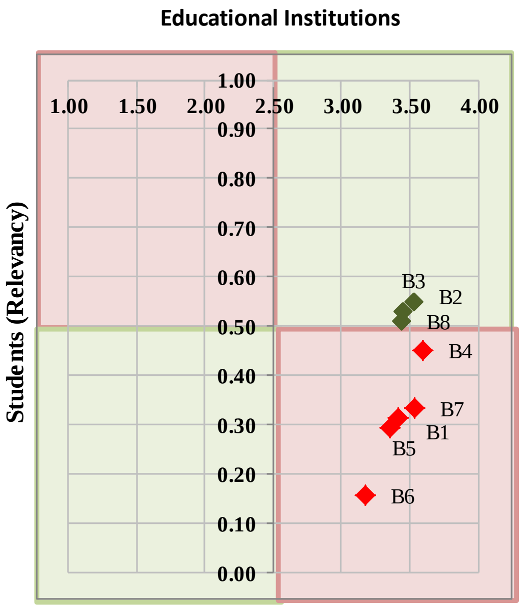


Figure 11.16 - Evaluation of Operations Competences' relevancy by Aerospace/Aeronautical Eng Students and the competences taught in Education Institutions

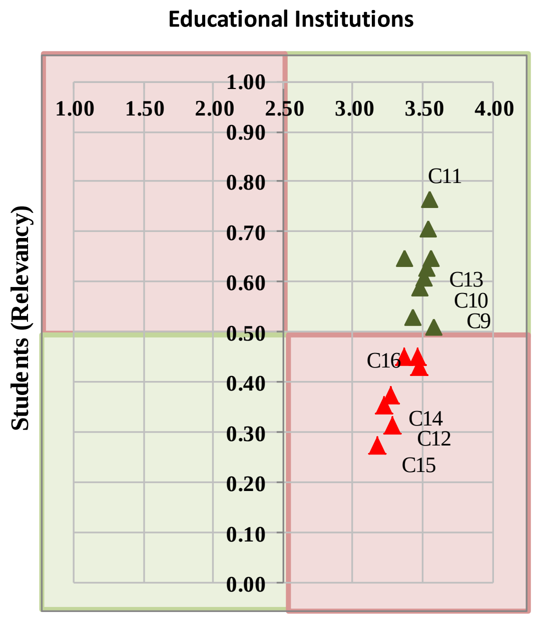


Figure 11.17 - Evaluation of Engineering Competences' relevancy by Aerospace/Aeronautical Eng Students and the competences taught in Education Institutions

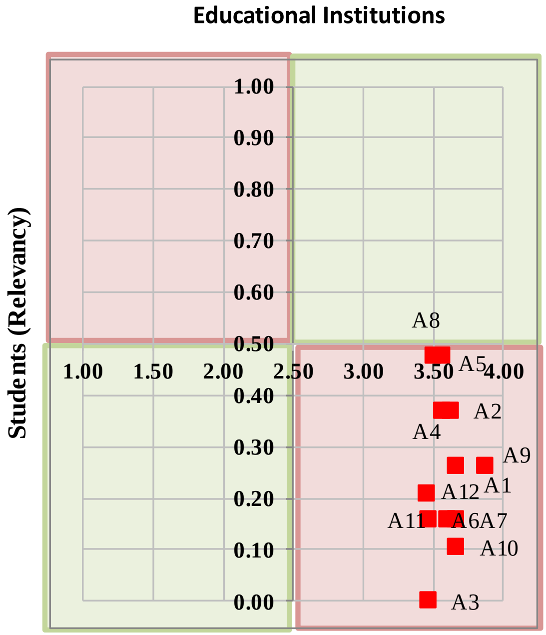


Figure 11.18 - Evaluation of Research & Development Competences' relevancy by Other Eng. Students and the competences taught in Education Institutions

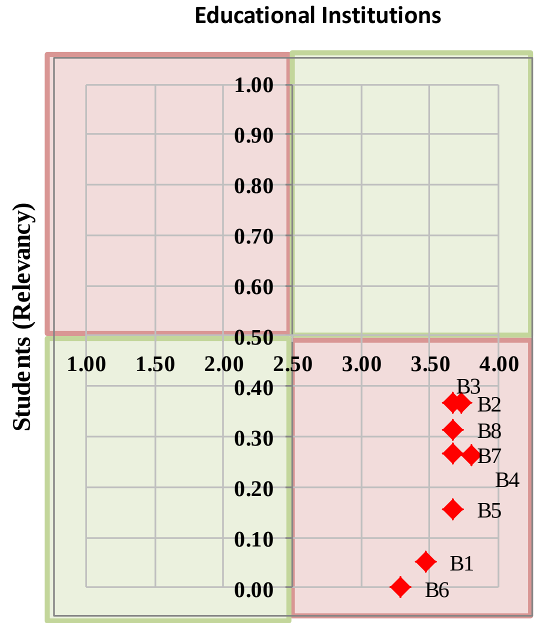


Figure 11.19 – Evaluation of Operations Competences' relevancy by Other Eng. Students and the competences taught in Education Institutions

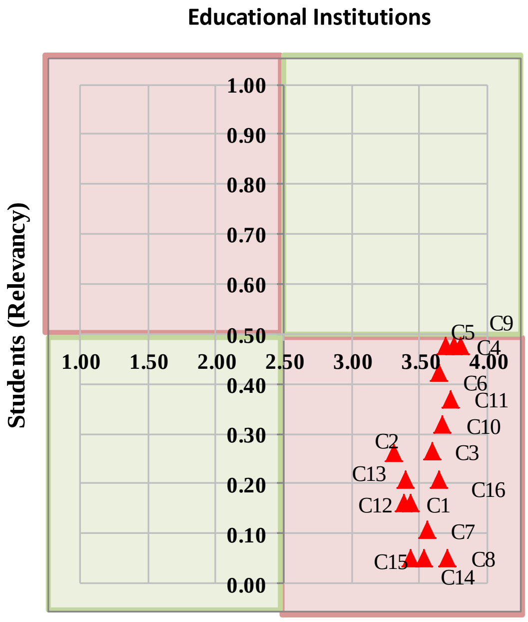


Figure 11.20 - Evaluation of Engineering Competences' relevancy by Other Eng. Students and the competences taught in Education Institutions

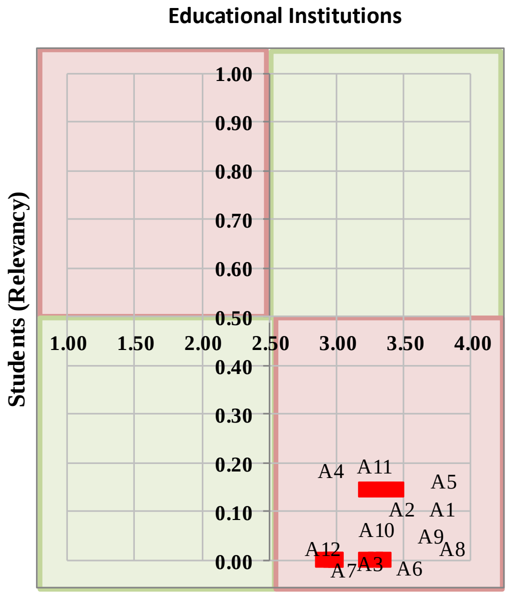


Figure 11.21 – Evaluation of Research & Development Competences' relevancy by Non-Eng. Students and the competences taught in Education Institutions

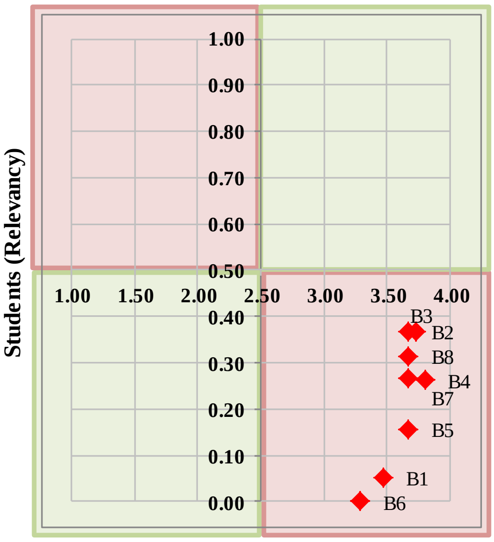


Figure 11.22 - Evaluation of Operations Competences' relevancy by Non-Eng. Students and the competences taught in Education Institutions

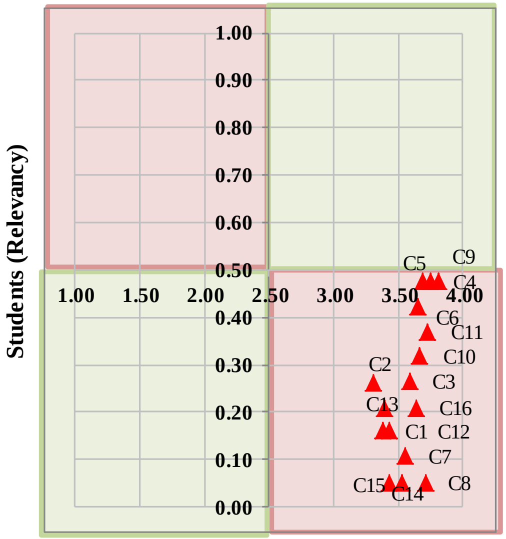


Figure 11.23 – Evaluation of Engineering Competences' relevancy by Non-Eng. Students and the competences taught in Education Institutions

11.4 Companies and Educational Institutes Competences Gap Assessment

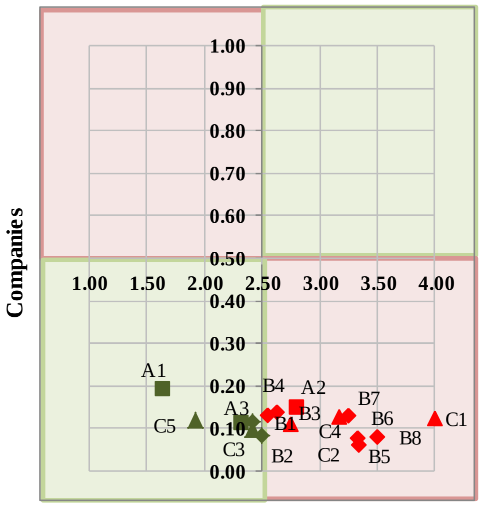


Figure 11.24 - Evaluation of Competences' relevancy by Airlines, Airports and ANSP Companies and the competences taught in Eng. Education Institutions

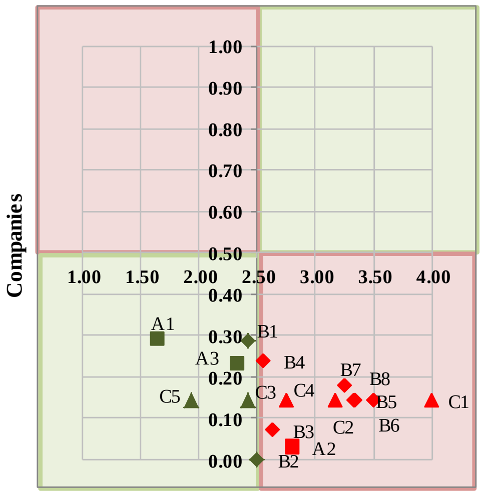


Figure 11.25 - Evaluation of Competences' relevancy by Airlines, Airports and ANSP Companies and the competences taught in Non- Eng. Education Institutions

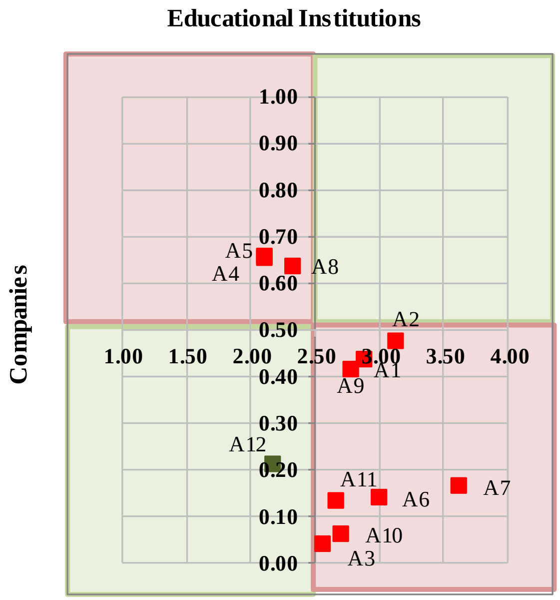


Figure 11.26 - Evaluation of Research & Development Competences' relevancy by Manufacturers Companies and the competences taught in Eng. Education Institutions

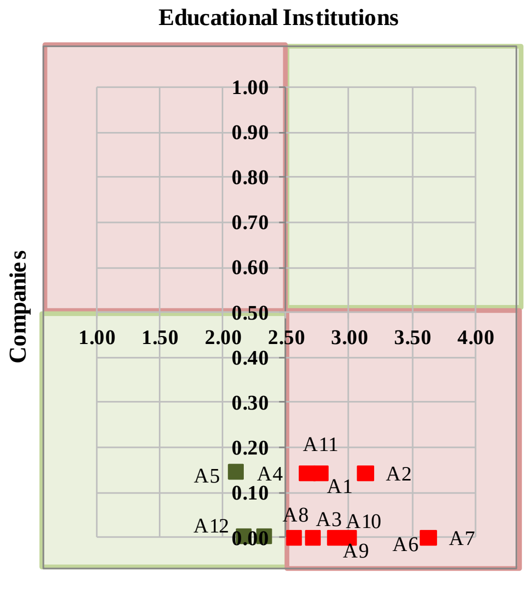


Figure 11.27 - Evaluation of Research & Development Competences' relevancy by Manufacturers Companies and the competences taught in Non- Eng. Education Institutions

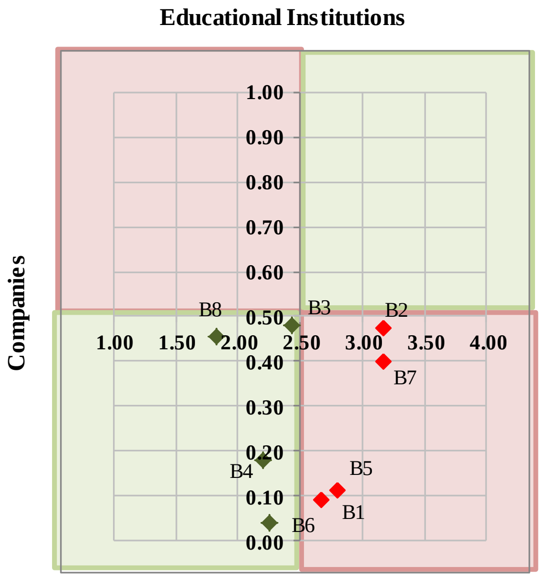


Figure 11.28 - Evaluation of Operations Competences' relevancy by Manufacturers Companies and the competences taught in Eng. Education Institutions

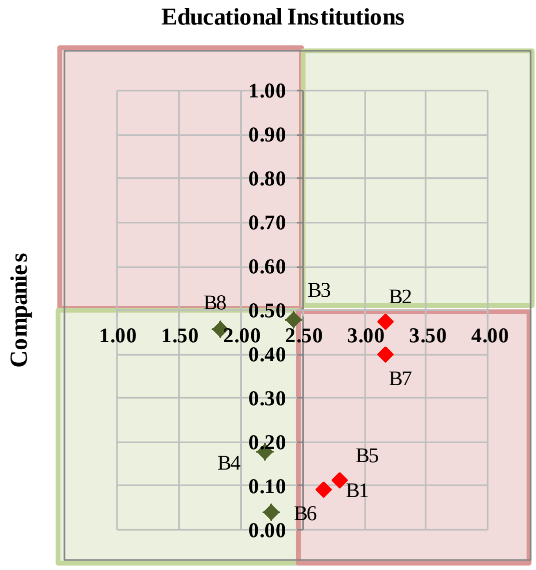


Figure 11.29 - Evaluation of Operations Competences' relevancy by Manufacturers Companies and the competences taught in Non- Eng. Education Institutions

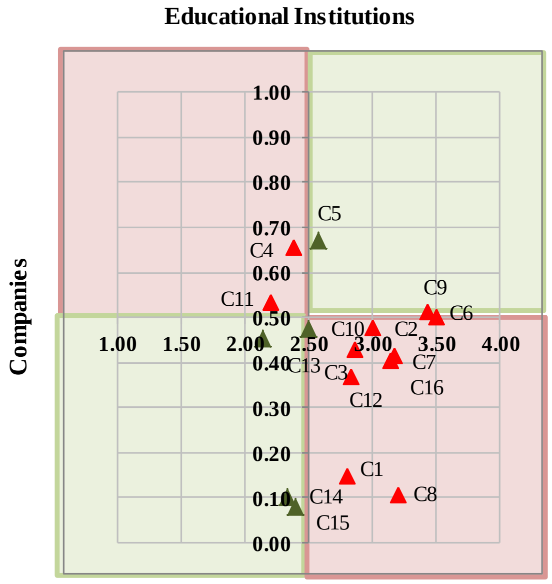


Figure 11.30 - Evaluation of Engineering Competences' relevancy by Manufacturers Companies and the competences taught in Eng. Education Institutions

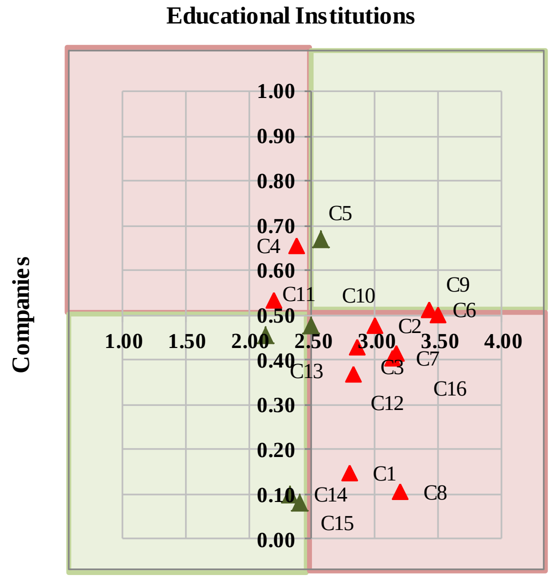


Figure 11.31 - Evaluation of Engineering Competences' relevancy by Manufacturers Companies and the competences taught in Non- Eng. Education Institutions

11.5 Students (self-assessment) Competence Assessment

11.5.1 Students (relevancy) vs. Students (self-assessment) Competence Assessment

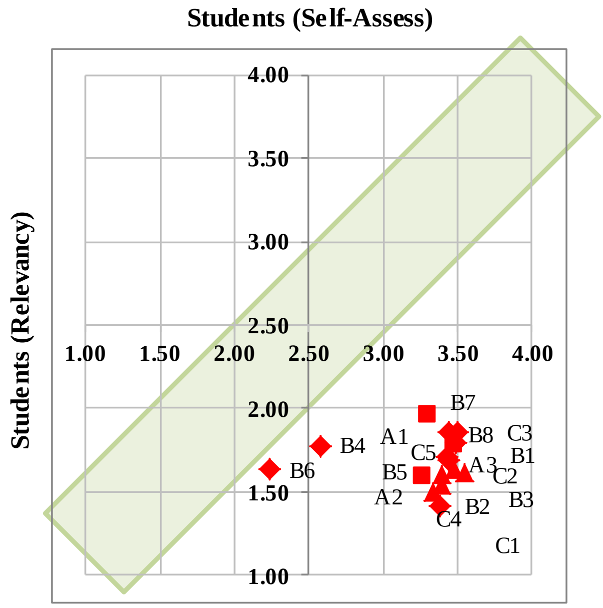


Figure 11.32 - Evaluation of Airlines, Airports and ANSP Competences' relevancy and Self-Asses by Aerospace/Aeronautical Eng Students

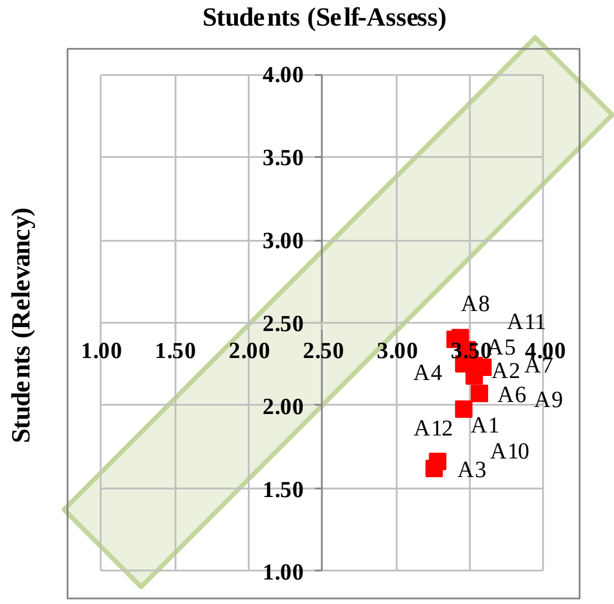


Figure 11.33 - Evaluation of Research & Development competences' relevancy and Self-Asses by Aerospace/Aeronautical Eng Students

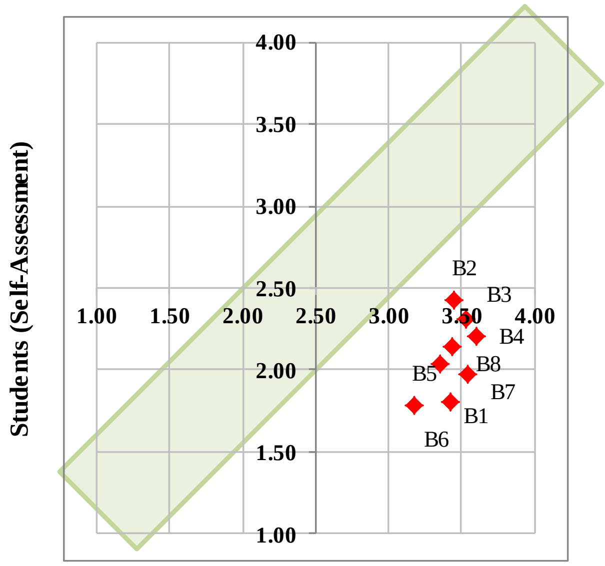


Figure 11.34 - Evaluation of Operations competences' relevancy and Self-Asses by Aerospace/Aeronautical Eng Students

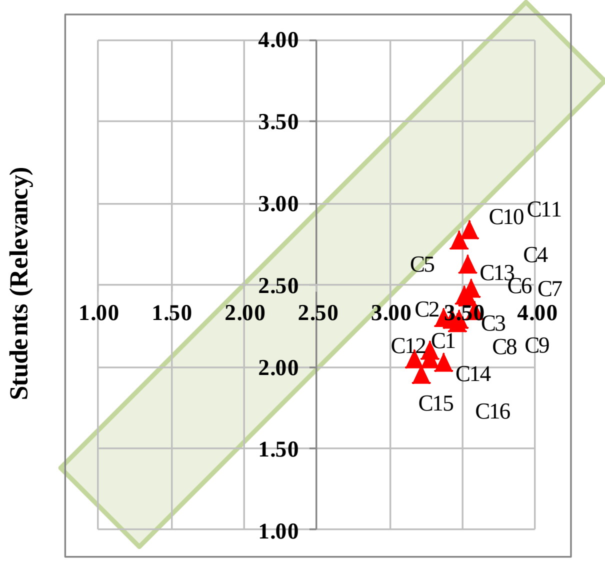


Figure 11.35 - Evaluation of Engineering competences' relevancy and Self-Asses by Aerospace/Aeronautical Eng Students

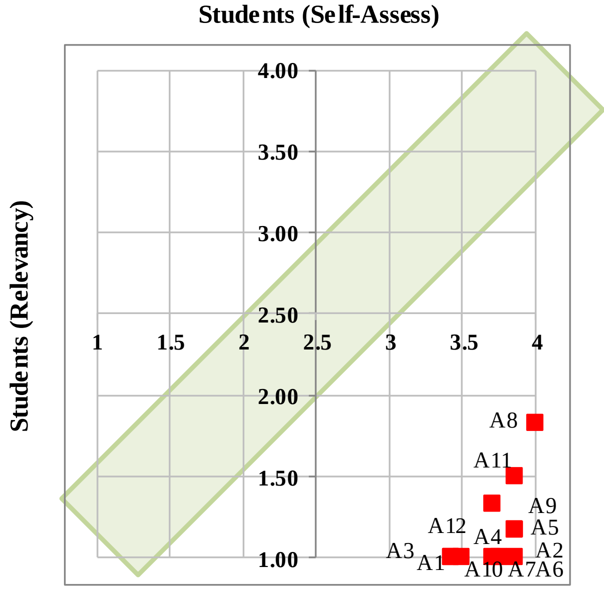


Figure 11.36 - Evaluation of Research & Development competences' relevancy and Self-Asses by Civil Eng Students

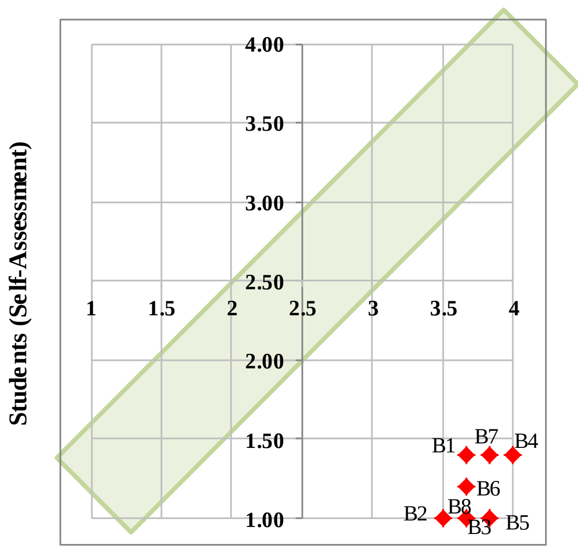


Figure 11.37 - Evaluation of Operations competences' relevancy and Self-Asses by Civil Eng Students

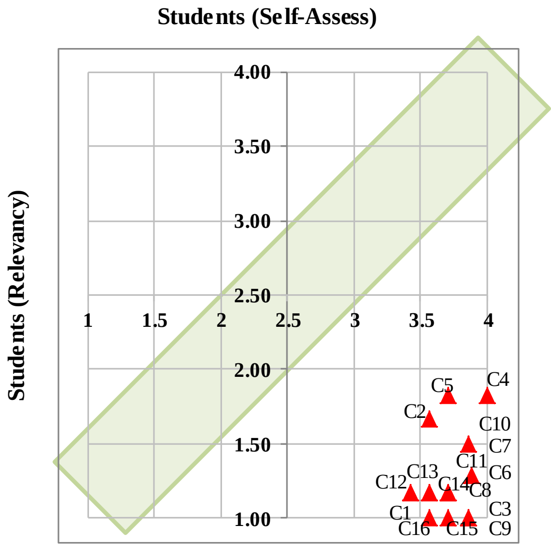


Figure 11.38 - Evaluation of Engineering competences' relevancy and Self-Asses by Civil Eng Students

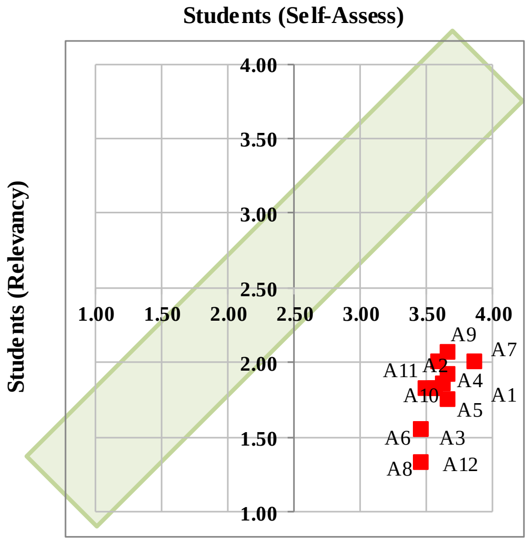


Figure 11.39 - Evaluation of Research & Development competences' relevancy and Self-Asses by Other Eng Students

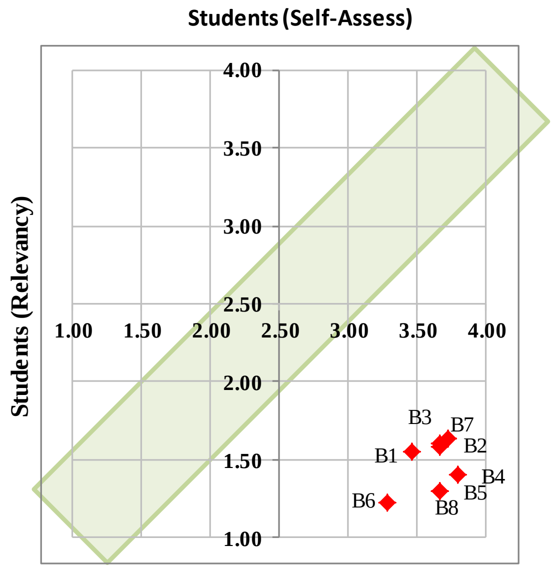


Figure 11.40 - Evaluation of Operations competences' relevancy and Self-Asses by Other Eng Students

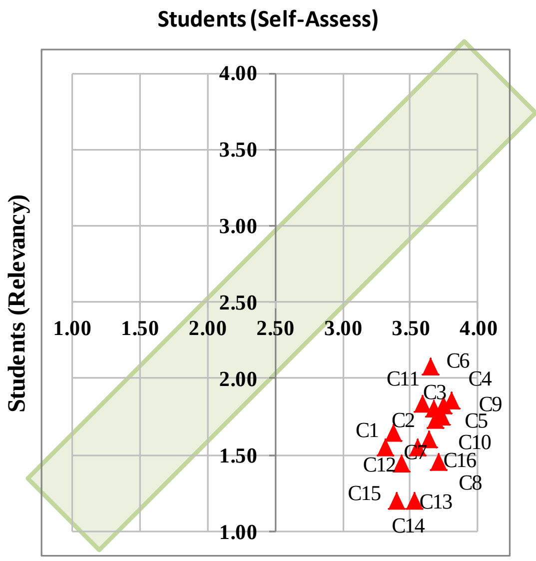


Figure 11.41 - Evaluation of Engineering competences' relevancy and Self-Asses by Other Eng Students

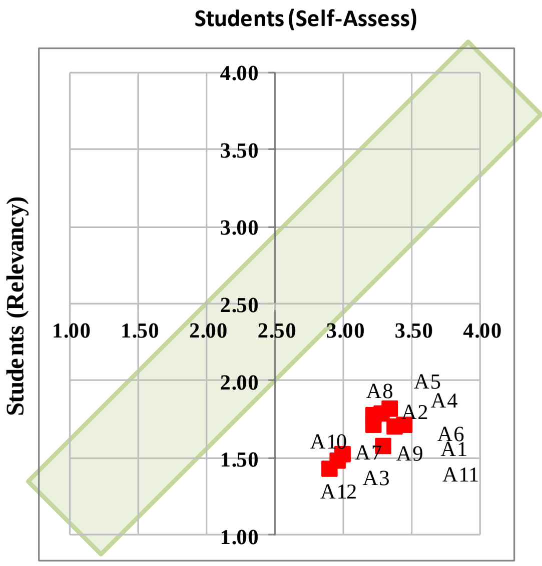


Figure 11.42 - Evaluation of Research & Development competences' relevancy and Self-Asses by Non-Eng. Students

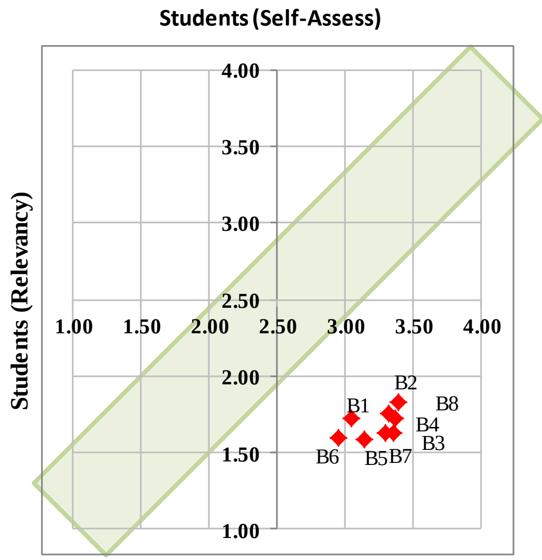


Figure 11.43 - Evaluation of Operations competences' relevancy and Self-Asses by Non-Eng. Students

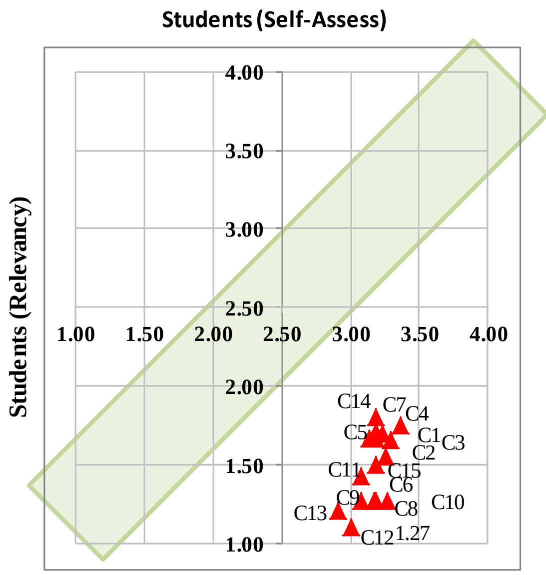


Figure 11.44 - Evaluation of Engineering competences' relevancy and Self-Asses by Non-Eng. Students

11.5.2 Educational Institutions vs. Students (self-assessment) Competence Assessment

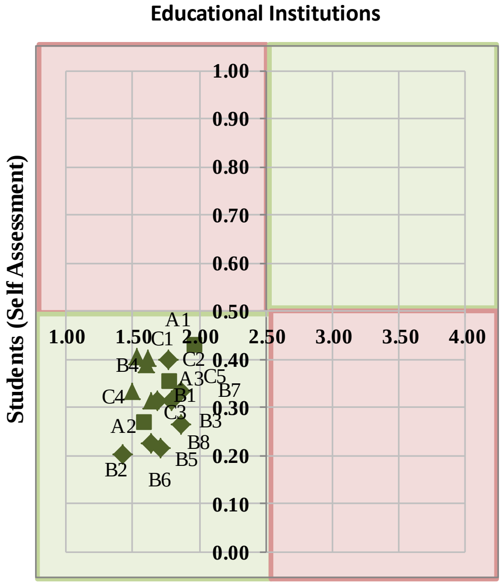


Figure 11.45 - Self Assessment of Airlines, Airports and ANSP Competences by Aerospace/Aeronautical Eng Students and the competences taught in Education Institutions

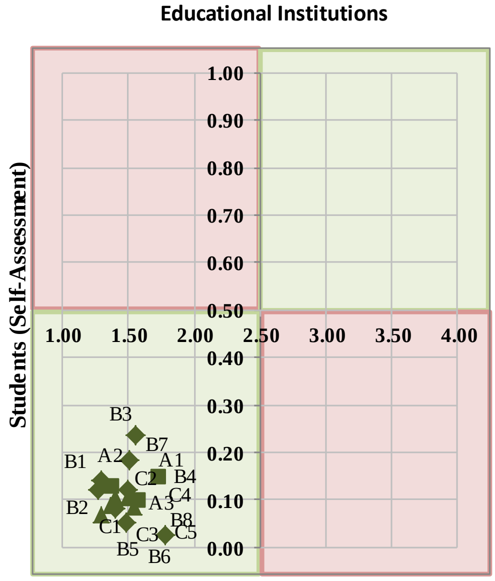


Figure 11.46 – Self-Assess of Airlines, Airports and ANSP Competences' by Other Eng Students and the competences taught in Education Institutions

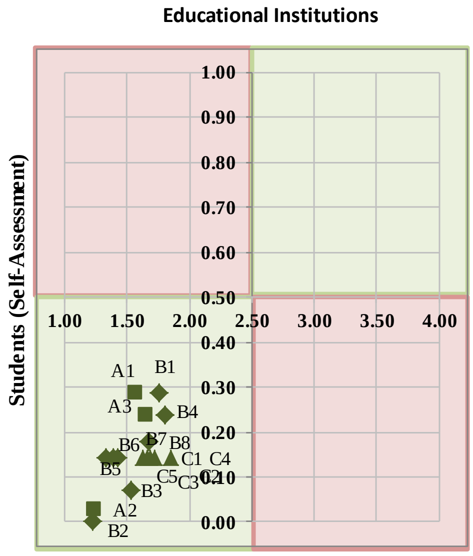


Figure 11.47 - Self-Assess of Airlines, Airports and ANSP Competences' by Non-Eng Students and the competences taught in Education Institutions

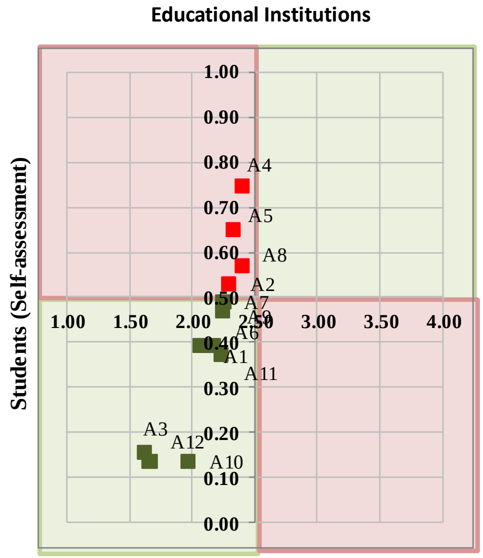


Figure 11.48 - Self-Assess of Research & Development Competences' relevancy by Aerospace/Aeronautical Eng Students and the competences taught in Education Institutions

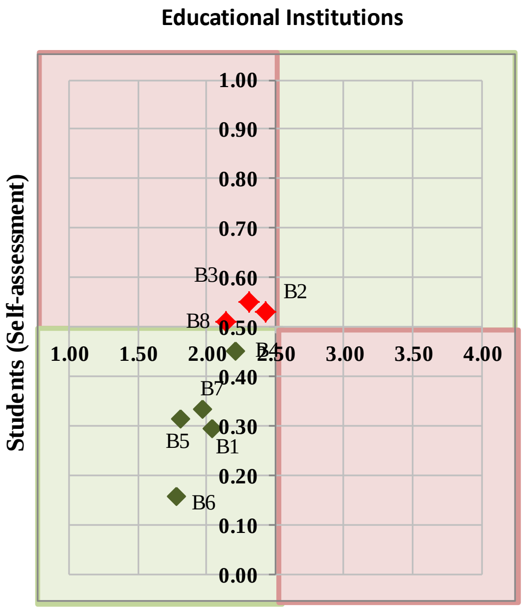


Figure 11.49 - Self-Assess of Operations Competences' by Aerospace/Aeronautical Eng Students and the competences taught in Education Institutions

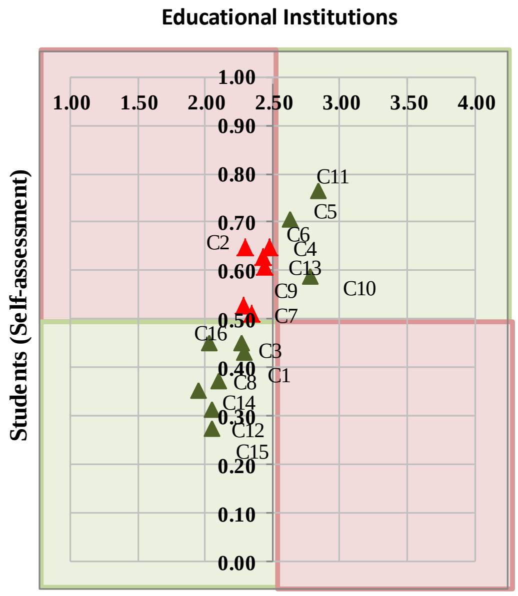


Figure 11.50 - Self-Assess of Engineering Competences' by Aerospace/Aeronautical Eng. Students and the competences taught in Education Institutions

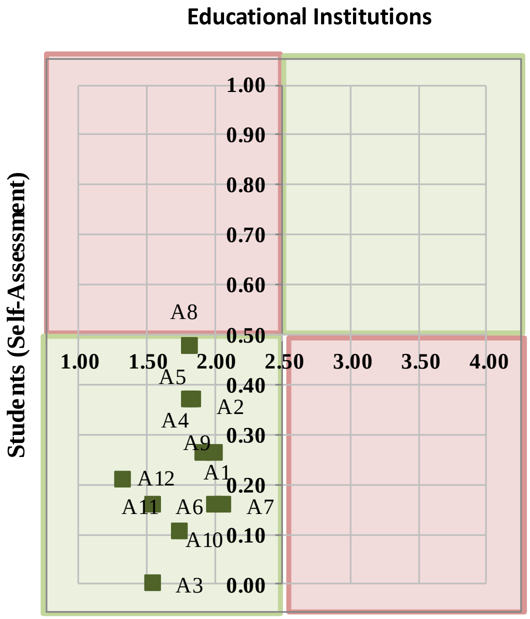


Figure 11.51 - Self-Assess of Research & Development Competences' relevancy by Other Eng. Students and the competences taught in Education Institutions

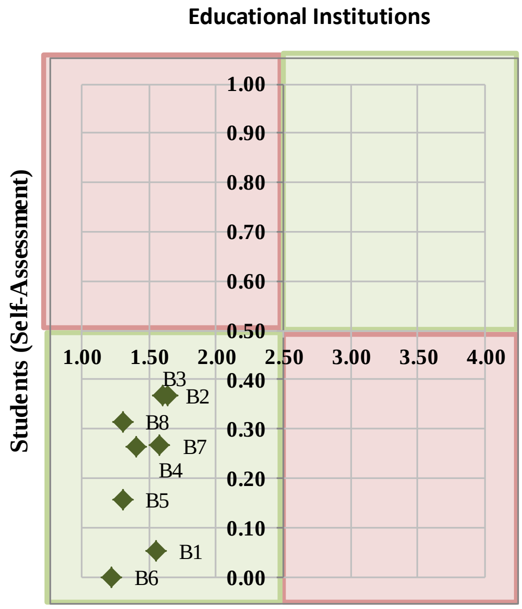


Figure 11.52 – Self-Assess of Operations Competences' relevancy by Other Eng. Students and the competences taught in Education Institutions

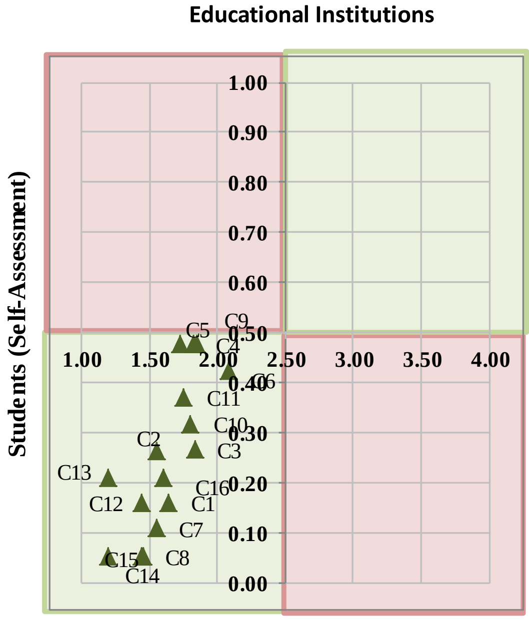


Figure 11.53 - Self-Assess of Engineering Competences' relevancy by Other Eng. Students and the competences taught in Education Institutions

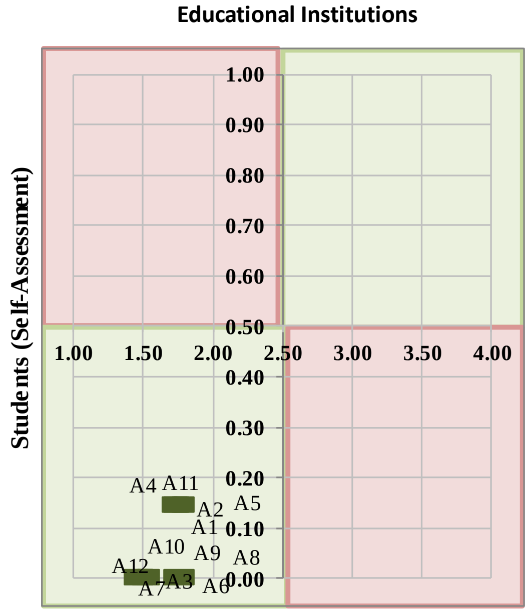


Figure 11.54 – Self-Assess of Research & Development Competences' relevancy by Non-Eng. Students and the competences taught in Education Institutions

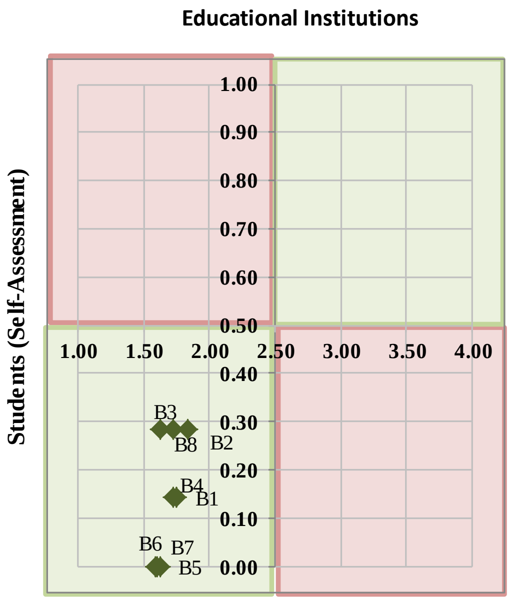


Figure 11.55 - Self-Assess of Operations Competences' relevancy by Non-Eng. Students and the competences taught in Education Institutions

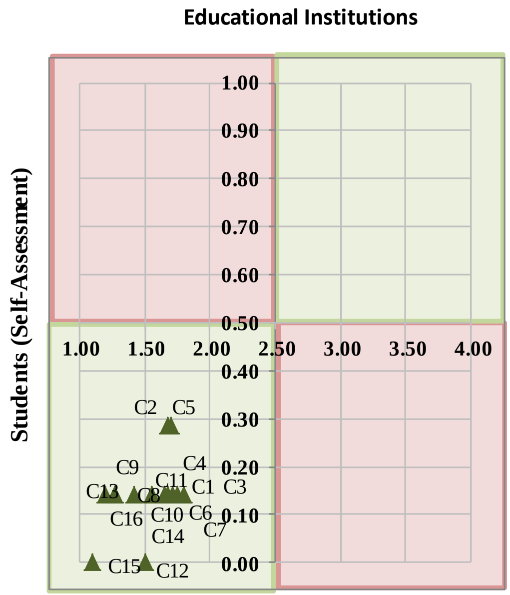


Figure 11.56 – Self-Assess of Engineering Competences' relevancy by Non-Eng. Students and the competences taught in Education Institutions

11.6 Competence Gap Assessment in the Manufacturing Companies and Aerospace & Aeronautical Engineering Educational program

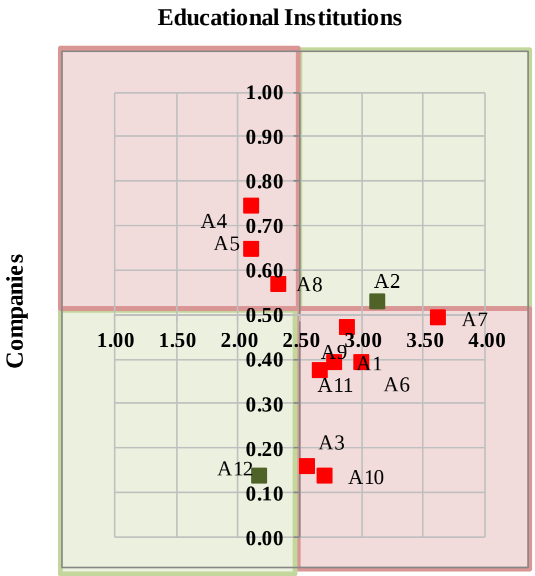


Figure 11.57 - Evaluation of Research & Development competences' relevancy by Manufacturing Companies and Aeronautical Engineering courses taught by Educational Institutes

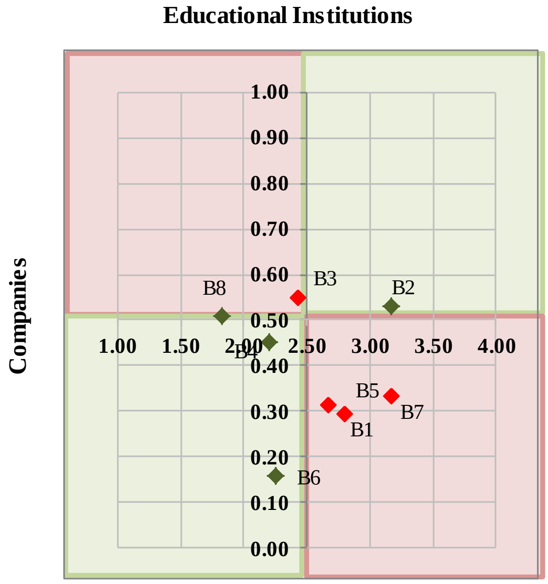


Figure 11.58 - Evaluation of Operations competences' relevancy by Manufacturing Companies and Aeronautical Engineering courses taught by Educational Institutes

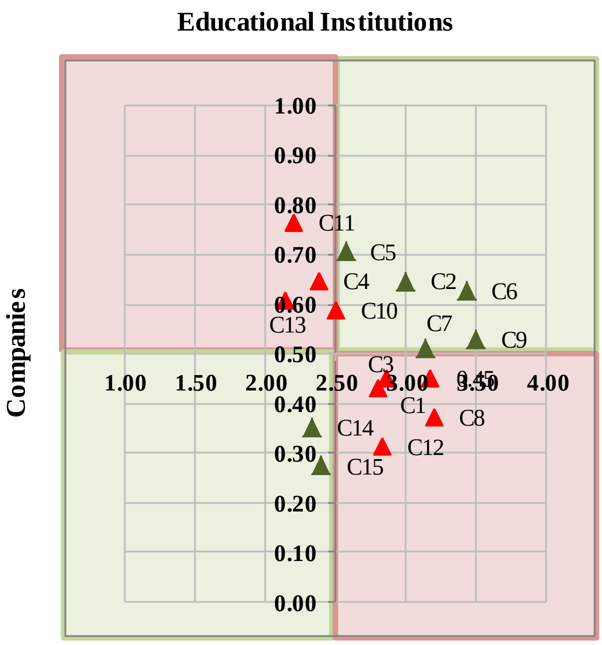


Figure 11.59 - Evaluation of Engineering competences' relevancy by Manufacturing Companies and Aeronautical Engineering courses taught by Educational Institutes