

THE WAY OF HARMONIZATION AND COOPERATION IN AEROSPACE EDUCATION IN EUROPE

A. Pernpeintner

**Institute for Fluid Mechanics TU Muenchen
Boltzmannstr. 15, 85748 Garching, Germany**

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Abstract

The ongoing opening of the education market across national borders necessitated new study structures in the tertiary education Europe wide. In the framework of the educational reform within the European Union initiatives have been taken with the objective to harmonize the educational systems of the different countries and to introduce new international oriented study curricula based on two main study cycles. In order to strengthen the internationalisation of the education numerous bilateral cooperation programs and university networks have been developed. The objective of this paper is to present the current engineering education system within Europe and to give an overview on the major cooperation programs and university networks.

1 General Introduction

The consolidation process of the European Aerospace Industry has implicated a continuous process of cooperation and mergers during the last decades, initially within national borders, but increasingly across these borders. Today, the major aerospace projects require development phases which are far longer compared to other industrial sectors and are so cost-intensive that they are only feasible with multinational cooperation [1], [2]. The international interlinkage of enterprises and the rapid technological change are closely associated with new qualification requirements [3]

The industry and the research establishments have clearly stated their requirements for future aerospace engineering

graduates. To work in an international team, with linguistic diversification and other cultural differences, will require a global mind setting which goes beyond a mere technical education. Already when studying, future aerospace engineers and technical managers of international aerospace projects have to learn to function in such an international environment. Considering the European dimension of engineering education, however, it has to be seen that graduates are differently prepared for industry, depending on the university they got their degree [4].

The European educational institutions will have to face a situation of competition of their graduates within Europe and beyond. To obtain international acceptance, the various educational programs will have to meet a certain standard of quality. In order to cope with this new requirements, the system of higher education has been restructured in most of the European countries. The basic approach of this restructuring process has been harmonization of the aerospace engineering curricula on the one side and the endeavour to intensify the cooperation, in particular in the development of common teaching programs, as well as to increase the exchange of students between different universities on the other side [1].

The first one encounters difficulties in many cases, because of the well-rooted local traditions and the different duration of university curricula. The second item is easier to be realised and well established, but it implies for the universities the creation of new international oriented staff for preparing mutual agreements and bilateral resolutions as well as

for supervising and recruiting outgoing and incoming students.

In the following, the present status and the way of harmonization of the European education environment is shown up. Furthermore, the most relevant European and transatlantic university cooperation programs on the aerospace sector are presented.

2 Harmonization Process of Aerospace Education in Europe

2.1 Aerospace Curricula in Europe – A Survey of Current Situation

The aerospace industry, with more than 425.000 employees Europe wide is one of the European key industry on the high technology sector. Among them 94% of all employees are concentrated on the 7 major aerospace industry nations which are Great Britain, France, Germany, Italy, Spain, Sweden and Netherlands. The complex questions in the field of aerospace require a share of 17% in research and development (see. Fig. 1). In consequence, more than any other branch, the aerospace industry relays on high level university graduates. In example, the European Aeronautic Defence and Space Company (EADS) will be taking on around 1,500 young graduates every year, primarily those specialising in aerospace engineering, electronic engineering, information technology and economics or business studies [5].

University education is a primary concern of government in all European countries, but the structures of education systems differ considerably, both within and between countries. A survey of representative university aerospace engineering education in the 7 leading European aerospace nations is shown in Fig.2 (for details it is referred to [7],[8],[9],[10],[11]).

In Germany, traditionally, aerospace engineering is a discipline within mechanical engineering. However, some universities have separate degree courses. Besides university education, more practical oriented and special

degree courses are offered by the *Fachhochschulen*.

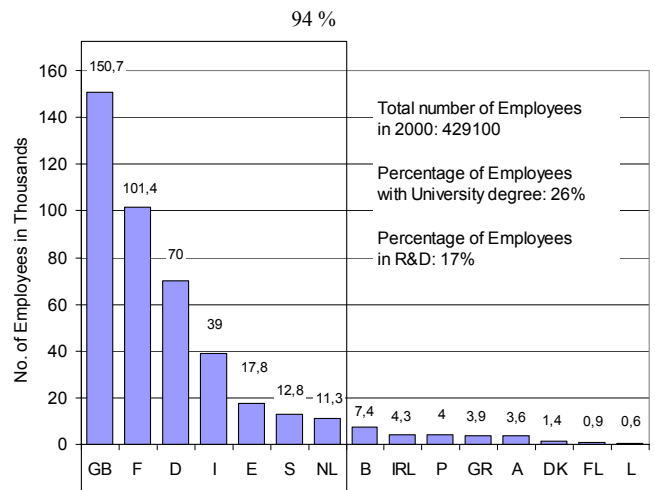


Fig.1. Number of Employees in the EU Aerospace Industry in 2000 according to [6].

University programs normally last five years, with two years (four semesters) of basic study covering fundamental natural sciences and completed by the Pre-diploma (*Vordiplom*) exam. It is followed by three years of advanced study. The study curriculum requires a total of 18 weeks of industry internship and is completed with a six month full-time scientific project: the diploma thesis. Upon completion, a University Diploma is awarded, abbreviated with Dipl.-Ing. (Univ.). The addition 'Univ.' serves to distinguish the University Diploma from the *Fachhochschule* Diploma.

Below the university level, the *Fachhochschule* education also leads to an engineering degree. Their programs usually have a duration of four years and are less based in theory than the university curricula. Their Diploma degree is abbreviated as Dipl.-Ing. (FH), to indicate its origin. It should be mentioned that it is not possible to obtain a doctoral degree from a *Fachhochschule*.

Since the amendment to the Framework Act for Higher Education of 1998, higher education institutions are entitled to award Bachelor or Master degrees. The new graduation system is supposed to supplement rather than to replace the traditional system.

Year	Semester	Germany Technical Universities	Netherlands Technical Universities	Spain Universities	France Grand Ecoles	United Kingdom Universities	Italy Universities	Sweden Universities
		Dipl.-Ing.	M.Sc.	Ingeniero Superior	Ingenieur Diplome	M.Sc.	Corso di Laura	Civilingenjör
5	10	Specialization Including 18 weeks Internship in Industry	Bachelor	Specialization	Specialized Engineering Cycle	M. Eng. Preliminary Year Bachelor	Specialization	Specialization
	9							
4	8							
	7							
3	6							
	5							
2	4	Basic Study Section						
	3							
1	2							
	1							

Fig. 2. Traditional Aerospace Educational Programs in Europe according to [12].

Bachelor programs normally require 3 years of studies, including the bachelor thesis. Master programs require an intermediate degree and typically have a duration of 3 semesters (1 ½ years), including the master thesis. For study courses with a more theoretical orientation, as is typical for universities, the Bachelor/Master of Science is awarded. As a rule, a Bachelor/Master of Engineering is awarded by the Fachhochschule.

Unlike in many Anglo-Saxon countries, students normally don't leave the university with a Bachelor degree but instead do a Master afterwards. Diploma students receive only one university degree that means that students in Germany work towards their Diploma degree from the first day they are enrolled at the university.

The French education system is specific. After the Baccalaureat (high school exam), there are two choices: the best students will enter in two years preparatory classes. After two years a national examination takes place to enter in "French Grandes Ecoles". The duration of

the studies in these establishments is three years to get the graduation of "French Ingenieur".

A shorter training called "Superior Technicians" with a two years duration (IUT or BTS Trainings) or the classical long training in French Universities with three years after the "Licence" and four years after the "Maitrise" is offered.

In parallel, there is a continuous education system inside the French "Grandes Ecoles" with a special training of one year after the graduation bac + 5 years; it is called "Mastère Spécialisé".

To respond to the internationalization of the curricula, some Grand Ecoles are offering a Master of Sciences Course program in parallel with the last semester of the second year and the whole third year.

In Italy aeronautical engineering degrees are offered by politecnics and universities. Their programs typically have a duration of five years with common first two years. In the third to fifth year a specialization in different classical

aeronautical disciplines takes place. Since 2001/2002 most of the universities are offering a three years Bachelor (Laura) and a two years Master program (Laura Specialistica).

In Spain, aeronautical engineering study on university level has a five year syllabus with the first three years to all aeronautical students and a specialization in the remaining part of the study.

In the Netherlands, aerospace engineering education is provided in an international atmosphere. The system is closer to the Anglo-Saxon system than in other European countries. At TU Delft Bachelor and Master programs are offered. The Bachelor (B. Sc.) has a nominal study duration of three years in total and consist of two compulsory years and a third year with optional courses. The Master program comprise 1.5 years of study.

In Sweden, 4.5 years of studies programs are offered leading to the Master of Science in Engineering (Civilingenjör). Bachelor of Science (B.Sc.) programs are also offered. They encompass three years of studies. The Master program is not a supplementary element to the Bachelor program. Students must choose either the shorter Bachelor or the longer Master program. These programs are all given in Swedish. In addition, M.Sc. programs entirely taught in English are offered. The duration of these programs is 1.5 years.

The Engineering degrees offered in Great Britain are the Bachelor of Engineering (B. Eng.) which is a three years program and the one year Master of Engineering (M. Eng.) or in some cases Master of Science (M. Sc.) program. A self-contained 5 year Master of Engineering program is offered by the University of Glasgow.

2.2 The 3+2 System – The Bologna Convention

The different traditional university degree structure and the ongoing opening of the education market across national borders as a consequence of the rapid change of the aerospace economy during the last decade initiated an educational reform within the

European Union. On the occasion of the 800th anniversary of the Sorbonne, on 25 May 1998 the Ministers of Education of France, Germany, Italy and the United Kingdom signed a special declaration for setting up of a European frame for higher education that would match and support the new requirements.

To make the rather complex European higher education systems more transparent, to increase compatibility between programs and certificates and even to promote a degree of consistency, a follow up meeting took place in Bologna (June 1999) where the Ministers of Education of all 15 EU member states as well as 14 non-EU member states signed the so-called “Bologna Declaration” [13]. This declaration was based on the vision of an open European area for higher education which would offer university students and researchers new prospects. It was agreed within the framework of a voluntary inter-ministerial arrangement to establish an attractive, internationally competitive European higher education area by the end of the decade, so that Europe can be recognized as a single higher education area from outside Europe. To achieve this goal, the following six objectives have been defined in Bologna:

- Adoption of a system of easily readable and comparable degrees (Bachelor, Masters’), including large-scale introduction of a Diploma Supplement,
- Adoption of a system essentially based on two main cycles,
- Adoption of a credit system similar to the ECTS, which facilitates the transfer and accumulation of study credits,
- Promotion of the mobility of university students, researchers and administrative staff, and the removal of all obstacles to the free movement of students,
- Promotion of cooperation in quality assurance, and
- Promotion of the European dimensions in higher education, particular with regards to the development of common curricula, cooperation between institutions of higher education,

integrated study programs and research projects.

On 29-30 March 2001, in Salamanca, over 300 European higher education institutions reaffirmed their support to the principles of the Bologna Declaration and their commitment to the creation of the European higher education area [14]. The institutes consider the establishing of the European University Association (EUA) to be of both symbolic and practical value in conveying their voice more effectively to governments and society and thus in supporting them to shape their own future in the European higher education area. Further purpose of the Salamanca Convention was to prepare their input to the Prague Summit (18-19 May 2001) of the Ministers for higher education in the countries involved in the Bologna process.

In the Prague Communiqué [15], again the six central objectives of the Bologna Declaration have been confirmed and some new emphases concerning improvement of the international attractiveness of the European higher education area and quality assurance have been added. In addition to the states that signed the Bologna Declaration, another three countries - Croatia, Cyprus and Turkey- became members of the Bologna process. Furthermore, the European Commission has become a full and active member of the Bologna process.

One of the most important results of the Bologna Declaration were a series of national reforms resulting in moving towards shorter studies, introduction of first degrees in systems where they were unknown, introduction of 3 years bachelor and 2 years master degrees (often designated as “3+2 year system”) instead of or parallel to long, “tunnel-type” curricula which offer no successful exit point before 5 or more years of study. Most of the countries have already started to introduce the new systems, as this is the case e. g. for Germany and Italy. In particular in the aerospace education the advantages of the new curricula are evident. They give students better chances on the international market, and encourage students to

study abroad if they know their degree will be accepted at the home country.

3 ECTS – The Common Language of Recognition

The European Community promotes study abroad as a means of improving the quality of academic cooperation. One of the major barrier for an inter-university exchange is that national records may not be recognised abroad. To improve access to information on foreign curricula and to provide common procedures for academic recognition, the European Course Credit Transfer System (ECTS) [17] has been introduced by the European Commission more than 10 years ago. ECTS was initially established under the Erasmus program (1988-1995). Based on the results of this pilot phase, the ECTS system has proved to be an effective instrument for creating curricular transparency and facilitating academic recognition, and, as a consequence, ECTS has been included in the Socrates Program within the framework of the cooperation agreements between the co-operating institutions. The major elements of ECTS are:

- The information package. It provides general information about the institution, its location, student accommodation, administrative procedures necessary to register and academic calendar and it describes the courses available at the partner institution. The content, prerequisites, mode of assessment, time unit, type of course, teaching and learning methods employed and ECTS credits allocated are all included in the information package, along with a description of the department offering the course. Details of examination and assessment procedures, the institution's grading scale and the structure of the curriculum of the degree are also included.
- The learning agreement describes the program of study abroad and is drawn up by the individual student and institutions involved before the student goes abroad.

- The transcript of records, shows the learning achievements of the student prior to and after the period of study abroad. The transcript of records show for every course taken by the student ECTS credits but also the grade awarded according to the local grading scale and the ECTS grading scale. These tools are used by the institutional and departmental coordinators, appointed by each institution to deal with the administrative and academic aspects of ECTS.

ECTS credits are a value allocated to course units to describe the student’s workload They are a measure for the quantity of work each course requires in relation to the total quantity of work required to complete a full year of academic study including preparation for exams. In ECTS, 60 credits represent one year of study in terms of workload, 30 credits six months (a semester) and 20 credits a trimester respectively.

To help institutions translate the grades awarded by host institutions to ECTS students, the ECTS grading scale has been developed (See Fig.3).

ECTS Grade	Percentage of students achieving the grade	Definition
A	10	EXCELLENT
B	25	VERY GOOD
C	30	GOOD
D	25	SATISFACTORY
E	10	SUFFICIENT
FX	-	FAIL
F	-	FAIL

Fig. 3. ECTS Grading Scale.

The ECTS grading scale provides additional information on the student's performance to that provided by the institution's grade, but does not replace the local grade. The cooperating institutions make their own decisions on how to

apply the ECTS grading scale to their own system.

If the study program described in the learning agreement is approved by both the home and the host institution and if it is completed satisfactorily by the student, it is fully recognised by the home institution.

The ECTS has been established as an effective instrument for promoting other inter-university cooperation and student exchange programs like PEGASUS or even the transatlantic programs such as the INTERNATIONAL MASTER OF SCIENCE IN AEROSPACE ENGINEERING PROGRAM (IMS).

4 International Cooperation

Multinational education and training requires exchange schemes and opportunities to study abroad. The mobility of students, staff and graduates is therefore an essential dimension of the European higher education area as this is expressed in article 149 of the treaties signed at Amsterdam on 2 October 1997. According to article 149, Community action shall be aimed in particular at encouraging mobility of students and teachers by encouraging the academic recognition of diplomas and periods of study, promoting cooperation between educational establishments of the Member States. At European level, several joint actions have been initiated. In the following, cooperation programs of the major European Aerospace Engineering Departments are described.

THE SOCRATES PROGRAM - Under the exchange schemes with higher education institutions the most important and successful one is the SOCRATES/ERASMUS program [17] which was conceived by the European Community in 1985 with the objective to enforce the student mobility within Europe. The Socrates program gives students the possibility to complete part of their studies abroad.

The prerequisites for participating in the Socrates program include mutual agreements between institutions and a guarantee that the periods of study abroad will be fully recognized by the student's home institution. In order to

transfer grades between European partner universities the European Credit Transfer System (ECTS) was introduced, facilitating academic recognition. In order to cover higher expenditures for the living costs abroad, a grant is appointed to the exchange students.

LEONARDO - Exchange schemes with higher education institutions and industry have grown in importance. Under these schemes the most important one is the Leonardo program [18] which was conceived by the European Community in 1994 and aims at to enforce cooperation between universities and industry within Europe. The Leonardo program gives students the possibility to complete part of their studies abroad in an industrial environment.

PEGASUS Network - As a consequence of the intensive restructuring process in industry and in particular the globalization of the market, the major universities involved in aerospace education reacted to the need to make aerospace education more transparent to companies within Europe. On this background, the Partnership of a European Group of Aeronautical and Space Universities (PEGASUS) [12] has been founded which currently consists of the members listed in Fig.4.

<p>U.K.: Cranfield University Imperial College, London Glasgow University Bristol University</p>	<p>Italy: Politecnico Milano Politecnico Torino Pisa University</p>
<p>France: ENAC, Toulouse ENSAE, Toulouse ENSICA, Toulouse ENSMA, Toulouse</p>	<p>Spain: ETSIA, Madrid</p>
<p>Germany: RWTH Aachen TU Berlin TU Braunschweig University Stuttgart TU Muenchen</p>	<p>S&M Countries: TU Delft, Netherlands KTH, Stockholm NTNU, Trondheim</p>

Fig. 4 The PEGASUS Network.

The general objective of PEGASUS is to optimise the aerospace educational systems offered by the leading universities both in terms of continuing to attract the best students and also to offer highly relevant educational and research programs at the participating institutions.

To achieve these objectives, the PEGASUS universities created a common forum of interaction with aerospace industry and national university links. The founding members of PEGASUS have cooperated for some years in an ad hoc manner through the Socrates/Erasmus program, but now intend to work more closely together in a manner that satisfies the needs of the students and their future employers across Europe. The general goal is to recognise graduate and diploma programs offered outside the own nation Europe wide. To reach this goal, the Pegasus group offers a range of high quality and efficient programs of support. These programs include

- Degree-awarding programs
- Continuing Education
- Research
- Intercontinental concerns.

Moreover, the intention of PEAGASUS is to create a European portal for higher education services in aerospace, with support of the aeronautical industry and government agencies.

THE TIME PROGRAM (DOUBLE DIPLOMA DEGREE) - Another program of European dimension is the Top-Industrial-Managers-For-Europe-Initiative (TIME) [19]. This program is a commitment of higher education institutions to the establishment of 'European courses of study' and courses of study leading to a double degree. Students typically spend two years of study at the partner university to complete the advanced study section of the curriculum there. Afterwards they complete their study at the home university, leading to the diploma/master's degree of both institutions.

INTERNATIONAL MASTER OF SCIENCE PROGRAM (IMS) - An agreement between the European Community and the United States of America in the area of higher education and vocational training was reached in October 1995 to set up a transatlantic cooperation program. In the aerospace sector, a formal International Master of Science in Aerospace Engineering Program (IMS program) has been established by a consortium of nine European and US universities [20], see Fig. 5. Within the IMS program, qualified students at each participating university are choosing course and/or course- and project modules from the overseas partner institution. The program extends over at least six months for each student. The curriculum is based upon coursework and individual research project modules performed under the supervision of the department of the host university. Students choose a research module to fill their schedule during their stay at the host university.

Mobility grants are provided to cover the major part of the student's travel expenses. The students native funding for living expenses is expected to cover the living expenses incurred in the host country.

The project modules and course modules are assessed similar to the European Credit Transfer System (ECTS) already established in most EU universities. The modules offered and the number of credits associated with them will be compiled in a course work and research project catalogue, issued by the consortia universities. Courses and research modules that a student selects is approved by the supervisor of the home institution prior to the student beginning any project work on the IMS program. After having successfully participated in the IMS program a certificate is awarded to the student in addition to the degree of his home institution.

INTERNATIONAL POST-GRADUATE EDUCATION IN AEROSPACE - As a reaction to the deficiency of a post graduate education program in the management of multinational programs, the Consortium for Advanced Training in Aerospace (ECATA) [21] was set in 1990. This countered the statement of the EUROMART Study that such an action would be necessary to ensure the competitiveness of Europe aerospace enterprises. The consortium consists of seven major European universities and major European aerospace industry. The ECATA consortium members are presented in Fig. 6.

The ECATA consortium followed this challenge with the Aerospace Business Integration Program (ECATA ABI-Program) which is conducted annually at two leading European aerospace training institutes with two key elements: An academic program and a multinational team project. The academic program is a comprehensive program provided by professionally trained and experienced industry experts. The program includes lectures, case studies, project simulations, technical visits and seminars.

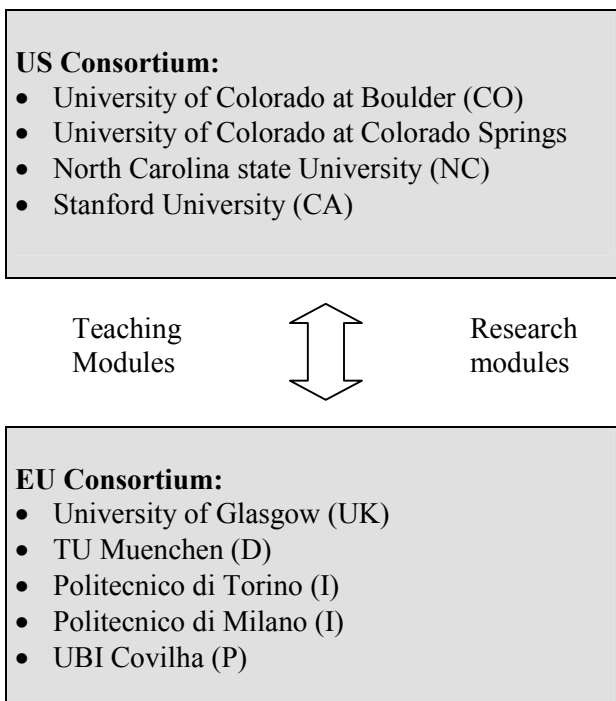


Fig. 5. The consortia of the International Master of Science Program.

<p>University Members:</p> <ul style="list-style-type: none"> • Cranfield University (UK) • Dipartimento di Ingegneria Aerospaziale Università di Pisa (I) • Ecole National Supérieur de l'Aeronautique et de l'Espace (ENSAE) Toulouse (F) • Escuela Tecnica Superior de Ingenieros Aeronauticos Universidad Politecnica de Madrid (E) • Institut fuer Luft- und Raumfahrt Technische Universitaet Muenchen (D) • Kungl Tekniska Hoegskolan Stockholm (S) • Technische Universiteit Delft (NL)
<p>Industry Members:</p> <ul style="list-style-type: none"> • Aerospatale (F), founding company, now part of the European Aeronautic Defence and Space Company (EADS) • Dassault Aviation (F) • DaimlerChrysler, founding company, now part of the European Aeronautic Defence and Space Company (EADS) • Alenia (I) • BAE Systems (UK) • Saab (S)

Fig. 6. The Consortium For Advanced Training in Aerospace (ECATA).

The ECATA network can be considered a fundamental step for future European Aerospace programs and joint ventures.

5 Conclusion

The structures of the European education systems differ considerably, both within and between countries. The international interlinkage of enterprises and the rapid technological change are closely associated with new qualification requirements. Future aerospace engineering graduates have to be capable to work in an international team, with linguistic diversification and other cultural differences and have to possess a global mind

setting which goes beyond the mere technical education.

To increase the international competitiveness of European higher education a harmonization and internationalization process of the tertiary education has been taken place within the European Union in recent years. In most European countries educational reforms and initiatives have been launched to open up the traditional educational systems and to increase the attractiveness of higher engineering education. Within the framework of a voluntary inter-ministerial arrangement all 15 EU member states as well as 14 non-EU member states agreed in the “Bologna Declaration” to establish an attractive, internationally competitive European higher education area by 2010, so that Europe can be recognized as a single higher education area. The major objectives of this initiative are the adoption of a “first cycle”, lasting a minimum of three years, and “second cycle” degree structure typically lasting two years, further, the implementation of the European credit transfer system (ECTS) to facilitate the transfer and the accumulation of study credits and the promotion of the mobility of university students and researchers.

Following these recommendations in addition to the traditional long cycle program, as this is e.g. the German diploma or the Italian Laurea, in most European countries Bachelor and Master degrees have been introduced. In accordance to the definition of the Bologna declaration Bachelor programs have a duration of three years. Successful completion of this degree qualifies for admission to a one or two years taught and/or research Master degree program. Furthermore the Bachelor degree should be “relevant to European labour market” as an appropriate level of qualification.

To make the rather complex European higher education systems more transparent and to increase compatibility between programs, many European countries have adopted the European Credit Transfer System (ECTS).

To take the ongoing international interlinkage of companies into account trans-border mobility has become vital. Spending part of the study abroad becomes more and more

obligatory in engineering study programs. To achieve this, a number of European and transatlantic cooperation programs and networks have been developed by engineering educational institutions in recent years.

Both harmonization of the curricula and mutual exchange and cooperation programs covering teaching and research considerably contribute to improve the quality of education Europe wide and create an attractive education area for students and scientists from the different member states and other regions of the world.

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