



**PARTNERSHIP OF A EUROPEAN GROUP
OF AERONAUTICS AND SPACE UNIVERSITIES**

**AEROSPACE ENGINEERING
PROGRAMMES**

**« ENSURING QUALITY
IN EUROPEAN AEROSPACE ENGINEERING EDUCATION »**

2nd Edition March 2005

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AEROSPACE ENGINEERING PROGRAMMES

PEGASUS AEROSPACE ENGINEERING PROGRAMMES
« ENSURING QUALITY IN EUROPEAN AEROSPACE ENGINEERING EDUCATION »

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INTRODUCTION

Aerospace Engineering education : the need for European harmonisation

The PEGASUS network of European aerospace universities 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. At that time, when the major employers of engineering graduates were about to be reduced to a small number of key players, the engineering education institutions could hardly remain isolated. At the other end, aerospace research also had been reinforcing its ties for years. Therefore, only engineering education would still have been scattered among tens of institutions across Europe, with just a few academic ties through sporadic student exchanges or joint research projects. PEGASUS was born as an initiative of academia to accompany research and industry in their move towards more synergy and effective co-operation.

One characteristics of aerospace engineering is that not all European countries are similarly involved in it (some countries are even not involved at all), which is less true for other engineering domains such as mechanical or electrical / electronics engineering. At the same time, being part of the high technology sector, aerospace is considered in certain countries with no or little aerospace industry as a field of interest for improving the overall level of engineering education and research. Geared towards the highest quality levels in the high-technology sector of aerospace, PEGASUS was first conceived as a restricted network of the main aerospace universities of the main aerospace countries and their partners. Therefore, the initial founding members group was deliberately limited to those 20 universities from 8 European countries (see list below) so that the first required analysis of aerospace engineering education could be done efficiently. In a second phase, PEGASUS has begun to open its membership to more aerospace universities (see list of associate partners page 10), the admission being granted based upon a set of admission criteria established by the 10th PEGASUS Council meeting held in Delft in March 2003.

As the most integrated industrial sector in Europe, aerospace can be seen as a real chance for the harmonisation of engineering education. Long-standing projects and structures have actually been launched years ago at the European Union level or even wider, in order to try to harmonise engineering education across all its domains, but with very little success in the end: engineering education is just too wide and too diverse to be framed in a simple, comprehensive set of criteria. On the other hand, engineering education in the single domain of aerospace may be easier to overlook. This was one of the leading ideas for the creation of PEGASUS : to build up a comprehensive understanding of what "aerospace engineering education" means in Europe, and then bring that knowledge to our integrating industry, in an interactive process of self-improvement. This action line has lead to the current catalogue of aerospace engineering education programmes in Europe.

Why PEGASUS ?

BACKGROUND: In Europe and worldwide, the aerospace industry is involved in an intense restructuring process that transcends national boundaries and interests. Increasingly the market polarises into two sectors, European and North American. At the same time in Europe, there is a move directed by the individual Ministers of Education to harmonise higher education (The Sorbonne / Bologna Declaration). For some nations this involves greater change than for others. For all, however, it involves only structure and not content of the education and training programmes. As a consequence, it does raise the question as to whether or not improvements can be made to those programmes offered by academia to the aerospace industry. Additionally, there remains the fact that our industry is in danger today of losing its appeal in the face of other growing industries, including services, with the possible consequence that there will soon begin a move of intellectual capital away from the aerospace programmes. Such a move has already begun within the USA and other places.

GENERAL OBJECTIVES OF PEGASUS: In full recognition of these facts, PEGASUS has been formed from an initiative taken by the four main French Grandes Ecoles involved in aerospace engineering. The general objective of PEGASUS is to optimise the services that its member institutions offer in the best interests of Europe both in terms of continuing to attract the best students and also to offer highly relevant educational and research programmes. Co-ordinated change and innovation will be required to achieve objectives to be defined through close links and interaction with our aerospace industry and relevant Government agencies. The founding partners of PEGASUS have collaborated for some years in an ad-hoc manner (largely supported by EU funding) but now wish to work more closely together in a manner that better satisfies the needs of their students and their employers across Europe. Today more than 2500 aeronautical engineers graduate from the member institutions of PEGASUS each year.

SPECIFIC OBJECTIVES: To achieve the general goals of PEGASUS, it is essential that there exists, on an on-going basis, a close working relationship with the European aerospace industry and Government Agencies. At the simplest level one aim would be to accelerate the process by which employers within each nation of Europe understand and fully appreciate the nature of the programmes of study offered outside their own country, and so assist in the 'European-isation' of employment opportunities. A more important aim would be that of tailoring the student experience so as to maximise the advantages that can be associated with the multi-language, multi-culture nature of our industry (as opposed to the single-language culture of the competition). Even more importantly, PEGASUS members must ensure that together they offer a range of high quality and efficient programmes of support. These programmes must include:

- Degree-awarding programmes
- Continuing Education
- Research
- International cooperation

Essentially, PEGASUS aims to offer itself as the European portal for higher education services in aerospace engineering.

ACTIONS TAKEN TO DATE: Working groups have been established to identify the areas of focus and first steps to be taken for each of the programmes listed above. The twenty founding partners have signed a **Partnership Agreement** on the common objectives of PEGASUS and these are reflected in the tasks set for the Working Groups. The emphasis on all affairs will be that of high level, high quality activities with the highest degree of relevance to the needs of the European industry and member States. Progress has been made in the definition of the upper aerospace engineering level requirements behind the granting of a European *Certificate* in the education and training of aerospace engineers and also of an *AWARD* in recognition of an individual student's multi-national experience (see Section 3.4). In this respect, all partners have agreed on a specific curriculum description format, enabling an immediate understanding by the industry of the level of education provided by the partners. Other collective actions were undertaken or completed, in partnership with the aerospace industry, like the **PEGASUS-AIRBUS Roadshow** (2002-2003) and the implementation of a European component to the annual AIAA (American Institute of Aeronautics and Astronautics) student paper competition: the **PEGASUS-AIAA Student Conference**.

LIST OF THE 20 PEGASUS FOUNDING PARTNERS (1998-2003):

- FRANCE (4):** **Groupe des Ecoles Aéronautiques et Spatiales (GEA):**
ENAC, ENSICA, ENSMA, SUPAERO
- GERMANY (5):** **RWTH Aachen, TU Berlin, TU Braunschweig,**
Universität Stuttgart, TU München
- ITALY (3):** **Politecnico di Milano, Politecnico di Torino, Università di**
Pisa
- THE NETHERLANDS (1):** **TU Delft**
- NORWAY (1):** **Norges Teknisk-Naturvitenskapelige Universitet (NTNU)**
- SPAIN (1) :** **Universidad Politecnica de Madrid (UPM) / ETSIA**
- SWEDEN (1):** **Kungl Tekniska Högskolan (KTH)**
- UNITED KINGDOM (4):** **University of Bristol, Cranfield University, University of**
Glasgow, Imperial College (London)

PEGASUS organisational structure: Council, Board, Chairman, Permanent Secretariat, Working groups, Admission criteria, Associate Partners

The PEGASUS network main organisational bodies are: the Council, the Board, the Chairman, supported by the Permanent Secretariat, and the Working Groups (WGs). The Council and the Board are permanent bodies, the Chairman is elected on a rotating basis, and the Working Groups are non-permanent bodies, being modified according to the actual needs.

The **Council** consists of one member of each partner University. The Council :

- defines the policy and the action plans of the network,
- decides admission of new members,
- decides the contents of the labels (Certificate and AWARD) and the awarding procedure.
- decides upon every important subject relevant to the PEGASUS objectives

The **Board** consists of 5 members elected by the Council, every two years. The members are selected by the Council among the Chairmen and Deputy Chairmen of the Working Groups. The Board :

- executes the decisions of the Council,
- represents the network to outside partners (industry, EU Commission, other organisations),
- checks the label awarding

Each member of the Board is responsible for one of the subjects :

- presentation of the network (Website, brochures, etc...),
- development of the labels, curricula, standards,
- continuing education,
- research,
- communication and co-operation (contractual affairs) among the partners.

The Council selects a **Chairman** (“PEGASUS Chairman”) who is also the Chairman of the Board, on a rotating basis (2-year). The Chairman :

- is the primary contact between the network and its outside partners,
- conducts the daily business in consultation with the board members (promotion of the network, financial, personal affairs, etc...),
- prepares the Board and Council meetings and the minutes of the meetings.

A **Permanent Secretariat** supports the PEGASUS Chairman and assumes the permanent administrative tasks and the coordination for the network. It is also in charge of the organization of common projects, events, of the promotion of the network towards industry. This Secretariat is located in Toulouse at ENSICA and provides information about the network.

There are presently five **Working Groups**, each one listed below with its tasks :

WG1 (organisational issues):

- to develop standards and criteria for active membership,
- to suggest development of the association,
- to suggest improvements of the organisational structure,
- to promote the association,
- to generate funding from the EU and the industry.

WG2 (curricula and labels) :

- to suggest descriptors for curricula,
- to develop labels, certificate and AWARD,
- to define standards
- to produce and update the PEGASUS catalogue of aerospace engineering programmes.

WG3 (continuing education) :

- to develop specific programmes for continuing education

WG4 (research)

- to evaluate commonality and level in research efforts,
- to evaluate the human potential and technical facilities,
- to suggest future research activities,
- to make research capabilities available to European organisations and industries.

WG5 (internal relations)

- to develop communication among partner Universities,
- to prepare contractual matters.

Admission criteria:

In 2003, the PEGASUS Council decided to open membership to new Partners who would be considered eligible by the Founding Partners and would demonstrate their willingness to actively participate in the network's activities.

Admission to PEGASUS is based on a set of criteria, focusing on two fundamental keywords: quality and international co-operation, all related to the higher education offered in aeronautical / aerospace engineering at European level. The criteria have been set on the basis of the decisions already taken and formalised by the Council in the Partnership Agreement, signed by all Pegasus founding members (see list of admission criteria below).

PEGASUS ADMISSION CRITERIA

The candidate should match the following criteria:

A. GENERAL

1. Be a public and/or non-profit institution of higher education in aeronautical / aerospace engineering
2. Have its main base of operations in a EU country
3. Demonstrate the willingness to sign the PEGASUS Charter and to actively commit to the PEGASUS network activities including working groups

B. EXCELLENCE

4. Have a good reputation and quality recognition (e.g. national accreditation by an official body) in education and research, nationally and internationally
5. Deliver one or several degrees in aeronautical / aerospace engineering in compliance with the European Bologna orientation (LMD, +5 level or M for Aerospace Engineering or higher)
6. The main curriculum in aeronautical / aerospace engineering should comprise a sufficient base in Fundamental Sciences (minimum 15%), General Courses including foreign languages, and Engineering Sciences (minimum 40%) of which at least 50% should be Aeronautical / Aerospace Engineering Sciences (that is: minimum 20% of the overall program, or 60 ECTS for a 5-year programme)
7. Have or plan to reach a sufficient volume of activity in terms of student output: 30 graduates per year at the +5 level or higher in Aeronautical / Aerospace should be considered as the minimum target volume
8. (supporting, non-mandatory criterion) Produce a record of first employment of the graduates in industry over the last 3 years, showing the relevance of the engineering programme for the aerospace industry

C. INTERNATIONAL COOPERATION

9. Produce a list of active partnership agreements with aeronautical / aerospace faculties or departments of foreign partner universities recognised at the international level, including at least 3 members of the PEGASUS network from at least 2 different countries
10. Produce a record of student and faculty exchanges with foreign universities over the last 3 years
11. (supporting, non-mandatory criterion) Produce a record of research activities involving international partnership

Associate Members:

After successful completion of the admission procedure and formal acceptance of the new entrant by the PEGASUS Council, the new Partner is granted the status of Associate Member for two years.

The status of Associate Member is equivalent to that of the Founding Members with two limitations:

- Associate Members cannot deliver the PEGASUS Certificate and PEGASUS Award to their students
- Associate Members cannot vote on the admission or exclusion of Partners at Council meetings

After two years from admission and following an assessment of positive involvement in PEGASUS, Associate Members can be confirmed and assume the same status as the Founding Members. Confirmed Associate Members and Founding Members are then identified by the same name of PEGASUS Members.

The Chairman and another Partner appointed by the Council will assess the involvement in PEGASUS of the Associate Member at the end of the two years. The Council decides on the passage to the status of Full Member on the basis of their report. In case of negative assessment, the Associate Member will still retain its status for two further years but in case of a second negative assessment, the associate membership will be terminated.

Current Associate Members (2005):

- TU Dresden (admitted September 2003)
- Università di Napoli – Federico II (admitted March 2004)
- Instituto Superior Tecnico (IST), Lisboa (admitted March 2004)
- Università degli Studi di Roma (La Sapienza) (adm. October 2004)

Full list of PEGASUS partners (2005):

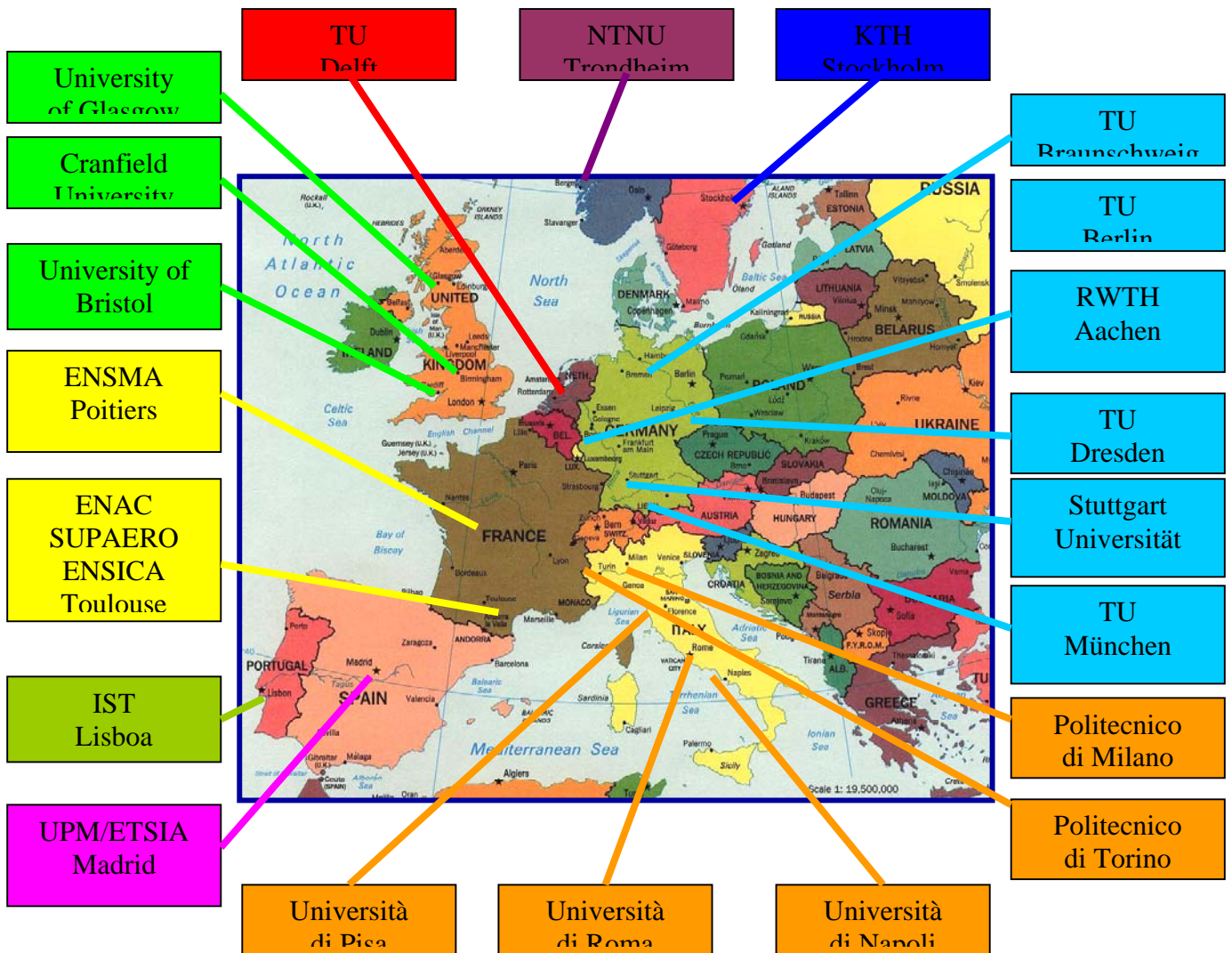
At the beginning of 2005, the PEGASUS network includes 23 Partners, among which 19¹ are Founding Members and 4 are Associate Members².

The full list is available from the map below.

¹ Imperial College's partnership expired in March 2005

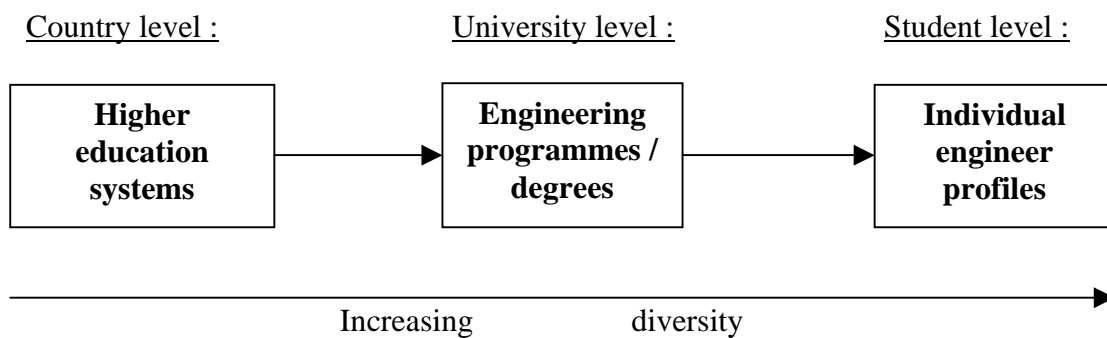
² In October 2005 also the Technical University (CVUT) of Prague was admitted in PEGASUS as Associate Member, after the editing of this document.

Map of PEGASUS Members



AEROSPACE ENGINEERING EDUCATION IN EUROPE

One characteristic of Europe is its cultural diversity across the nations. Consequently, mainly for historical and cultural reasons, there is a pretty large variety of **higher education SYSTEMS** and various **engineering PROGRAMMES** structures in each national system. Moreover, different education systems and engineering programmes combine together to produce a great diversity of **engineering DEGREES** across the European nations. This makes a good understanding of the available offer quite difficult for non specialists, and even more outside the educational world. Moreover, recent trends in the organisation of the educational programmes make for a greater diversity, particularly through the development of student exchange programmes across European countries (SOCRATES programme of the European Union) and new European resolutions (European scheme 3-5-8) or programmes (Erasmus Mundus).



Students today have many opportunities at hand to shape their own **individual PROFILES** through a choice of elective courses at home and / or participation to exchanges for extended periods in a foreign partner university. This increased diversity of student profiles makes it more and more difficult, if not impossible, to provide a simple, monolithic overview of higher education institutions outputs which cannot be characterised with just a few key words relating to their scientific / technical fields. The ambition of this document is to try to provide a relatively simple and, at the same time, accurate description of the current national higher education **systems** and PEGASUS aerospace engineering **programmes** and **degrees**.

But before addressing these educational issues, the prospective situation of employment for aerospace graduates in the European aerospace industry must be examined. This is the subject of the next chapter.

1. THE EUROPEAN DIMENSION OF AEROSPACE ENGINEERING

1.1 THE NEEDS OF THE EUROPEAN AEROSPACE INDUSTRY

1.1.1 AEROSPACE, A HIGH-TECH SECTOR IN NEED OF SKILLED ENGINEERS

From its early days at the beginning of the 20th century till today the aerospace sector has required a highly educated and innovative work force. The degree of scientific knowledge of the aerospace engineers has at all times been the driving factor for technological developments and new aerospace concepts. This is even truer today. The challenges of global market competition and the ever growing complexity of systems and structures that is needed to meet customer requirements, demand a permanently increasing degree of system integration. Environmental implications and sustainable development further feed this process.

Over the past decades, aerospace has been characterised as the most research-intensive industrial sector in developed countries, with research investments as high as 30% of the overall revenue in some companies - a much higher percentage than in other high-tech sectors. Consequently, the need of the aerospace industry for talented young engineers and scientists is still relentless today. The competition for the best brains has now gone on a global scale, with aerospace companies trying to lure the best, high-potential employees not only from their home universities 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.

Additionally, the aerospace industry is also engaged in a strong competition with other industrial sectors such as the information technology or automotive industry for the best young engineers. Even those having chosen the aerospace engineering speciality for their diploma studies do not necessarily work in the aerospace industry afterwards: the scientific and technical skills that they acquired in their aerospace engineering studies can also be very useful in other industrial sectors!

1.1.2 QUANTITATIVE NEEDS FOR AEROSPACE ENGINEERS IN EUROPE

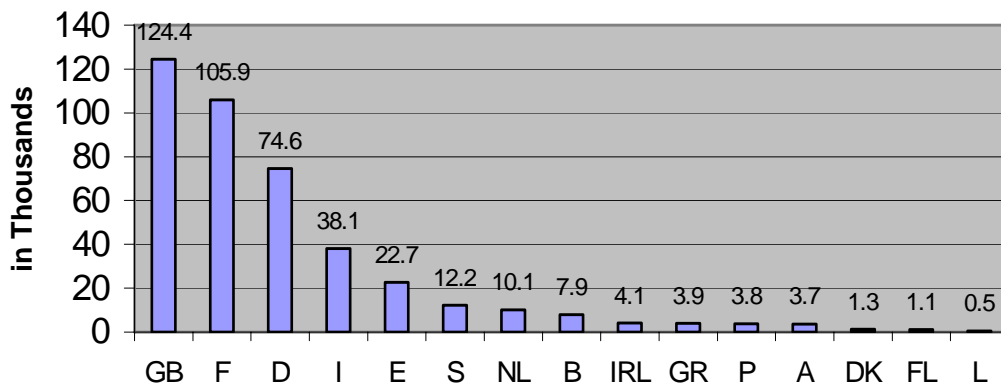
At the end of 2003 the total direct employment in the European aerospace industry was about 414,500 employees ³ with a turnover of roughly 74 €billion. Almost 95 % of the employees work in countries where PEGASUS is present with at least one member.

The consolidation in the aerospace industry propelled an enormous growth in the productivity per employee, also driving up the total turnover. Over the past years an average

³ Reference : ASD, Facts & Figures 2003

of 14.5 % of this turnover was spent on research and development (R&D). This is a relatively large percentage pointing out the high-technology leadership of this industry. With 19 % of all employees working in the field of R&D and a cumulated 29 % having a university degree or equivalent, this industry absorbs a large number of university graduates every year.

Number of Employees



Besides the key players in the aerospace industry, there are a large number of suppliers cumulating about twice the total number of employees mentioned above. And then there is the scientific community and the national as well as international research institutions in Europe, which also contribute to the overall work force. And which strongly depend on highly qualified aerospace engineers.

Considering an average employment period of about 30 years, only simple math is necessary to calculate **an annual replacement need of more than 2600 experts in R&D** at the key aerospace companies, of whom most will be engineers.

Aerospace companies do not solely recruit aerospace engineers. And when surveying the employment situation, we should also keep in mind that aerospace engineers are welcome in other industries as well. Thus, the number of 2600 experts per year can only serve as a very rough indication. Nonetheless, it puts us in perspective and allows some judgement on the quantitative needs in the European aerospace industry.

1.1.3 QUALITATIVE NEEDS FOR AEROSPACE ENGINEERS IN EUROPE

There is no question that the European aerospace industry, like the non-European remains in fundamental need of scientific and technical talents, skilled engineers and scientists with a strong knowledge and aerospace engineering background. In recent years a trend has emerged among human resources departments of aerospace companies towards hiring general engineers, which can transfer to other sectors more easily. This requires some

broad concept for the academic education of the later employee. From discussions with industry in each PEGASUS country we understand, that there is a good correlation between the aerospace programmes offered at our member universities and the scientific / technical needs of aircraft / systems design offices and various other technical divisions in the industry.

The growing integration of industry – the aerospace industry is the most integrated economic sector in Europe – and the globalisation of markets and production means generate new training needs in order to maintain the competitive advantage of the industry. The implications for the preferred employee profiles are twofold. One aspect is the need for motivated workforce, skilled in general and project management, with team work as well as multicultural abilities. Today’s most wanted profile is a good engineer with a profound knowledge of soft skills, which he can confidently apply.

Another aspect is the requirement to prepare the engineers for life-long education. The universities are asked to include this preparatory work in their programmes and to offer respective courses for specialists in the future.

1.1.4 HOW DOES PEGASUS MEET THOSE NEEDS?

The output of the PEGASUS network appears relatively adequate to the needs of industry as described above, both in terms of quantity and quality. When the quantitative needs of the European industry can be estimated at around 2600 engineers per year (see 2.2), the output of +5 level aerospace engineers from the PEGASUS network amounts to **ca. 2500** each year (see table below). On top of that, PEGASUS institutions also produce around **280** “Doctorates” (+8 level) per year, who are of big value to R&D divisions in the aerospace industry.

Of course, not all PEGASUS aerospace engineers enter directly into the aerospace industry after completion of their studies. About 50% of the PEGASUS engineering graduates go into other sectors such as automotive and mechanical industries, information technology companies, consulting firms, etc. Surely, the percentage varies considerably according to regional employment opportunities.

On the other hand, the aerospace industry does not limit its recruitment of engineers to the sole source of PEGASUS. Other universities and engineering schools also provide the industry with talented people, but in much less numbers than PEGASUS. Overall, under today’s conditions the graduates output of the PEGASUS partners appears to be adequate to the needs of the aerospace industry.

The concept of international studies and industry collaboration on the educative side of the study programmes are essential to the ambitions of PEGASUS. All members promote the idea of cultural mobility of their students and academic staff. In order to make this process sustainable, the members set up high quality standards to ensure excellence.

Thanks to the permanent communication of interests with the European aerospace industry, the PEGASUS group is on top of the evolving needs of the aerospace industry. And,

thus, is able to consider these needs in the adaptation of the study programmes. One such need is the support of life-long education. This has been implanted as a major nucleus in the PEGASUS activities. Today, the partner universities already offer a variety of respective courses.

YEARLY AVERAGE NUMBER (2002-2004) OF THE AWARDED +5 AND HIGHER LEVEL DEGREES

Average 3-year value 2002-2004 PER YEAR			
University		+5 level (Masters included)	+8 level (Doctorate, PhD)
ENAC Toulouse	(F)	225 ⁴	5
SUPAERO Toulouse	(F)	280	30
ENSICA Toulouse	(F)	210 ²	5
ENSMA Poitiers	(F)	150	26
RWTH Aachen	(D)	42	13
TU Berlin	(D)	58	14
TU Braunschweig	(D)	40	10
TU Dresden	(D)	36	5
U. Stuttgart	(D)	125	22
TU Munich	(D)	77	13
Politecnico di Milano	(I)	153	8
U. Pisa	(I)	85	5
U.Napoli	(I)	100	10
U.Roma	(I)	130	10
Politecnico di Torino	(I)	120	8
TU Delft	(NL)	130	25
NTNU Trondheim	(N)	11	2
ETSIA Madrid	(E)	200	10
IST Lisboa	(P)	30	3
KTH Stockholm	(S)	40	5
U. Bristol	(UK)	143	9
Cranfield U.	(UK)	153	38
U. Glasgow	(UK)	60	3
TOTAL		2518	279

⁴ including 50 Chinese Masters taught on-site in China. Since ENAC, ENSICA and SUPAERO have several Master programmes in common, whose students should not be counted twice, the total number of +5 level students from the 3 schools is only 635.

1.2 NATIONAL HIGHER EDUCATION SYSTEMS FOR ENGINEERING IN EUROPE

1.2.1 ENGINEERING DIPLOMAS VS. ENGINEERING PROFESSION

The word "Engineer" does not mean exactly the same thing across the various European countries and around the world. Therefore, engineering education may also vary considerably according to differing national specificities.

In France, for example, to be an engineer first means to *exert a profession* that requires a good level of technical expertise, directly or indirectly bound to producing goods or services for the community. An engineer designs new products, has a manufacturing responsibility or is a project manager. He/she should be able to discuss technologies and methods being used and argue about them if needed. This is how "engineers" differ from "technicians" who only conform to guidelines for implementation of processes. To be an engineer also has a second meaning : *to be the holder of an engineering degree*, after a rather long training period (usually 5 years) including a balance of scientific, technical and even economic studies. These two definitions do not always overlap within companies in France :

- Some people can get an engineering job without holding an engineering degree ;
- The career of graduate engineers often leads them to managerial positions where technical aspects may be strongly reduced.

In France, only the title of "graduate engineer" ("*ingénieur diplômé*") - which refers directly to the kind of studies and degree obtained - is controlled and protected by law. Only the institutions that have been accredited by a national accreditation body (*CTI: Commission des Titres d'Ingénieur*) to this purpose are allowed to propose a course programme that delivers a diploma entitling to use the above title.

The situation is different in other European countries where professional titles may exist like **in the UK** ("*chartered Engineer*"). A special procedure exists to acquire that title but it is not absolutely necessary to be "chartered" to exert the profession of engineer, only those willing to do business with the public sector really need it. Actually, less and less engineers engage into it.

In Italy to be engineer ("*ingegnere*") first of all means to be holder of an engineering degree awarded by a recognised University or a *Politecnico* (there is no substantial difference between both, a Politecnico being focussed on engineering studies – i.e. it is a technical university - whereas a University encompasses all human and scientific Faculties). As a matter of fact, all universities delivering engineering degrees in Italy are public institutions and their degrees are protected by law. Nevertheless, to exert a profession, the degree alone is not sufficient because his holder must be listed in the roll of engineers ("*Ordine degli Ingegneri*"), which requires passing a special examination ("*Esame di Stato*").

In Spain the diploma of *Ingeniero Aeronáutico* has an official recognition both academically and professionally. The national education authority defines the major subjects of the curricula, which constitutes a compulsory core of any university programme on the subject. In addition, a university needs the approval of the national university council for the whole programme that it proposes. The possession of the diploma empowers the exercise of the profession. A professional college of aeronautical engineers controls that the management and main responsibility of any aerospace project is carried out by a holder of a recognised diploma.

In some countries, two different levels of "engineers" co-exist : an **upper level** (after 5 to 7 years of higher studies) and a **lower level** (3 to 4 years). This is the case for instance in **Germany**: *Diplom-Ingenieur TU (Technische Universität)* vs. *Diplom-Ingenieur FH (Fachhochschule)*, and in **Italy** (*Ingegnere Laureato Magistrale* vs. *Ingegnere Laureato*).

The essential difference between these shorter programmes and the +5 ones is that they are more practice oriented: therefore they aim at providing the students with the skills needed for their immediate employment. The +5 programmes, on the contrary, aim at the best trade-off between fundamental and basic knowledge and technical capabilities. In the field of engineering, this leads traditionally to professional figures able to adapt themselves to different situations, even if the measure of this result is different in the various national systems, which at the end turns out to be a peculiar richness of the European higher education as a whole.

1.2.2 CONVERGENCE OF NATIONAL HIGHER EDUCATION SYSTEMS FOR ENGINEERING IN EUROPE

Higher education follows traditionally different schemes in the various nations, according to its being structured or not on intermediate levels, each one terminated by the award of a degree, to the number of years requested to the students to achieve each degree, to the stiffness vs. the compliance of its curricula and to several other aspects.

However, the European continental countries display all some similarities which can be traced back to the common origin and development of their systems and to their long tradition of contacts, student exchanges and interactions. First, the central body of the European university education is tuned on a duration of **five study years**. This is the case, in particular, for the most qualified engineering studies. There are some important exceptions to this rule: for instance the Faculties of Medicine generally request a longer time. Nevertheless, nearly all European Faculties offer a five year curriculum, possibly associated to shorter and longer ones, either parallel to the first one or in a sequence with it.

So, in Continental Europe, quoting a given degree (Diplôme in France, Diplom in Germany, Laurea Magistrale in Italy) is tantamount to specifying the legal study duration necessary to be awarded with it. This is not only true for the five-year degrees, but also for the intermediate or the longer (Doctorate) ones.

These similarities have brought the European Ministries of Education to foster a large European **harmonisation scheme known as 3-5-8** (first mentioned in July 1999 at La Sorbonne, Paris and then precised in the Bologna Declaration the following year)⁵. According to that scheme, all European countries are encouraged to adapt their national systems to a three-story structure of degrees (each level allowing graduates to be readily employable on the job market):

- first level (+3) after 3 years of post-secondary education, leading to the (L) **Laurea** (Italy) or **Licence** (France) grade, or the Bachelor's degree in some Northern European countries;
- second level (+5), after 2 more years (5 years of higher education), leading to the **Master** (M) grade;
- third level (+8), after 3 more years (8 years of post-secondary education overall), leading to the **Doctorate** (D) grade.

Since then, many universities have started to adapt their programmes structures according to that 3-5-8 scheme. As far as Engineering studies are concerned, at least on the European continent⁶, the adaptation is not terribly difficult since, as we said before, Engineering programmes have had that 5-year structure (M level) for a long time, some having an intermediate level at the +3 level, others not. When an intermediate degree already existed at the +3 level (Italy, Netherlands, French universities, ...), the adaptation mainly consisted in rearranging the programmes so that +3 graduates could be readily operational in companies (which meant sometimes less theoretical studies and more professional topics in the 3rd year of study). When an intermediate degree did not exist within a 5-year Engineering curriculum (French Engineering schools...), the adaptation to that level has, so far, simply been ignored!

In spite of these remaining differences between European countries, the 3-5-8 evolution for the Aerospace Engineering studies can be more or less summarised as follows (5-year programmes):

- the **first two years** of post-secondary education are essentially devoted to Fundamental Sciences and general Engineering Sciences. Some Aerospace Engineering topics may also be addressed in some cases;
- the **third year** appears as a transition year, sometimes leading to an intermediate degree (Licence / Laurea / Bachelor's) allowing the holder to start working and / or pursue studying for a higher level degree. The contents is more Engineering and Aerospace Engineering oriented;
- the **fourth and fifth years** are the core of the advanced Aerospace Engineering topics, with sometimes a first glance at research activities. These highly specialised years of study can be complemented with general management courses, foreign languages and other "soft" skills, as well as an industrial internship period allowing the students to have a first taste of company life as an engineer. In some countries however (Germany, Italy...) this internship may be anticipated to the second or the third study year.

⁵ In France and Italy, the national transcription, currently under way, translates into L-M-D (Licence or Laurea, Master or Magister, Doctorate)

⁶ In the case of UK, the situation is different, as we will see later in this document

1.2.3 COMPARISON WITH THE NORTH AMERICAN (U.S.) SYSTEM

In the U.S. system the Bachelor's degree always corresponds to four years (+4 level) of higher education (Freshman, Sophomore, Junior, Senior) unlike the UK system where the Bachelor's degree is usually at the +3 level (and therefore already complies with the Bologna scheme). In the USA, only the Bachelor's degrees benefit from an accreditation system managed by an independent association, ABET (Accreditation Board for Engineering and Technology) or regional groupings of colleges.

For the Master's degrees, different situations may occur :

- the Master of Engineering (ME) with a duration of one year ;
- the Master of Sciences (MS) with a duration between one and one and a half year, depending on the duration of the final thesis (Research work).

For a student with an "assistantship" (Teaching assistantship, Research assistantship, Fellowship) the total duration can be two years. After the MS, Ph.D (Doctor of Philosophy) studies are generally longer than three years (four or five years).

Currently, due to the job market situation, a large majority (around 80% to 90%) of U.S. students stop their higher education studies at the Bachelor's level to enter directly into the industry. The Master of Sciences or Master of Engineering can also be undertaken after a work period in industry (one or several years).

As a matter of fact, the overall duration of studies for the Bachelor's or Master's degrees is not rigidly specified by the universities. Degrees are granted based on completion of certain amounts of credits and, sometimes, conditions on achievements (grades) but there is no real time limitation to complete the requirements. The usual number of credits required for a standard Bachelor's degree amounts to 120 on average (that is, more or less 30 U.S. credits per year in the first four years). For a Master's degree, 30 to 40 more credits are usually required.

This can be compared to the European Credit Transfer System (ECTS, see below), where each year of study represents 60 credits. For a 5-year engineering programme (+5 level), this corresponds to 300 ECTS credits in Europe and 150 – 160 U.S. credits in the USA. The correspondence between these two scales is roughly 2:1 .

1.2.4 EUROPEAN EXCHANGES, ECTS, ERASMUS MUNDUS

In the last 15 years, **student exchanges** have developed considerably within Europe as well as between Europe and the rest of the world, particularly North America. This evolution of higher education was triggered within Europe by the EU programme ERASMUS, which put some funding (student grants) and mutual recognition tools (ECTS) at the disposal of

universities for developing student and professors mobility, one of the main goals of the EU (workforce mobility) to promote a better integration of the single European market.

Student mobility has increased at different rates, from modest single-figure percentages up to 100% in some institutions where a minimum international mobility (usually 3 months) has become mandatory to receive the degree. In quantitative terms, for aerospace engineering studies within PEGASUS, the average mobility rate is currently around 15% with some partners reaching over 50% of their student population studying abroad.

Inside the PEGASUS network, mobility of students has steadily increased since the network was launched in 1998, as shown in the following table. This table shows that **student exchanges have more than tripled in 6 years**, which is quite an impressive result, well above the average European growth of student exchanges. Therefore, this effect is clearly in relation with the existence of the PEGASUS network. More precisely, the main driver of this growth is less the exchanges of final laboratory projects but rather the “substitution” semesters / years which have more than tripled in 6 years. This means that PEGASUS students feel more and more confident to study abroad, that is to take courses and exams in a foreign language.

Quantitative student exchanges within the PEGASUS network since its creation
(number of students per year)

Year	Substitution years or semesters, including double degrees	Only lab projects	Overall inside PEGASUS
1998/99	31	44	75
1999/00	40	53	93
2000/01	69	77	146
2001/02	58	97	155
2002/03	99	97	196
2003/04	112	83	195
2004/05 ⁷	136	93	229

Perhaps even more importantly, in qualitative terms, the **cooperative interaction between PEGASUS institutions has increased dramatically** since the creation of the PEGASUS network, as shown in the following table (next page). It shows that there are currently **125 bilateral partnerships** within the PEGASUS network. Every PEGASUS partner has, on average, over 10 active bilateral partners within the PEGASUS network, some partners having up to 15 bilateral counterparts, and even 18 (out of 23 maximum) including exchange partners of the same country, like in France where GEA schools have started to exchange final year students between them since 2002 (they are not counted above).

⁷ Some figures are still unavailable at the time of redaction, so the 2004/2005 figures are underestimated

This stimulated cooperation is building up more and more, from simple lab projects or semester exchanges to professors exchanges, research cooperation up to double degrees programmes or even integrated educational programmes involving more than two partners (ECATA, Erasmus Mundus Masters programmes...) forming together smaller networks (“intra-networks”) of 3 to 8 partners inside PEGASUS. Certainly, the better reciprocal understanding and the better knowledge of each other’s educational and research activities, fostered by the PEGASUS network own activities, have contributed to that development of the internal cooperation in aerospace education, one of the main goals of PEGASUS since its creation.

This growth of the internal cooperation within PEGASUS was facilitated by the general implementation of **ECTS (European Credit Transfer System)**, which established a common measurement tool for the workload of higher education studies. Along with extensive information about courses through ECTS catalogs and, later, web pages, European students have been enabled to compose for themselves individual study paths over several European institutions, validated both quantitatively and qualitatively by their home and host universities.

ECTS credits are numerical values allocated to course units to describe the student workload required to complete them. They reflect the quantity of work each course unit requires in relation to the total quantity of work necessary to complete a full year of academic study at the institution, that is, lectures, practical work, seminars, tutorials, fieldwork, private study - in the library or at home - and examinations or other assessment activities. ECTS is thus based on a full student workload and not limited to contact hours only. In ECTS, 60 credits represent the workload of a standard academic year of study (30 credits for one semester and 20 credits for one term). Once fully implemented, one ECTS credit corresponds roughly to 30 hours of student workload (classroom and self-study included). In some countries still in a transition phase, this estimation can range from 20-30 hours.

ECTS also enables further studies away from the student’s home institution since ECTS gives a standard measurement of academic achievements, theoretically recognised all over Europe. This facilitates one or several semester periods of studying abroad but also an improved mobility within the national university system, for example when transferring from an initial 3-year curriculum to a 2-year Master course at another university. The institutions themselves decide whether or not this is acceptable and what conditions the student must fulfil to obtain a diploma or transfer registration. The transcript of records is particularly useful in this context as it provides a history of the students’ academic achievements, which will help institutions to make these decisions.

All this process is leading to a better mutual understanding, the creation of new cooperative ties, integrated programmes or double diplomas agreements. In that respect also, the ERASMUS programme (now SOCRATES / ERASMUS) has proved to be a great success which was limited only by its insufficient funding to cope with the explosive student demand.



AEROSPACE ENGINEERING PROGRAMMES

ENAC Toulouse	ENSICA Toulouse	ENSMA Poitiers	SUPAERO Toulouse	RWTH Aachen	TU Berlin	TU Braunschweig	TU München	Universität Stuttgart	TU Dresden	Politecnico di Milano	Politecnico di Torino	Università di Pisa	Università di Roma I	Università di Napoli I	Cranfield University	University of Bristol	University of Glasgow	KTH Stockholm	TU Delft	NTNU Trondheim	ETSIA Madrid	IST Lisboa		
					x	x	x	x		x	x		x		x	x	x	x	x		x		ENAC Toulouse	
				x		x	x	x		x	x				x	x	x	x	x	x	x	x	ENSICA Toulouse	
								x		x	x		x		x	x			x	x	x		ENSMA Poitiers	
					x		x	x		x	x	x	x	x	x		x	x				x	x	SUPAERO Toulouse
										x	x							x	x	x	x			RWTH Aachen
										x					x	x			x	x		x		TU Berlin
															x			x						TU Braunschweig
										x	x		x	x	x		x	x				x	x	TU München
										x	x	x			x	x		x	x			x		Universität Stuttgart
											x	x				x		x		x				TU Dresden
															x		x	x	x			x	x	Politecnico di Milano
															x	x	x	x	x	x	x	x	x	Politecnico di Torino
															x			x	x					Università di Pisa
															x		x		x			x		Università di Roma I
															x		x		x					Università di Napoli I
																			x			x		Cranfield University
																				x				University of Bristol
																						x		University of Glasgow
																							x	KTH Stockholm
																							x	TU Delft
																								NTNU Trondheim
																								ETSIA Madrid
																								IST Lisboa

**Overview of active bilateral exchange agreements within the PEGASUS network
(all types: ERASMUS, double-degrees, students and professors mobility....)**



Recognising the situation, the European Commission went one step further and decided to launch a new phase of European higher education integration with the creation of the **ERASMUS MUNDUS** programme. Launched in 2002, ERASMUS MUNDUS aims at fostering integrated high level programmes (Masters) for which it delivers a label (European Master), administrative funding as well as generous grants for non-European students. The idea behind this scheme is to create multinational poles of excellence able to compete with the best U.S. university programmes. A first, limited set of ERASMUS MUNDUS projects was approved in 2004, none in aerospace engineering. For the 2005 campaign, one aerospace engineering programme, endorsed by PEGASUS (comprised of 5 PEGASUS partners) may be selected by the EU (see chapter 2.2).

2. THE PEGASUS EDUCATIONAL OFFER IN AEROSPACE PROGRAMMES

2.1 PEGASUS AEROSPACE ENGINEERING PROGRAMMES

2.1.1 General structure of PEGASUS engineering degrees

The PEGASUS member institutions are no exceptions to the general European rules when it is about their own programme structures. The PEGASUS aerospace engineering programmes considered here (+5 level) still reflect their national structure particularities. One first big difference appears between Continental Europe on one hand, Great Britain and Ireland on the other hand, where the programmes have an overall shorter duration (see 2.1.2). This paragraph will consequently only discuss the aerospace programmes structure encountered on the Continent.

As it was said before, the PEGASUS engineering programmes (leading to the corresponding degrees) are, on the European continent, structured over a period of **5 YEARS** of post-secondary studies. In terms of the European norm ECTS, such 5-year programmes represent a total of 300 credits (60 credits per year). The students who successfully complete the whole programmes quantitatively (number of credits) and qualitatively (sufficient grades), including core (mandatory) courses and optional (elective) courses prescribed by the engineering programmes syllabi, are awarded the corresponding degree, at the +5 level, entitling to assume all the fonctions of an engineering job (in the highest sense) and, in some cases to enjoy the privileges of a “Master” grade / title and / or a “Graduate Engineer” title.

Within the PEGASUS network, the degrees corresponding to that definition are the following (exhaustive list):

France

<u>ENAC Toulouse:</u>	Diplôme d’Ingénieur de l’ENAC
<u>SUPAERO Toulouse:</u>	Diplôme d’Ingénieur de SUPAERO
<u>ENSICA Toulouse:</u>	Diplôme d’Ingénieur de l’ENSICA
<u>ENSMA Poitiers:</u>	Diplôme d’Ingénieur de l’ENSMA

Germany

<u>RWTH Aachen:</u>	Diplom-Ingenieur Maschinenwesen ⁸
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⁸ Ingenieur Maschinenwesen (or Maschinenbau) = Mechanical Engineer

TU Munich: Diplom-Ingenieur Maschinenwesen

U. Stuttgart: Diplom-Ingenieur Luft- und Raumfahrt⁹

TU Braunschweig: Diplom-Ingenieur Maschinenwesen

TU Berlin: Diplom-Ingenieur Verkehrswesen¹⁰

TU Dresden: Diplom-Ingenieur Maschinenbau

Italy

Politecnico di Milano: Laurea Magistrale in Ingegneria Aeronautica / Spaziale¹¹

Politecnico di Torino: Laurea Magistrale in Ingegneria Aerospaziale

U. di Pisa: Laurea Magistrale in Ingegneria Aerospaziale

U. di Napoli I : Laurea Magistrale in Ingegneria Aerospaziale

U. di Roma I : Laurea Magistrale in Ingegneria Aerospaziale

The Netherlands

TU Delft: M.Sc. Aerospace Engineering

Norway

NTNU Trondheim: M.Sc. Mechanical Engineering

Portugal

IST Lisboa: Licenciatura Engenharia Aeroespacial

Spain

ETSIA Madrid: Diploma de Ingeniero Aeronáutico

Sweden

KTH Stockholm: M.Sc. Engineering (Civilingenjör)

⁹ Ingenieur Luft- und Raumfahrt = Aerospace Engineer

¹⁰ Ingenieur Verkehrswesen = Transport System Engineer

¹¹ Ingegneria Aerospaziale = Aerospace Engineering

A synopsis of the overall structure of these programmes is given here:

Comparative scheme of the Engineering programmes' structure in continental Europe

<i>Country</i>	<i>University</i>	<i>Year 1</i>	<i>Year2</i>	<i>Year3</i>	<i>Year 4</i>	<i>Year 5</i>	
FRANCE							
	ENAC Toulouse	Scientific preparatory classes + national entrance exam		Ingénieur diplômé			
	SUPAERO Toulouse			Ingénieur diplômé			
	ENSICA Toulouse			Ingénieur diplômé			
	ENSMA Poitiers			Ingénieur diplômé			
GERMANY							
	RWTH AACHEN	Vordiplom		Diplom- Ingenieur			
	TU BERLIN	Vordiplom		Diplom- Ingenieur			
	TU BRAUNSCHWEIG	Vordiplom		Diplom- Ingenieur			
	U. STUTTGART	Vordiplom		Diplom- Ingenieur			
	TU MUNICH	Vordiplom		Diplom- Ingenieur			
	TU DRESDEN	Vordiplom		Diplom- Ingenieur			
ITALY							
	Politecnico MILANO	Laurea			Laurea magistrale		
	Univ. di NAPOLI				Laurea magistrale		
	Univ. di PISA				Laurea magistrale		
	Univ. di ROMA				Laurea magistrale		
	Politecnico TORINO				Laurea magistrale		
THE NETHERLANDS	TU DELFT	BSc. AE			MSc. AE		
NORWAY	NTNU TRONDHEIM	MSc. Mechanical Engineering					
PORTUGAL	IST LISBOA	Licenciatura engenharia aeroespacial					
SPAIN	ETSIA MADRID	Ingeniero aeronáutico					
SWEDEN	KTH STOCKHOLM	MSc. Engineering (Civilingenjör)					
Nominal Student Age:		18	19	20	21	22	23

Among continental PEGASUS members, there is a good degree of homogeneity as far as the length of the aerospace programmes is concerned. Although all engineering programmes are full 5-year programmes, some are 2+3 (Germany, France), others 3+2 (Italy, the Netherlands), some full 5-year courses of study with no intermediate step (Spain,

Sweden, Norway). Some include a preparatory period (2 years in France) putting a strong emphasis on Fundamental Sciences (Maths, Physics,...) and General Courses (foreign languages) put not on Engineering itself, while others start Engineering courses as soon as in the 2nd year of a more integrated 5-year programme.

However, the “stiffness” of the Continental European systems (probably an heritage of the centralised characters of the old individual European nations) is moderated by the possibility broadly offered to the students to freely choose a certain amount of subjects (electives), fixed by their faculties. This possibility is reinforced by the international exchange agreements (see paragraph 1.2.4) and strongly contributes to an increasing flexibility of the university syllabi, leading to more customised, individual student profiles.

2.1.2 Aerospace Engineering programmes in the United Kingdom

Aerospace Engineering programmes in the UK substantially vary from what we see on the European continent. The differences are less in the contents - although UK universities seem to put a stronger emphasis on specialised, technical subjects than most universities elsewhere – but more in the duration of the studies and the structure of the programmes.

Generally speaking, the duration of the engineering studies is shorter than on the continent: 3 to 4 years of post-secondary education would make for the initial training, the title of “*Chartered Engineer*” being actually acquired later, after a few years of professional experience.

Another characteristic of the UK engineering programmes is that there is no unified structure, nor unified duration of the programmes. Only in aerospace engineering within PEGASUS coexist programmes in 3 years (Bachelor of Engineering, Bachelor of Sciences in Aerospace Engineering), 4 years (Master of Engineering, Scottish Bachelor of Engineering), and 5 years (Scottish Master of Engineering and Masters of Science, regarded as postgraduate degree programmes that can also be undertaken after a period of work in industry). Nevertheless, the current trend for mainstream aerospace engineering students seems to become more and more the MEng. and less the BEng.

Within the PEGASUS network, the degrees corresponding to the definition of main, initial training programmes in aerospace engineering are the following (exhaustive list):

United Kingdom

U. of Bristol: MEng. in Aeronautical Engineering
MEng. in Avionic Systems

Cranfield Univ.: *Only (postgraduate) one-year MSc. Programmes*¹²

¹² see chapter 2.2

U. of Glasgow: MEng. in Aeronautical Engineering (5year-programme) *
MEng. in Avionics (5year-programme) *

A synopsis of the overall structure of these programmes is given here:

Country	University	Year -1	Year 1	Year2	Year3	Year 4	Year 5	
UNITED KINGDOM								
	U. of BRISTOL	(High School)	B.Eng.			M.Sc.		
			M.Eng.					
	CRANFIELD U.	(High School)	(BA / BEng / BSc / MEng)->				M.Sc.	
	U. of GLASGOW *		B.Eng.					
			M.Eng.			M.Sc.		
Nominal Student Age :		17	18	19	20	21	22	23

(* : nominal starting age of undergraduate students in Scotland is 17, one year earlier than the rest of the UK)

Within PEGASUS UK members, the aerospace engineering programmes vary considerably as shown in the table above. Whereas the “standard” curriculum may appear as in Bristol to be a Bachelor of Engineering in 3 years and a Master of Engineering in 4 years, Cranfield University offers only one-year specialisation programmes (Master of Science, MSc.). It is not even easy to characterise the overall profiles of a Cranfield graduate since the entrance level for the Cranfield MSc. may be as diverse as the existing degrees in the UK: Bachelors of Arts or Science, Bachelor or Master in Engineering...

Scotland shows also some differences. Unlike the rest of the UK, the programmes in Glasgow include Bachelors of Engineering in 4 years and Masters of Engineering in 5 years. But the duration of high school studies in Scotland is on average one year less than in the rest of UK, which makes Scotland students enter the higher education system one year earlier. As a consequence, the duration of higher education studies is longer than in the rest of UK but does not lead to longer studies overall.

In any case, it was discussed and admitted, within PEGASUS, that the UK engineering programmes are shorter than the standard +5 level encountered on the continent. This is the main reason why UK graduates would get the PEGASUS certificate and award (see Chapter 6) only after one year of professional experience.

2.1.3 Engineering programmes: definition of course categories

As shown in chapter 3, the various national structures of higher education for engineering in Europe are a source of diversity across PEGASUS members. Beyond the structure of engineering programmes, the programme contents themselves may vary considerably from one institution to another. But in the end, all PEGASUS member programmes produce aeronautics or space engineers who can be recruited as such and are quickly operational in their aerospace companies. This is no real wonder, it just shows that, beyond the rich variety of the PEGASUS engineering programmes, there is also a large amount of commonality, that gives a sense to the phrase « European aeronautics / space engineer ».

In order to simplify and summarise these commonalities in our PEGASUS engineering programmes, our approach has been to classify their contents into the following categories:

FS : FUNDAMENTAL SCIENCES

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

ES : ENGINEERING SCIENCES

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

AE : AEROSPACE ENGINEERING SCIENCES

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

GC : GENERAL COURSES

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

IT/FYP : INDUSTRIAL TRAINING / FINAL YEAR PROJECT

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

There is some logical sequence in the various categories above. The Fundamental Sciences (FS) – as their name indicates – are mostly courses upon which the others are built up (such as maths) and are therefore mostly taught in the first part of the curriculum (generally the first two years). Engineering Sciences (ES) and Aerospace Engineering (AE) courses are taught at a later stage and constitute the core of the engineering teaching in all the PEGASUS institutions. On the other hand, General Courses (GC) have an extremely varying status, ranging from almost nothing in certain programmes up to a substantial part in others (almost 20%), spread all over the 5 years of training. Finally, the practical experience (IT/FYP) varies also considerably from one country to another according to national or local guidelines.

2.1.4 Commonalties of PEGASUS aerospace engineering programmes

All PEGASUS aerospace engineering programmes are comprised of courses / practical training in each of the above 5 categories. A closer look at the figures show that, based on a complete 5-year aerospace engineer programme (+ 5 level), all programmes include :

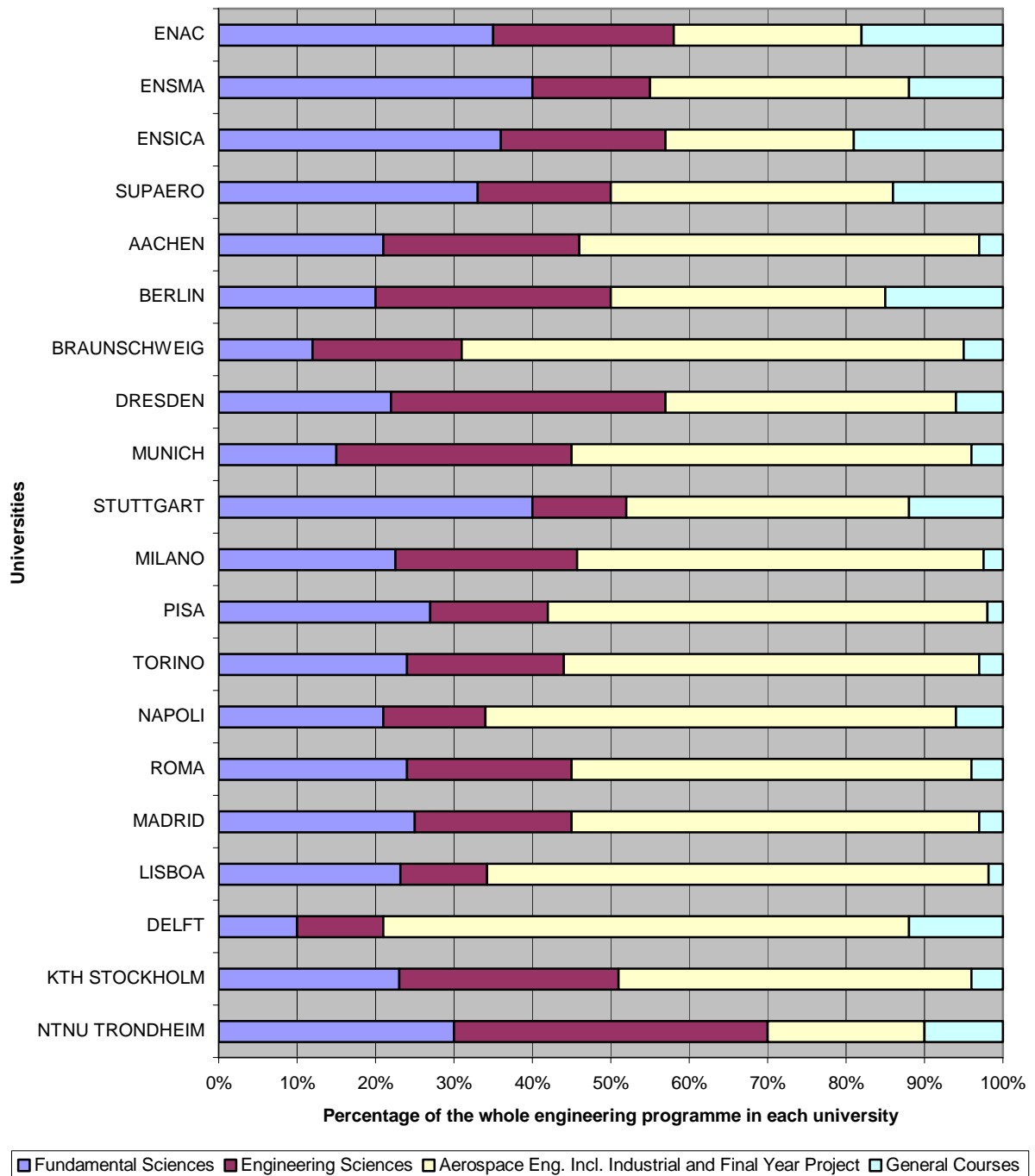
- 15 % or more of fundamental sciences
- 40 % to 60 % of engineering sciences (including aerospace engineering sciences)
- up to 15 % of general courses
- a practical experience from 5 % up to 25 % of the whole programme.

According to what was said in the previous chapters about the duration differences between the UK and the continent, it is easier to compare first the continental PEGASUS aerospace engineering programmes (see chart above). There is a striking similarity in most of the programmes, in that they are balanced in more or less the same way across national boundaries.

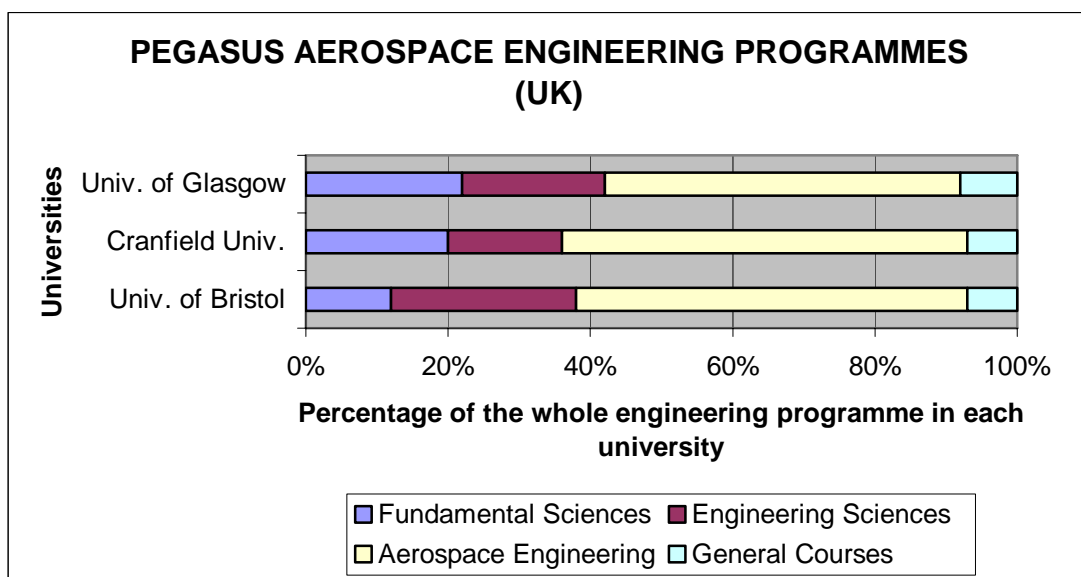
Obviously, countries with a strong centralised administration of education (France, Italy) show little dispersion in their programmes' profiles, but their programmes are also quite similarly balanced as those of Spain, Portugal and Sweden. For instance, in all those countries, the proportion of basic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

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

PEGASUS AEROSPACE ENGINEERING PROGRAMMES (Continental Europe)



Coming now to UK universities, there is a larger dispersion between universities, notably Cranfield (which offers only one-year specialisation programmes). A better description of the full profile of a Cranfield graduate would be obtained by “mixing” the Cranfield programme profile with one “standard” Bachelor’s or Master of Engineering programme (say : Bristol or Glasgow, for instance). The resulting “corrected” Cranfield profile, over 5 years, would give less abnormal figures like: FS = 20% , ES = 16% , AE = 57% , and GC = 7% (roughly speaking).



After taking into account the above “correction” to estimate a full curriculum profile, the universities of UK show a better correlation in their programmes, with around 40% devoted to FS and ES.

In any case, the main consideration about UK universities is their strong emphasis put on specialisation courses – in this case Aerospace Engineering courses – which represent over 50% of the overall engineering programme. If we add up the Engineering Courses category (ES), the total amounts at over 70% (up to 82% for Bristol). Clearly, this strong emphasis on specialised engineering courses leaves few space for fundamental sciences and general courses in UK universities.

2.2 PEGASUS MASTER DEGREES

2.2.1 Aerospace Master degrees

The word “Master” has become quite confusing today in the world of higher education. Coming from the anglo-saxon academic world (UK and USA), where it already has a different meaning across the Atlantic, as we could see from the previous chapters, it has spread all over the world, some countries sticking to the UK scheme, others to the US model, and others still adapting the word to their local descriptions !!! This is the case in some European, non culturally anglo-saxon countries (France, Italy, Spain,...) where the word “Master” also has some similarity with old Latin roots. The consequence of this richness of sources and adaptations appears in what can be considered as a conceptual maze for people not directly involved in the field of higher education!

If we try to summarise the different meanings the clearest way possible, let’s say that:

- a Master’s degree is always a degree given at a higher level of education, after a first degree (Bachelor’s) and / or after completing a sufficient number of years of post-secondary studies (4 to 6 years);
- Master’s degrees entitle their holders to pursue doctoral studies / research work towards a higher degree (Doctorate / PhD) or to work directly as an engineer in the industry ;
- In the USA and countries having adopted a higher education system derived from the US system (like Canada, Japan, China...), the first degree (Bachelor’s) corresponds to 4 years of study and the Master’s to 18 months to 2 years on top of the first degree (5,5 to 6 years of post-secondary studies);
- In the UK and countries having adopted a higher education system derived from the UK system (many Commonwealth countries, except Scotland, see chapter 2.1.2), the first degree can be 3 or 4 years and the Master’s corresponds to 1 to 2 years of studies on top of it (5 to 6 years of post-secondary studies);

In **France**, we encounter a mix of different meanings:

A “**Mastère spécialisé**” (in short: MS, english translation: Specialised Master) is a *label* given by the French “Conférence des Grandes Ecoles” to a one year programme for higher education graduates holding a French engineering diploma (or equivalent) and in-company engineers who wish to acquire a complementary training or a specialisation in a given topic(continuing education).

It usually amounts to about 350-400 hours of classroom teaching and includes a 4 to 6 month- industrial placement or internship in a research laboratory, assessed by a professional thesis.

A “**Mastère en Sciences**” (in short MSc., english translation: Master of Science) is also a *label* given by the French “Conférence des Grandes Ecoles” to a one year and a half programme for students holding an American Bachelor (4-year higher education) or

equivalent. It is an initial education programme aimed at students and not a continuing education programme targeting professionals like the MS.

It usually amounts to about 500-600 hours of classroom teaching and also includes a 4 to 6 month- industrial placement or internship in a research laboratory, assessed by a professional thesis.

For adapting the French system to the European framework 3-5-8, the French Ministry of Education recently created a national diploma called “**Diplôme National de Master**” (DNM). These new programmes are accredited by specific committees having a delegation from the Ministry of Education. They are open to students holding a +3 level degree of the European scheme or equivalent (French Licence, Italian Laurea or English BSc., etc...).

Their duration (for the Engineering schools) is 2 full years (4 semesters), corresponding to 120 ECTS credits, and including a final 4 to 6 month- industrial placement or internship in a research laboratory.

Last but not least, the DNM like the French “Diplôme d’ingénieur” (see chapter 2.1) automatically grant to their holders the universitarian “grade” of **Master** (in French!). This new “grade” was created recently (again for European purposes) and corresponds to the 3-5-8 scale:

- 3-level: grade of “Licence”
- 5-level: grade of “Master”
- 8-level: grade of “Doctorate”

In any case, all these French categories of Masters share the general characteristics of the Masters depicted above (higher level, substantial duration of studies: 4,5 to 6 years, etc...).

In **Italy**, the Master courses are open to holders of the Laurea or Laurea Magistrale degrees and consist of one to one-and-a-half year programmes. They are usually specialised and strongly job-oriented and include a significant industrial internship period and a project. At the end of the course, students are awarded a “Diploma di Master” (nationally recognised by the Ministry of Education).

Spain is introducing Master courses open to students holding a first university degree: “Diploma de grado” (3 to 4 years of study). They include one to one-and-a-half year programme plus a final project and entitle the student to get a “Diploma de Master” (nationally recognised by the Ministry of Education).

In **Germany**, some universities are also introducing Master courses which are derived from their Diplom-Ingenieur courses, but often taught in English in order to better attract foreign students. Through an agreement reached between 9 German technical universities (“TU Neun”), all 6 German PEGASUS partners are committed to recognise each other’s Master’s degrees.

Full list of currently existing PEGASUS Aerospace Master degrees

France

ENAC Toulouse:

- M.S. Aviation Safety / Aircraft Airworthiness¹³
- M.S. in Satellite-based Communications, Navigation and Surveillance (CNS)
- M.S. in Airport Design and Management
- M.S. in Air Transport Management (*jointly with Toulouse Business School*)
- M.S. in Aeronautical Operations
- M.S. in Aviation Safety Management – Airworthiness¹¹
- M.S. in Aviation Safety Management – Flight Operations¹¹
- M.S. in Aviation Safety Management – Maintenance¹¹

SUPAERO Toulouse:

- M.S. Techniques for aeronautics and space : option Aeronautics
- M.S. Techniques for aeronautics and space : option Astronautics¹¹
- M.S. Aeronautical telecommunications and electronic systems
- M.S. Command and embarked systems
- M.S. Light aeronautical structures
- M.S. Aerospacial propulsion systems
- M.S. System engineering
- M.S. Integrated logistic support¹¹
- MSc. Aeronautical engineering
- MSc. Aerospace communications systems (*jointly with Télécoms Paris*)

ENSICA Toulouse:

- M.S. Aeronautical Maintenance
- M.S. in Helicopter Engineering
- M.Sc. Aerospace Engineering (DNM) (*in accreditation process*)
- M.S. Aviation Safety / Aircraft Airworthiness¹²
- M.S. in Aviation Safety Management – Airworthiness¹²
- M.S. in Aviation Safety Management – Flight Operations¹²
- M.S. in Aviation Safety Management – Maintenance¹²
- M.S. Techniques for aeronautics and space : option Astronautics¹³
- M.S. Integrated Logistics Support¹³

¹³ Jointly with ENSICA

¹² Jointly with ENAC

¹³ Jointly with SUPAERO

ENSMA, Poitiers (*partnership with University of Poitiers*) :

M.S. Mechanics, Energetics and Engineering, options in:

- Engineering in Solid Mechanics
- Fluids, Acoustics, and Energetics

M.S. Physics and Materials Engineering, option :

- Physical Properties and Materials Mechanisms

Italy

Univ. di Roma :
 Master in sistemi di trasporto spaziale
 Master in satelliti e piattaforme orbitanti
 Master in trasporto aereo (*jointly with ENAC*)

The Netherlands

TU Delft MSc. Space Systems Engineering

Spain

ETSIA Master Sistemas Aeroportuarios

United Kingdom

U. of Bristol: MSc. Aerospace Design, Manufacture and Management
 MSc. Aerospace Engineering

Cranfield U.: MSc. Aerospace Dynamics with options in
 - Aerodynamics,
 - Flight Dynamics
 - Computational Fluid Dynamics.
 MSc. Thermal Power with an option in Aerospace Propulsion
 MSc. Aerospace Vehicle Design with options in
 - Structural Design
 - Avionics
 MSc. Air Transport Management
 MSc. Astronautics and Space Engineering
 MSc. Human Factors and Safety Assessment in Aeronautics

Cranfield U. (cont'd):

The following MSc programmes are available on a part time basis requiring a total study period of 45 weeks over three years:

MSc. Aircraft Engineering
MSc. Airworthiness
MSc. Safety and Accident Investigation

U. of Glasgow: MSc. Aerospace Engineering

2.2.2 Other Aerospace-related Master degrees

Cranfield U.: MSc. Applied Psychology
MSc. Advanced Materials
MSc. Structures, Crashworthines and Impact

ENSMA, Poitiers (in partnership with the University of Poitiers) :
M.S. Automatics & Control

2.2.3 ERASMUS MUNDUS European Masters

A proposal has been submitted in Brussels as an answer to the call for tender in the framework of the Erasmus Mundus programme for 2005-06 and was officially selected for the second round in January 2005.

The consortium is made of University of Pisa, TU München, ETSIA in Madrid, Cranfield and SUPAERO, which are all PEGASUS members.

Successful student candidates are awarded a European Master in Aeronautics and Space Technology as the result of two years of study in at least two of the universities within the consortium, accumulating 120 ECTS credits.

Scholarships are available for candidates from countries outside of the European Union and the first course will begin in Pisa, Italy in the autumn of 2005.

2.2.4 Specific modules offered by the PEGASUS partners

Every institution of the PEGASUS network offers specific modules to students, in areas usually related to the activities developed in its research laboratories.

Leaving apart individual lectures or dedicated seminars, dictated by the academic staff of the institution or by visiting professors, the specific modules considered here are well established, permanent teaching activities, offered to students as complementary or additional to the curricula, or as modules embedded in the main curriculum as specific specialization, always with a well characterised development, including the evaluation criteria.

The format of the specific modules, by its nature, may vary appreciably, ranging from one week duration to several months and are measured in ECTS.

It is not the intent of this paragraph to include a comprehensive list of all the modules being offered by each institution; it suffices to say that they cover a great variety of fields and techniques with a diversity of approaches. As illustrative examples, some may have a deep scientific content (ex.: "dynamics of space tethers", 4 ECTS), while others permit the familiarisation with specific techniques (ex.: "Preparation and utilisation of aeronautical manuals and other aeronautical documentation", 3 ECTS).

2.3 STRONG AREAS OF THE VARIOUS PEGASUS AEROSPACE ENGINEERING PROGRAMMES

Individual PEGASUS member institutions show various aerospace engineering specialities. These specialities are reflected through a variety of courses or programmes, some of which are mandatory for all students while others are optional (electives). Consequently, some PEGASUS members display a large offer of courses but this does not mean that they are taken by all of their students. In some cases, these courses are taken by a very small number of students each year, whereas others are not even open each year because of a lack of students willing to attend them.

If we focus more closely on the aerospace engineering sciences category, our approach shows that some topics are widely taught across the PEGASUS engineering programmes, such as aerodynamics, aeronautical structures & materials, aircraft design, propulsion & combustion... Others are more concentrated in some member institutions, which put on emphasis on certain specialities like aircraft operations, air traffic control, space engineering & technology, etc...Further analysis, including a fine description of research topics and publications, would also differentiate PEGASUS members from one another and put forward areas of excellence/expertise niches.

The overall offer of disciplines (mandatory and elective) of each PEGASUS member is reported in relative terms (as percentages of ten selected comprehensive aerospace domains

over the total amount of aerospace ECTS offered in that university) in the figures of the Annex.

These ten categories are:

- 1. Aerodynamics, Gas Dynamics, Heat Transfer**
- 2. Structures, Materials**
- 3. Aircraft Design, Subsystems and Integration**
- 4. Rotary Wing Systems and Non-conventional Aircraft**
- 5. Performance, Stability and Control, Flight Dynamics**
- 6. Propulsion & Combustion**
- 7. Production & Maintenance**
- 8. Aircraft Operations, Aviation Safety, Airlines / Airports Operations and Management, Air Traffic Management**
- 9. Aircraft Navigation, Avionics, Communications**
- 10. Space Engineering & Technology**

As a consequence of the possibility given to the students to freely choose a certain number of disciplines, an occurrence profile for each PEGASUS members' programme can only be characterised in the very general sense of the gross percentages of the last section above. However, it is also possible to list "strong" areas for each institution, around which students have more or less opportunities to shape their own individual profile. This is possible in different ways: either by choosing certain courses or ranges of courses within their own university, or in a PEGASUS partner university, in the home country or abroad, for a short or a longer period. For this latter case, PEGASUS coated a special recognition: the PEGASUS A.W.A.R.D. (see chapter 3.4). The "strong" areas deduced from the data mentioned above are listed below:

STRONG AREAS OF THE VARIOUS PEGASUS MEMBERS
(AEROSPACE ENGINEERING CATEGORIES)

FRANCE

ENAC (Toulouse)	Aircraft operations, aviation safety, airline/airport operations & management, air traffic management; Aircraft navigation, avionics, communications; Aircraft Design, Subsystems and Integration; Performance, Stability and Control.
ENSICA (Toulouse)	Aircraft design, subsystems & integration; Aircraft navigation, avionics, communications ; Structures, materials; Aerodynamics, gas dynamics ; Space engineering & technology.
ENSMA (Poitiers)	Aerodynamics, gas dynamics, heat transfer; Structures, materials; Propulsion, combustion.
SUPAERO (Toulouse)	Aerodynamics, gas dynamics; Propulsion, combustion; Aircraft, navigation, avionics, communications; Space engineering & technology; Structures, materials.

GERMANY

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



AEROSPACE ENGINEERING PROGRAMMES

TU DRESDEN Structures, materials; Aerodynamics, gas dynamics,; Propulsion, combustion ; Space Engineering & Technology ; Aircraft Navigation, avionics & Communications.

ITALY

POLITECNICO DI MILANO Structures, materials; Aerodynamics, gas dynamics; Propulsion, combustion; Space engineering & technology.

UNIV. DI PISA Structures, materials; Aerodynamics, gas dynamics; Performance, stability & control, flight dynamics; Space engineering & technology.

POLITECNICO DI TORINO Structures, materials; Aerodynamics, gas dynamics; Propulsion, combustion; Aircraft design, subsystems & integration; Performance, stability & control, flight dynamics.

UNIV. DI NAPOLI Structures, materials; Aerodynamics, gas dynamics; Aircraft navigation, Avionics, Communications; Performance, Stability and Control; Aircraft design, Subsystems and Integration.

UNIV. DI ROMA Space Engineering & Technology; Structures, materials; Aerodynamics, gas dynamics; Propulsion, combustion; Performance, Stability and Control, Flight Dynamics.

THE NETHERLANDS

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

NORWAY

NTNU TRONDHEIM Aerodynamics, gas dynamics; Structures, materials; Propulsion, combustion; Production, maintenance.

PORTUGAL

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



SPAIN

ETSIA MADRID

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

SWEDEN

KTH STOCKHOLM

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

UNITED KINGDOM

UNIVERSITY OF BRISTOL

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

CRANFIELD UNIVERSITY

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

UNIVERSITY OF GLASGOW

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

3. ENSURING ADEQUATE, HIGH QUALITY AEROSPACE ENGINEERING PROFILES FOR THE EUROPEAN INDUSTRY.

3.1 QUALITY, A “MUST” FOR A HIGH-TECH SECTOR LIKE AEROSPACE

The statement that the European aerospace sector relies on the availability of highly qualified engineers, and hence of **high quality universities and schools** that educate them, may look somewhat obvious. As already emphasized in section 2.1 above, from its inception at the beginning of the 20th century, aerospace concepts and technology never ceased to require the highest degree of scientific knowledge and technological developments and to look for the most talented young engineers and scientist.

However, speaking today of *quality* has a more complex significance than in the past. While still retaining its traditional and generic meaning of *merit* or *value*, in fact, the word *quality* is now used also to imply that a more or less large set of established criteria is satisfied and that this is testified by a formal judgement following a neutral evaluation procedure. In the domain of high education, this lexical evolution is related to the new demand of increased transparency and comparability of the European curricula raised by the Sorbonne - Bologna process and ultimately aims to promote European-wide and global recognition of the degrees. Only curricula of comparable quality, then, can be recognized as leading to engineers of equivalent value, no matter how different some aspects of their specific technical knowledge may be.

This request of comparability of the curricula and of transparency of the degrees are of course general, but it is in the aerospace domain that their importance becomes vital. Here all significant activities are transnational, at European or world-wide level, and engineers from different countries work every day alongside. The possibility to employ graduated from everywhere in Europe, then, is a formidable resource for aircraft manufacturers and space agencies, provided these are duly informed on the quality of the high education institutions graduating them. The simplest way to provide this information for an institution is to display a **quality label**, which can also mean **to be accredited** by some independent body. The latter could be an European Quality Assurance Agency for Higher Education, but at present its constitution is still a middle term objective.

But, as remarked above, European aerospace does not only require comparability and transparency. The documented quality has also to be *high* in order to allow this high-tech sector to withstand the world-wide competition. High quality usually means efficient structures, internal processes under standing control and good management, all aspects ruled by the ISO 9001 standards and similar. In the educational domain, however, high quality means also that the contents and the methods of teaching have to be qualitatively and quantitatively fitted to the purpose of meeting the societal needs. Stating the threshold requirements for such a quality assessment needs a deep insight into the specific aspects of aerospace which can be accomplished only through a joint analysis performed by the main European high education institutions together with the European aerospace industries, space

agencies and all other possible stakeholders. In this activity PEGASUS can play the essential role outlined below in section 3.5.

3.2 INNOVATIVE PEDAGOGICAL METHODS, BEST PRACTICES

Most PEGASUS partners have already started to implement quality processes and some of them have also obtained accreditation labels in their countries or outside. These may be of different kind. To quote here only some instances:

- The programmes of the **UK universities** are assessed by the Quality Assurance Agency for Higher Education (QAA). Further, aerospace programmes are also assessed by the Royal Aeronautical Society (RAeS). Since RAeS and ABET reciprocally recognize each other, UK programmes assessed by RAeS are fully recognized also in the US.
- The **Dutch** engineering programmes are accredited by the national agency VSNU. Additionally, the complete aerospace programme of TU Delft (structured according to the 3+2 Bologna scheme) is also accredited by the US agency ABET.
- The aerospace programmes of the **French** GEA schools are audited every 6th year and nationally accredited by the Commission des Titres d'Ingénieur (CTI), which releases the permission to award the engineering degree (national diploma authorised by the Ministry of Education).
- The aerospace programme of the 1st degree of **Politecnico di Torino** (structured according to the 3+2 Bologna scheme) is fully accredited by the Region of Piedmont. Additionally, its job-oriented path is accredited by ENAC (Ente Nazionale per l'Aviazione Civile) as compliant to the norm JAR 66 (now EASA Part 66) for the release of the Aircraft Maintenance Licence Class C.
- In **Sweden**, only MSc-level programmes accredited by the National Agency for Higher Education (Högskoleverket, HSV) are allowed to award the "civilingeniör" diploma. This is the case of KTH Stockholm.
- In **Portugal**, IST Lisboa programmes are certified by the professional association (Ordem dos Engenheiros), which allows graduates to be immediately admitted in it after the diploma. Additionally, the IST programmes are also certified by the Council of the Rectors of the Portuguese Universities (CRUP).

All these certifications and/or accreditations are obtained after rather demanding evaluation processes conducted by independent experts. These include compilation of extensive dossiers, audits, interviews, inspection of the administrative and organisational procedures, visits to the lecture rooms and to the laboratories and so on. The evaluations are usually repeated every 3 to 6 years, but this deadline can be much shorter in the initial phase.

The produced dossiers document, among others, all the **best practices** adopted by the high education institutions to identify possible weaknesses and to remove them in order to improve the pedagogical and administrative efficiency of the overall structure. Focusing on teaching in particular, some of the most recurrently quoted best practices are:

- questionnaires on the teaching quality, to be anonymously filled by the students in each course or before end of a cycle. The way these questionnaires are evaluated and the feedback they originate is also evaluated;
- documented existence of official and periodical occasions to discuss curricula and teaching methods with the societal counterparts (employers, local authorities, ...) and the other stakeholders;
- accurate monitoring of the student provenance and composition (also with reference to the percent of females), of their progresses during the studies (including statistical evaluations), of their employment rates after the degree;
- availability of the detailed programmes of all offered courses and, in general, the transparency of the practical information to the students.

It is worth noting that most (if not all) these practices have already been implemented not only by the above quoted PEGASUS partners, but also by several others not yet provided with accreditation labels of any kind. For instance, student questionnaires are applied in almost all German and Italian PEGASUS universities. As to the regular contacts with the societal counterparts, particularly with the industry, PEGASUS itself offer the best framework for it at the European level, i.e. at the most significant level for the aerospace activities. Therefore, simple belonging to PEGASUS strongly helps an aerospace institution to satisfy this request.

From this short outline it appears that, on average, **the partners of the PEGASUS network are already well provided** with the main requisites needed to be awarded with accreditation labels, if not already possessed. Some requisites, however, are not always requested by the current evaluation procedures in spite of their great importance for the aerospace environment. For instance:

- the quantitative and qualitative level of the European and world-wide students and teacher mobility;
- the offer of courses in English language to facilitate the student exchanges but also to improve the attractiveness of the PEGASUS institutions in the world;
- the possibility offered to the students to work in European teams, for instance during the preparation of their final projects.

It is no wonder that requests like these are not explicitly posed by most quality assurance agencies, since these still work on national bases. The value of quoted requisites, on the contrary, becomes immediately visible in a domain which surpasses the national one, as in Europe. Undoubtedly they are equally best practices deserving consideration: additionally, they are possessed at a high degree by the PEGASUS institutions. Hence the emphasis, placed

by PEGASUS, on the need for an European accreditation scheme for engineering studies and for the aerospace studies in particular.

3.3 CONTRIBUTION OF PEGASUS TO TRANS-NATIONAL STUDENT PROFILES

The curricula offered by individual universities show a wide variety of courses and programs. Thus, the students trained by any individual university have different profiles from each other. The student exchange programmes inside PEGASUS increase this variety since the diversities of the curricula of the host and the home universities can be added. All PEGASUS students granted with the PEGASUS AWARD (see below) present such crossed engineering profiles.

In an increasing number of cases, the exchange programmes between PEGASUS members may also lead to double degrees. PEGASUS represents an ideal framework for such developments, leading to new, mixed curricula using the best pedagogical and research resources of its members to optimise these new programmes.

Furthermore, still aiming at improving quality, the PEGASUS network provides the right environment to implement practices of transnational benchmarking in aerospace. In a recent ENQA Workshop Report¹⁴ this is called *creative benchmarking* and the related activity is defined as that of a “department of a university performing comparative assessment with foreign partners”. Moreover: “In an ideal situation it may lead to the development of study programmes that adapt the best practices of both partners”. Further: “A balance between the similarities and differences between the benchmarking partners is one of the crucial elements”. It is apparent that the PEGASUS partner institutions have already made some important steps forward on this way and that a further intensification of this action, provided it is supported in the framework of the quality processes encouraged by the EU, will directly result in a lot of new crossed curricula and other pedagogical activities commonly offered to the European aerospace students.

3.4 PEGASUS CERTIFICATE AND AWARD

Even before constituting themselves as an association the PEGASUS universities were related to one another through a tight net of scientific collaborations, student exchanges for projects or courses, mutual recognition of parts of curricula and, in some cases, also double degree agreements. On the basis of this long experience they build up in the course of the years a framework of reciprocal trust, so that today each of them could testify the quality of the aerospace studies performed in each other of all PEGASUS institution.

It is therefore almost natural that at the very moment of its foundation PEGASUS, aiming to become the portal of the European higher aerospace education in front of the European aerospace industry and research centres, appointed itself with the task of ensuring employers of the common level of quality of the different degrees awarded by its member

¹⁴ *Benchmarking in the Improvement of Higher Education*, ENQA Workshop Report 2, Helsinki 2003

institutions across Europe. At the present stage this engagement refers only to the level +5 of the Sorbonne – Bologna scheme. Moreover, it should be intended that the testified common level of quality is an equivalence of standard, not of contents. Indeed, the programmes of the PEGASUS universities still differ remarkably from each other. PEGASUS shares nevertheless the view that these differences have to be safeguarded, as it is just in this variety that the wealth of the European higher education lies.

To officially make the academic achievements of its students internationally recognisable throughout Europe, two labels are issued and awarded by PEGASUS to complement the national degrees: the **PEGASUS Certificate** and the **PEGASUS A.W.A.R.D.** Both are signed by the Chairman of PEGASUS and by the Dean of the University and report on the back side the complete list of all PEGASUS members. They provide the possible embryo for a future European quality label in aerospace engineering.

The PEGASUS Certificate

The PEGASUS Certificate is to be attributed to all graduates of the PEGASUS institutions. It states their successful completion, within one or several partner institutions of the PEGASUS network, of a prescribed programme of study giving them the skills required to the exercise of the engineering profession in aeronautics and aerospace. By attaching the PEGASUS Certificate to his demands for employment in Europe, a young engineer will be enabled to demonstrate that the quality of his studies is comparable to that of the PEGASUS home universities of the employing company. It is believed that the PEGASUS Certificate will encourage the European mobility in the aerospace domain.

The PEGASUS A.W.A.R.D.

Differently from the Certificate, the PEGASUS AWARD (“special Achievement through Working Abroad for academic Research or industrial Development projects”) is to be attributed only to those students spending at least five months in either an international exchange programme in a partner institution or in an industrial or research project conducted in a partner company or laboratory. The PEGASUS AWARD is therefore a statement of recognition of the successful activity conducted by the student in an international environment under PEGASUS responsibility. This is an important point, because through the AWARD label PEGASUS certifies an international experience for which its own institutions have provided to the students the necessary conditions. It is expected that a young graduate engineer able to display the PEGASUS AWARD will already be in possession of a European vision, which will make him particularly attractive for employment in the aerospace world.

All issued PEGASUS AWARDS are registered in a central database by the PEGASUS Administrative Office in Toulouse, where their complete list is regularly updated.

3.5 QUALITY ASSESSMENT AND ADVICE: A POSSIBLE EUROPEAN ROLE FOR PEGASUS

In conclusion of section 3.2 the need for an European accreditation scheme for general engineering studies was raised. However, this is not an easy task and its accomplishment will probably take some years. Conversely, Quality Assurance activities inside specific fields can be envisaged in a shorter term and can provide the initial experience to be incorporated into more general projects. In this sense aerospace is certainly the best candidate to start with.

As highlighted above, a fundamental element in all programme evaluation procedures is provided by the societal requirements, among which the needs of the reference industry play a very important role. The European aeronautical and space industry is characterized by a very high level of integration (particularly if compared to other industrial branches) and already states common requirements to the high education in aerospace engineering. Parallel European integration processes are active also in the field of air transport (carriers, regulations ...).

On the opposite side also the university world has set itself in motion: PEGASUS already collects and compares the curricula of its member institutions and, through the requirements stated to the admission of the new members, is today able to provide a very fundamental and concise set of quality standards or threshold statement. In a future Quality Assurance system this set should of course be expanded and improved. In addition to this, PEGASUS started a dialogue with the European aeronautical industry. All these activities will ultimately lead to recommendations to the member university about the best way to modify their curricula in order to harmonize them and to meet the societal needs by preserving at the same time their traditional cultural values. In the usual language of Quality Assurance, this will be tantamount to a dissemination of best practices.

Based on the above considerations PEGASUS recommended to ACARE (the Advisory Council for Aeronautical Research in Europe) an action towards the EU Commission aimed to study a Quality Assurance system for the European high education in aerospace engineering. This study could ultimately lead to a true European Accreditation Board releasing some kinds of recognized label. Even if the whole process will probably take some years, the result would be of immense value. In doing this PEGASUS, through its member institutions, could be the best partner. The PEGASUS institutions, in fact, have gained a clear view, documented by the PEGASUS Brochure, of the contents of their courses and of the quality level of their graduating students, as an outcome of many years of established student exchanges.

There is also another, more general, point to be considered when evaluating or accrediting university programmes or structures. Even if restricted to local or national levels, accreditation of university curricula represents a formidable challenge because many available evaluation tools are still derived from ISO 9001 and cannot be directly applied. The traditions of free teaching and research still alive in our universities, in fact, can hardly be forced into the rigid requisites of ISO 9001, which are mainly based on the respect of an exhibited set of formal procedures and on the bare disposal of structures and manpower. But almost equally

important (if not more important) for universities is the assessment based on the comparison of the educational results to the educational objectives stated in advance. How to document these results in an objective way without simply recurring to a set of “blind” parameters is one of the open questions.

The underlying idea is that of the three current main evaluation philosophies respectively focussed on: a) the internal efficiency of the organisational machine; b) on the economic efficiency; c) on the external efficiency, i.e. meeting the needs of the students and their potential employers, the last one should be given precedence when a higher education institution is evaluated. Applying such innovative “non-ISO9001” procedure in a restricted regional or national framework makes little sense. Conversely, a proposal finalized to a common European Quality Assurance system offers the right opportunity to discuss this issue at a continental level, in order to finally arrive at an accreditation scheme which is not only commonly agreed, but also well suited to the university education.

As discussed above, this activity can be more easily performed in a limited domain and aerospace offers itself as the most natural candidate. In doing this PEGASUS, the European network of excellence in aerospace engineering education, can surely provide a significant contribution to be added to, and possibly to anticipate, more general accomplishments as those expected by ENQA (the European Network for Quality Assurance, which the Conference of the European Ministers of Education, gathered in Berlin on 18-19 September 2003, called upon to develop an agreed set of standards, procedures and guidelines on quality assurance) and its member agencies.



ANNEX

AEROSPACE ENGINEERING PROGRAMMES (Paragraphe 2.1)

AEROSPACE ENGINEERING COURSES CATEGORY

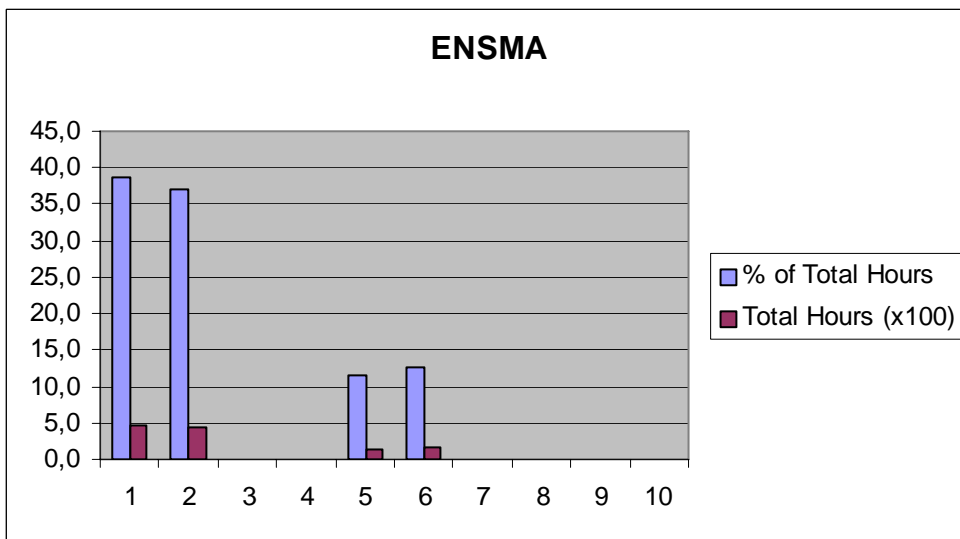
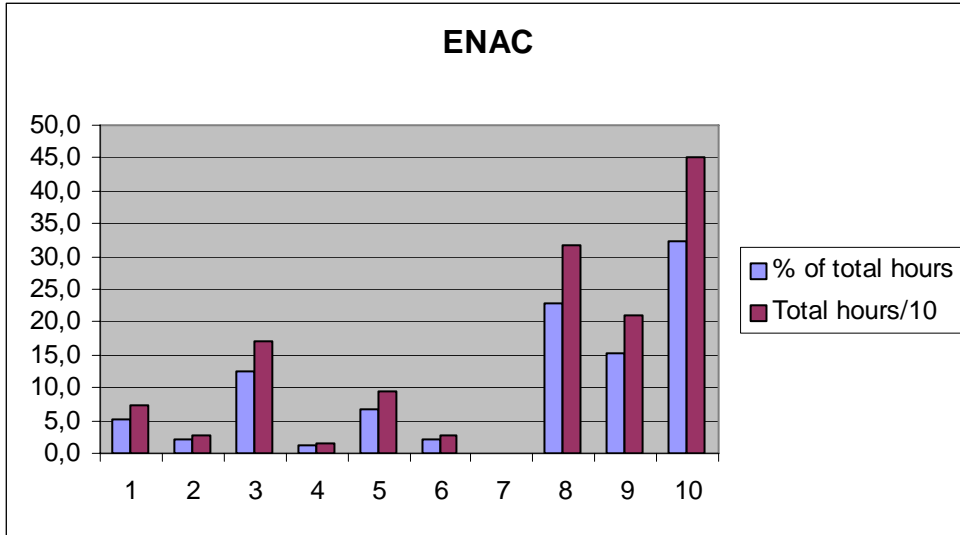
PROFILE OF EACH PEGASUS PARTNER PROGRAMME

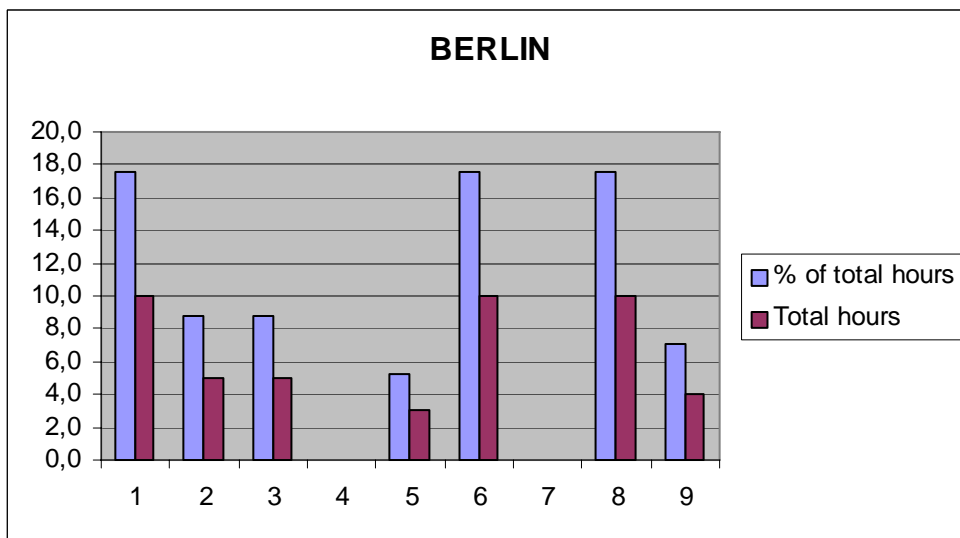
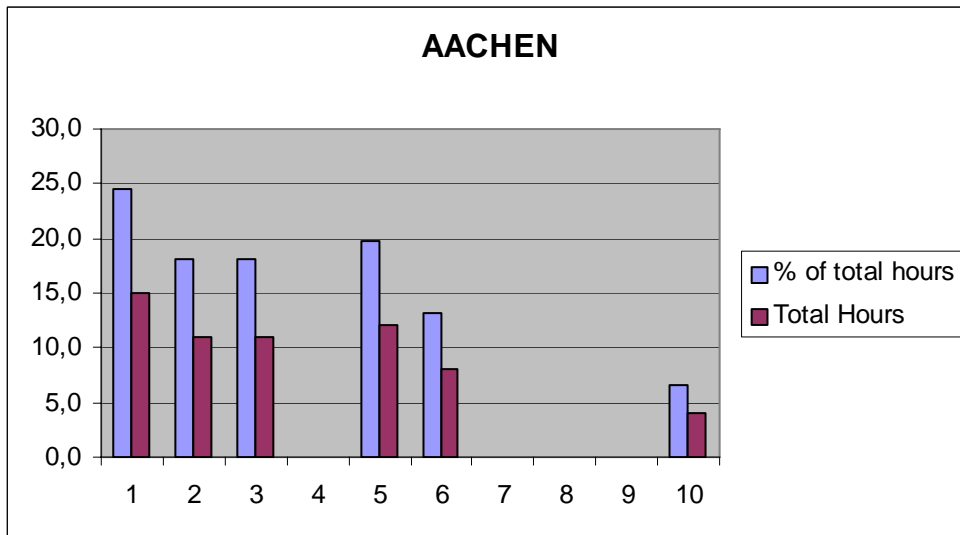
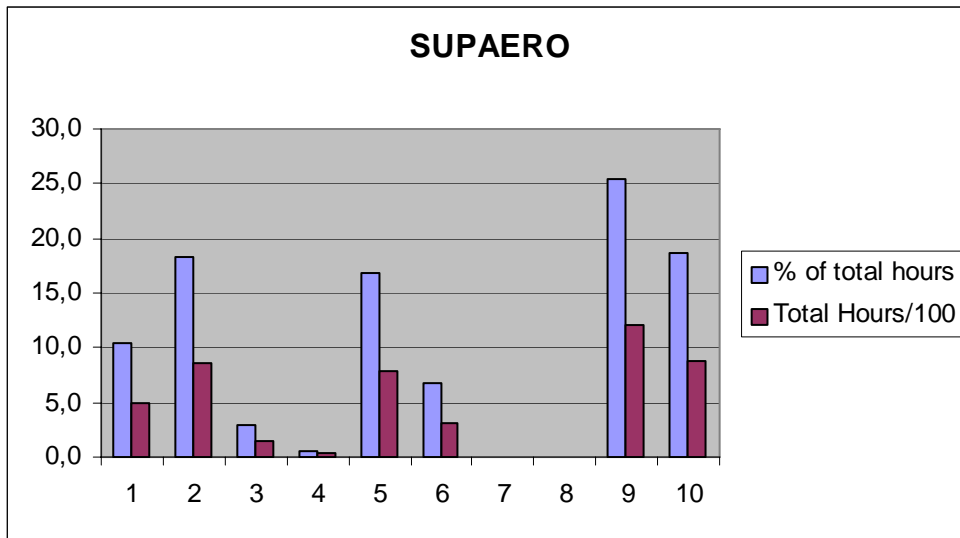
(in % of the total Aerospace Engineering courses offered in each institution)

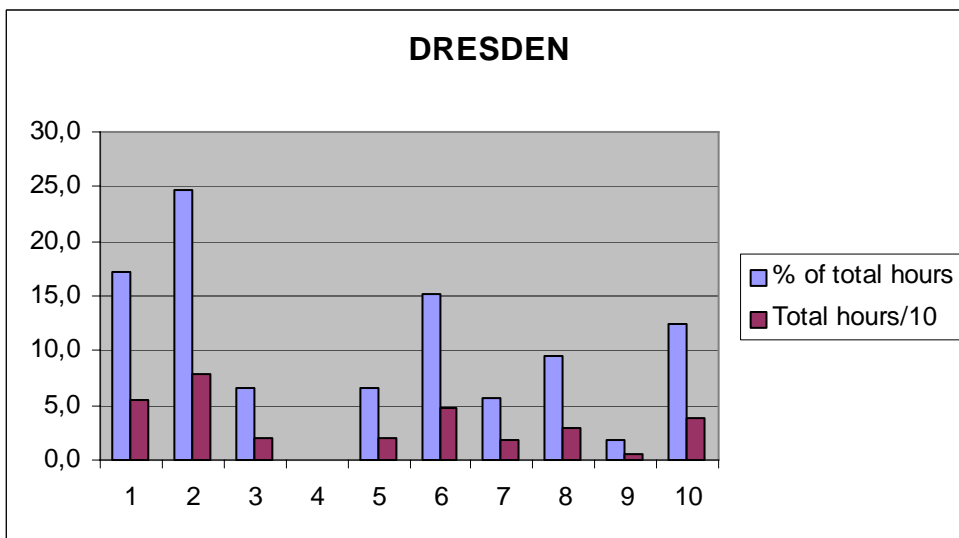
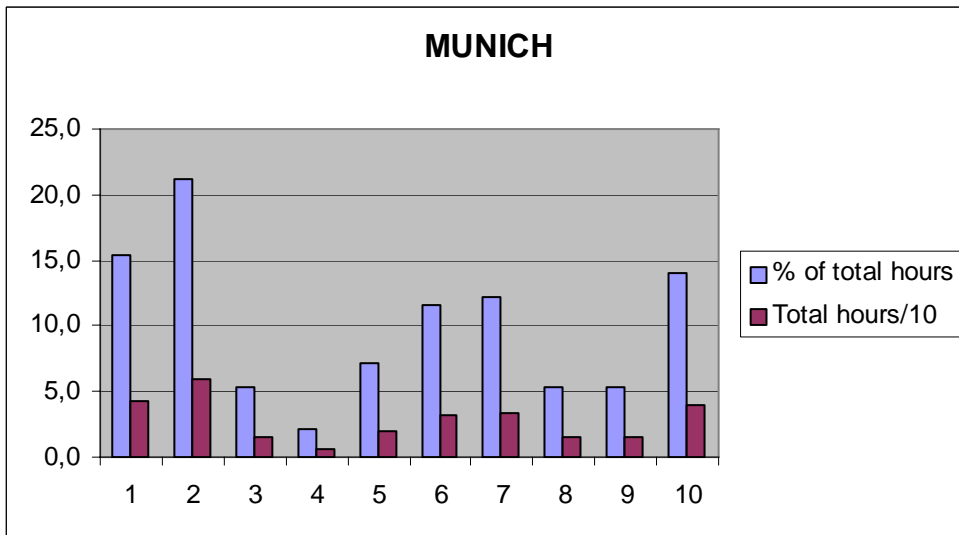
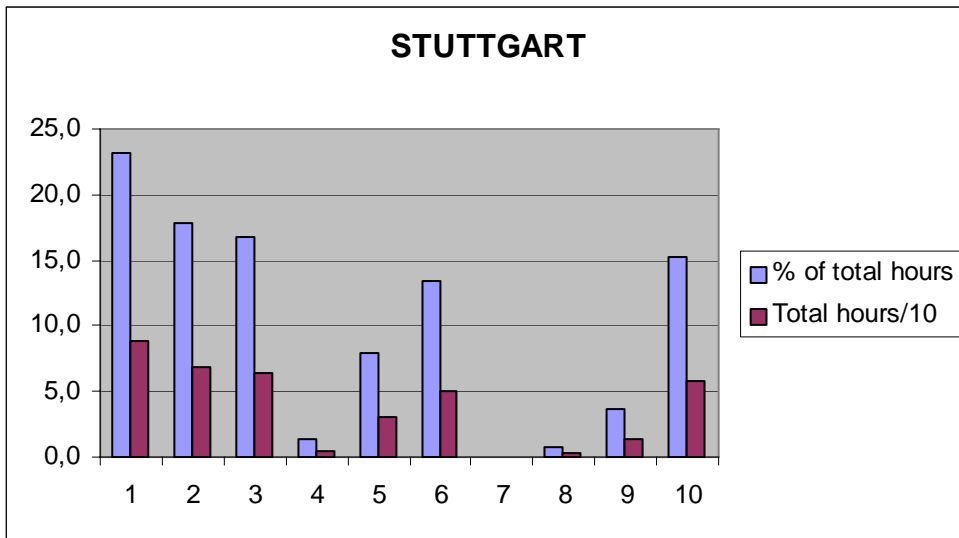
The ten categories are:

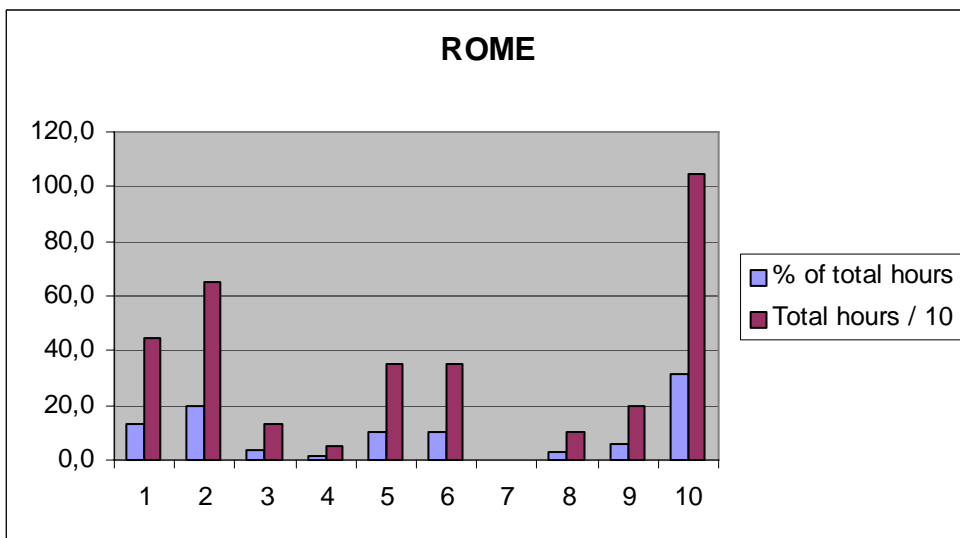
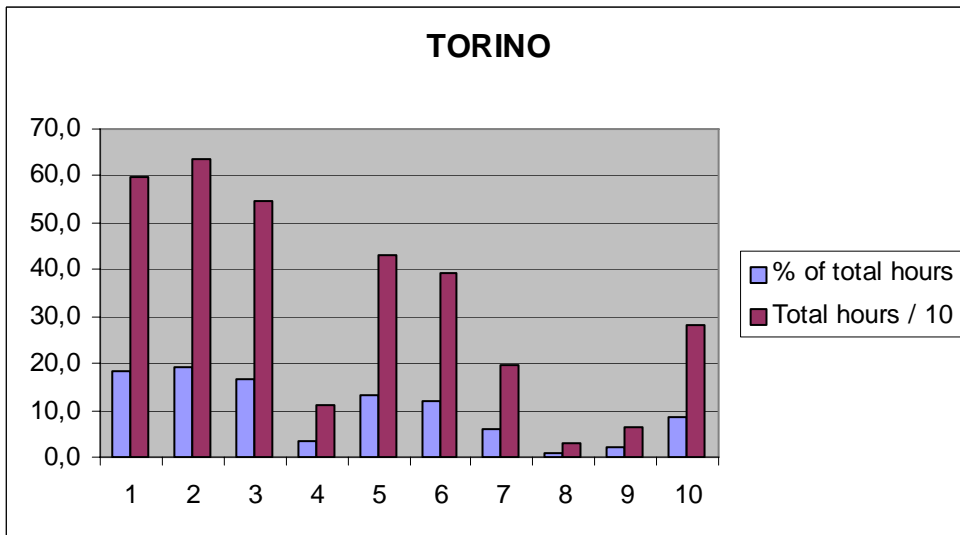
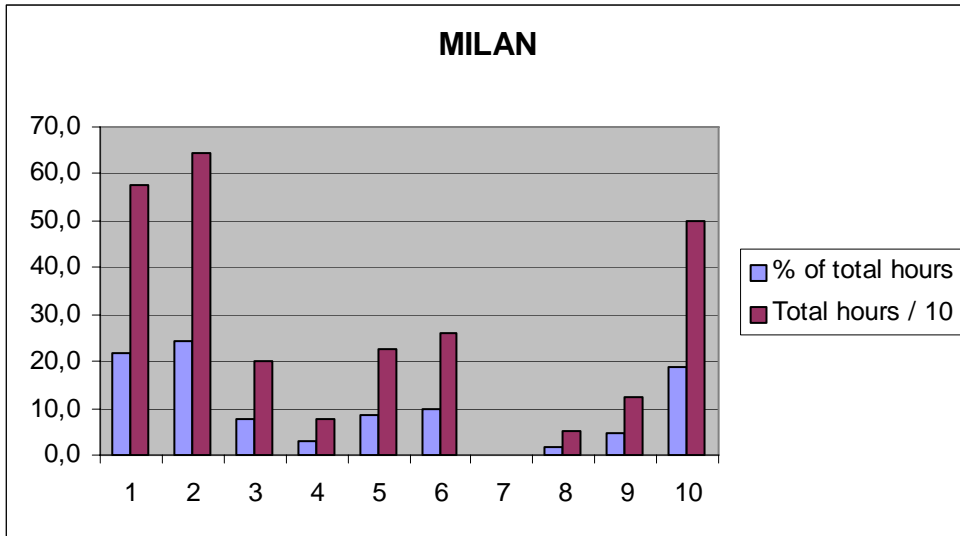
- 1. Aerodynamics, Gas Dynamics, Heat Transfer**
- 2. Structures, Materials**
- 3. Aircraft Design, Subsystems and Integration**
- 4. Rotary Wing Systems and Non-conventional Aircraft**
- 5. Performance, Stability and Control, Flight Dynamics**
- 6. Propulsion & Combustion**
- 7. Production & Maintenance**
- 8. Aircraft Operations, Aviation Safety, Airlines / Airports Operations and Management, Air Traffic Management**
- 9. Aircraft Navigation, Avionics, Communications**
- 10. Space Engineering & Technology**

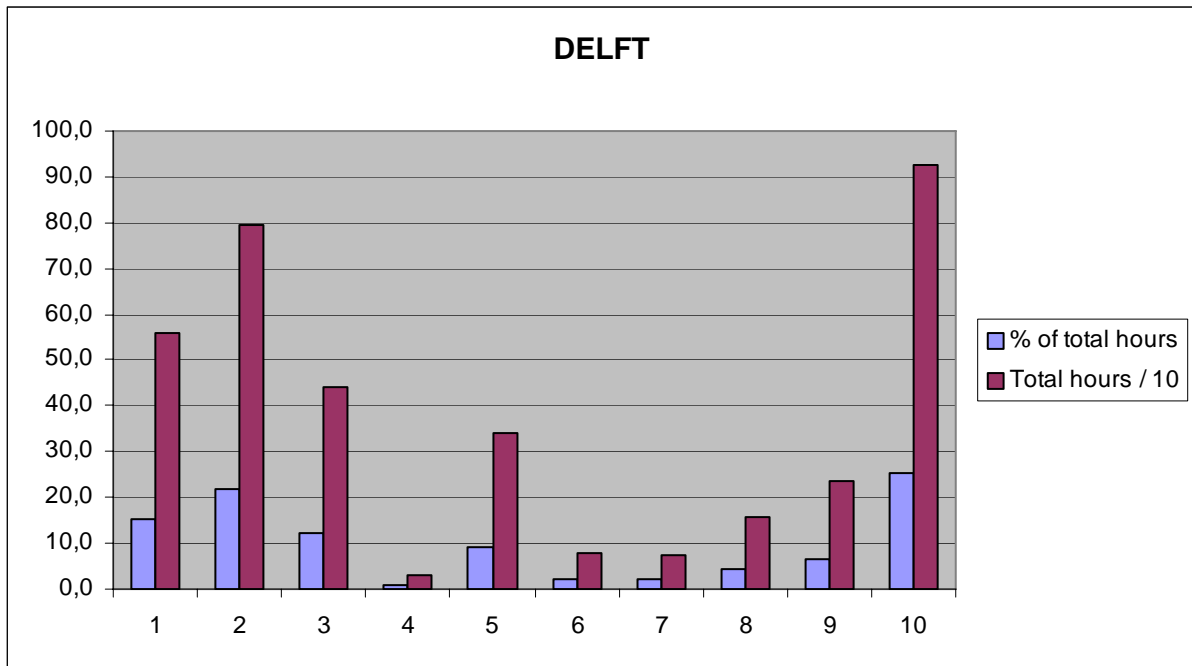
AEROSPACE ENGINEERING PROGRAMMES (in percentage of the total AE courses)











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