G-TRAIN : Supporting education and training in the field of satellite navigation in Europe

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Abstract— **The aim of the G-TRAIN project is to set up a framework for higher education addressing different academic (MSc, Specialising Master and PhD) and networking activities. Indeed, it has been identified that on the one hand there are not enough people trained in the field of satellite navigation in Europe to support the finalization of the Galileo system as well as the foreseen development of satellite navigation applications and on the other hand there are no "European GNSS education" only activities. The goal of the project is to set up a long-term model for the coordination of universities, students exchanges and researchers co-operation in order to exploit synergies and to cover all the different needs of GNSS training, expressed by both industry and research worlds. The paper describes the achievements already obtained in the first part of the project lifetime and its future activities.**

Higher Education; GNSS; University Network; PhD education and training; PhD research work; networking; MSc; Specialising Master

I. INTRODUCTION

Global Navigation Satellite System (GNSS) technology and the related applications are booming worldwide. In Europe, the development of the Galileo system, the recent EGNOS (European Geostationary Navigation Overlay Service) operational status and the increased interest towards satellite navigation and its applications highlighted that there is a lack of trained workforce in this high technology field. Satellite navigation is a complex field involving several disciplines, from the basic technologies for the development of the different system segments to the capabilities to push the market creating innovative and effective products. Today, the European Union (EU) is experiencing a contradictory situation: a common system, Galileo, but a highly fragmented offer of dedicated education; a growing GNSS market that is becoming one of the most important drivers of economic growth from the technological side, but an insufficient offer of education and training in the field.

On the other hand, outside of the European boundaries, the interest towards satellite navigation is not restricted anymore to the sole United States or Russian Federation. Indeed, other countries such as China, India, Japan, or Australia are eager to play an important role, not only deploying their own systems, but developing technologies, applications and services able to get a share of the global market.

It is clear that a key to the success of Europe in this field is its capability to educate people in all the different topics related to GNSS. The lack of a global framework on GNSS education has been witnessed by several initiatives that sketched the picture of this kind of education in Europe during the past years. In 2008, the ERIG (Education, Research and Innovation in GNSS) project, funded by the European Commission, depicted the situation of education, innovation and research activities in the field of GNSS in Europe. During the project a method to evaluate the centres of excellence was proposed and applied; the obtained results were presented [1].

Given this picture, the G-TRAIN project has initiated the coordination of some already existing initiatives in Europe and the establishment of new ones in the regions that are considered as areas of excellence in GNSS due to their solid

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records not only in education, but also in terms of research results and presence of innovation tools for technology transfer. G-TRAIN is coordinated by Politecnico di Torino (Polito – Italy) and the consortium gathers Universitaet der Bundeswehr Muenchen (UniFAFM - Germany), Ecole Nationale de l'Aviation Civile (ENAC - France), Istituto Superiore Mario Boella (ISMB - Italy), and Institut Supérieur de l'Aéronautique et de l'Espace (ISAE - France). The project started in 2010 and lasts 3 years.

This paper describes the objectives of the project, the results obtained so far and future activities. In particular, Section II gives a high-level description of the project, its objectives and the expected impact, while a deeper view on the activities which are carried on is in Section III. The results already achieved are presented in Section IV, while future activities are tackled in Section V.

II. THE G-TRAIN PROJECT

A. Objectives

G-TRAIN aims at supporting the creation of a generation of GNSS experts open to cross-border and international cooperation, trained by recognized European universities in this field. Activities focus in particular on the higher levels of education that are the enablers for research and innovation, providing both social and business benefits. This is realized through the setup of a European coordinated environment for GNSS training, starting from already implemented actions, while creating the framework for joint educational initiatives which involve the major educational and research areas in Europe. G-TRAIN actions address the upper two levels as described in the Bologna process definition [4]:

- Master of Science (MSc) (second level)
- Specialising Masters and PhDs (third level)

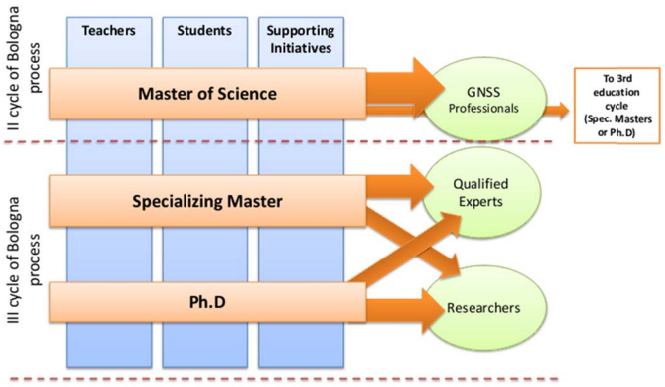

Figure 1 - The outputs of the project following the Bologna scheme

B. A Collaborative Project: Roles of partners

The G-TRAIN project is a Collaborative European project in which European partners are asked to cooperate in order to establish a strong European framework in the field of GNSS education. Each action which can be seen in Figure 1 is under the responsibility of one partner while all others are participating with their expertise in a dedicated way. In particular, the project includes the following activities, which will be further detailed in Section III:

- Design and implementation of a Collaborative Master of Science in GNSS, led by ENAC in collaboration with ISAE
- Strengthening the Specialising Master on Navigation and Related Applications, coordinated by POLITO and ISMB
- Organisation of GNSS PhD Summits, coordinated by UniFAFM
- Organisation of GNSS PhD Training Days, carried on by UniFAFM and ENAC
- Set up of the Satellite Navigation University Network, under the responsibility of UniFAFM
- Support to PhD students to attend conferences and events on GNSS topics, coordinated by UniFAFM.

The collaboration between the different partners takes place at 3 levels:

- At the teaching level: a specific education time is allocated to each partner (POLITO, UniFAFM and ISAE) allowing them to contribute to the MSc and to the GNSS PhD Training by teaching in their area of expertise (navigation/communication, precise positioning and space telecommunications respectively). This provides a strong added value to the programmes in terms of diversity and excellence while keeping a long term collaborative objective.
- At the internship level: partners welcome, through a collaborative effort, students of the Master of Science and of the Specialising Master who are doing their internship in the laboratories of the consortia partners for the research stream.
- At the supervising level on the GNSS PhD Summit: partners and experts from in- and outside the consortium are invited to give advice and guidance to PhD students preparing their PhD thesis. This collaborative effort of educating PhD candidates supports EU's objectives of creating a European Higher Education and a European Research and Innovation Area.

C. Project innovation

G-TRAIN is the very first attempt to create a coordinated environment in the field of Higher Education on Satellite Navigation in Europe. Through its actions, the project is expected to put the basis for a long-term and Europe-wide education approach in the GNSS field based on the cooperation of universities and on the students/researchers exchange. G-TRAIN is expected to develop a functional model that could last beyond the project's timeframe.

D. Potential impact

G-TRAIN focuses on students, researchers, experts, and professors; through the project they have the opportunity to get in contact with each other and to share expertise and ideas.

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Predominately, most of the activities are addressing students and PhD candidates by providing travel support, possibilities to do an internship, opportunities for networking and to get in contact with experts from all over the world. In addition, the establishment of a network of universities and institutions involved in GNSS education as well as the joint courses and events are addressing professors and educational experts in terms of developing joint educational programmes and exchanging expertise.

This "investment on people" will create a community of GNSS experts which is fundamental to flourish a good GNSS education environment. Furthermore, the set up of a strong framework for qualified education will ease the collection of funding for the continuation of the project. Eventually, the strengthening of GNSS education will be beneficial for the competitiveness of European companies and for the scientific level of Europe in GNSS at large. In addition, it is suited to make the European GNSS education more attractive and competitive to the rest of the world. Last but not least, the upcoming Galileo system is expected to boost even more GNSS based applications requiring more specifically trained manpower so that there will be a larger trained workforce ready to cover the new job positions.

III. Focus on G-TRAIN Activities

A. *Collaborative MSc in GNSS*

Concerning the second level of the Bologna Process, a Collaborative MSc in GNSS has been set up by ENAC and ISAE in collaboration with the academic partners of the G-TRAIN project. It has been approved by relevant national authorities and will officially start in September 2012, hosted by ENAC in Toulouse (France). The course will be entirely taught in English to ease the enrolment of European and international students and will last for 2 years. This MSc is organised around 2 main time periods:

- The first 3 semesters provide an academic training that encompasses fundamental and advanced knowledge in the scientific fields surrounding GNSS (signal processing, signal propagation, electromagnetism, network, telecommunications, etc.) while taking into account the requirements from the several GNSS and telecommunications applications such as aeronautics, geodesy, pedestrian and urban positioning, or location-based services. It also provides classes in business planning, project management, intellectual property rights, etc.
- The fourth semester is dedicated to an internship in a company or a research laboratory in order to provide the students with a relevant work experience. Validation of the semester and the whole MSc is dependent on the successful oral defence of a thesis report produced during the internship period.

This MSc is built to provide students with necessary technical and managerial knowledge to enter job market. The MSc graduate students are expected to match the main needs of industry and research centres.

B. *Specialising Master on Navigation and Related Applications*

Specialising Master programmes are usually managed in cooperation with companies and with the support of institutions in the field, and aim at educating qualified professionals able to get positions of responsibility in the companies, or in some cases in the research and development departments. The strengthening of the Specialising Master experience in Europe leverages on the initiative of Polito and ISMB in Italy, the Master on Navigation and Related Applications, making it a European initiative.

The Specialising Master on Navigation and Related Applications [3] is a 1-year programme organised at Politecnico di Torino (Italy). The programme is entirely taught in English and it is open to graduate students who already hold a Master Degree. The Specialising Master is organised in four quarters:

- The first 3 quarters are devoted to lectures on GNSS-related topics, from basics on navigation systems to advanced technologies and applications.
- The last quarter is dedicated to an internship in a company or research laboratory.

Students have to prepare a Final Report on their work during the internship period. The Report has to be approved by both the internship supervisor and the Scientific Coordinator of the Specialising Master.

The G-TRAIN objective of making this Specialising Master a Europe-wide initiative is achieved through the following actions:

- Selection of the best two students for each of the academic years covered by the project duration and provision of a grant to develop their internship in one of the other areas of excellence (Munich and Toulouse).
- Creation of a new branch devoted to EGNOS and Aeronautical applications taught in collaboration with professors from ENAC.
- Design of a new short course on GNSS business and market.

These activities have already been implemented in one edition of the Specialising Master and received very positive feedbacks from students.

C. *Support to PhD Students*

According to the results of the ERIG study, the number of PhDs in Europe is less than the number of PhDs in US or China. Doctoral work is playing an important role regarding knowledge creation, innovation and technology transfer. Therefore it contributes directly to the goals of the EU as mentioned in the Lisbon strategy "to become the most competitive and dynamic knowledge-based economy in the world" [2]. So for example ESA has announced to support PhD work in funding PhD research projects to increase numbers of PhD thesis in the field of GNSS as proposed in the

ERIG study [1]. The proposed G-TRAIN actions aim at supporting PhDs students during the time of thesis preparation providing high level training on the one hand and supporting them at an early stage to network with other PhD students, young researchers as well as discuss their research ideas and results. Three actions have been implemented so far:

1. **GNSS PhD Summit**: This action aims at fostering the networking skills of young researchers at an early stage and giving them the possibility to discuss own ideas and research results with other PhD students and academic advisor and experts on an international platform. The concept of GNSS PhD Summit includes lectures and discussion rounds.

    - The lectures target topics PhD candidates need for their work. They are dealing with questions on how to improve scientific writing, the challenges of PhD thesis in navigation/GNSS today and in the past or the PhD thesis as project and the project management related to it.
    - The discussion rounds are conceived as small groups up to 4 to 5 PhD candidates where every student presents his/her research work and discuss it with the other PhD students and academic experts. The small groups offer the possibility not only to discuss the topic itself but also to raise questions and address doubts on the work, the topics as well as on the chosen methods as it is providing a protected and confidential area.

Besides this, the GNSS PhD Summit provides the possibility for own networking at an early stage of the career. The conference day is open for participants who are PhD candidates preparing a thesis related to satellite navigation or GNSS never mind if this thesis is related to technical or other matters.

2. **GNSS PhD Training:** This action is addressing PhD education which is albeit the Bologna process different in European countries and is targeting to provide solid high level lectures during the duration of 3 days. The GNSS PhD Training will be hosted during the duration of the project in different universities once on specific topics. The training is offered once a year and is open to PhD students and candidates. It is organised by the university where the training takes place. In the first year it took place in Munich and in the second year it will take place in Toulouse. The responsible universities are ENAC and UniFAFM, while faculty members of all the other partners are participating by giving lectures. The training aims at providing technical knowledge as well as necessary skills and competences.
3. **PhD grants**: This action is conceived to support PhD students attending relevant GNSS events like conference, workshops and summer schools. PhD students can apply for a grant to attend one of the mentioned events. Up to 8 students per year are selected on the basis of meritocratic criteria. All partners of the G-Train consortium are involved in the decision on who is being awarded.

D. Satellite University Network

Cooperation between G-TRAIN partners brings in the loop the added value of multi-disciplines, mixing the different expertise as well as national ways of addressing GNSS/satellite navigation education. In addition, cooperation and inter-change between professors and students of different countries are beneficial in creating a new generation of GNSS experts at European level open to transnational cooperation. This cooperation and interchange supports the creation of new joint educational programmes and innovation and technology transfer.

The newly established Satellite navigation University Network (www.gnss-sun.eu), which is open to other universities and education providers in satellite navigation, has already attracted the interest of other educational institutions. One of the main objectives of the network is to link all universities providing education in satellite navigation as well as existing and planned educational initiatives in this field. It aims to propose new strategies for education in GNSS to fulfil the needs in the design and development of GNSS systems and related application. In addition, it aims to promote GNSS education throughout Europe and Working Groups within the network are dealing with actual topics such as the legal framework to establish joint courses.

The Satellite navigation University Network is open to universities providing a sufficiently qualified education in GNSS, to organisations providing higher/academic GNSS education as well as organisations which are not providing education in GNSS but are involved in events and activities related to GNSS/satellite navigation.

IV. ACHIEVED RESULTS

The new Master of Science in GNSS has been accredited by the French Ministry of Higher Education and will thus start in September 2012. Its structure makes it compatible with the Bologna process, and thus with the overall European education format. This was necessary to attract international students. Besides the teaching by the G-TRAIN academic partners, many professionals from institutions and companies will contribute to the teaching, thus providing concrete inputs from the targeted employers. The expected outcome of this MSc is the training of about 15 to 20 experts every year.

As for the Specialising Master, experts from UniFAFM gave seminars to the students on state-of-the-art topics such as interoperability and compatibility in a Multi-Constellation GNSS scenario.

In addition, a new module on Wide Area Augmentation Systems was designed and included in the Specialising Master Programme. This module was combined with a new branch on GNSS Applications to Air Traffic Monitoring, which was taught by ENAC professors and was very popular among students, since more than 50% of them choose this branch. Feedbacks from students were collected which show a general

appreciation of the course contents and of the adopted teaching methodology. Suggestions about possible improvements will be taken into account for the next edition of the Specialising Master Programme.

Concerning the topics on business in GNSS, the "GNSS Related Applications" module of the Specialising Master hosted several teaching initiatives, such as seminars delivered by experts in development of GNSS applications and business planning. Furthermore, organizers of the European GNSS University Challenge were invited to illustrate to students the possibilities offered by the Challenge. Students worked in group to sketch possible ideas to be submitted to the Challenge.

Finally, two students spent their internship period at ENAC and UniFAFM, where they worked on their Final Project under the supervision of the partners, experts and professors.

Two GNSS PhD Summits have been organised in November 2010 and 2011 as one day conference. The general feedback from the participants is that the PhD Summit was a unique and very helpful event considering the advantage of gaining lots of feedbacks and ideas from a wide expert audience about the research work each PhD candidate is carrying out. The meeting gave also the possibility to trigger collaborations between people working on the same topic. In addition, the lectures on different technical skills were appreciated very much. This feedback underlined the necessity for this different kind of conference for PhD students.

The first GNSS PhD Training took place in 2011 in Munich. The number of applicants was nearly doubling the places available. This and the positive feedback of the participating PhD students underlined that courses suited to PhD students coming from various disciplines are highly required.

V. MOVING FORWARD

The project is arriving at the end of the second year of activities. G-TRAIN partners have still one year available to continue carrying on the foreseen activities. The consortium recognized that the actions of the G-TRAIN project are very well accepted by the different target groups and that there is really a big need for them. In an evaluation form, the PhD students were asked if they would pay a fee. Most of them agreed, which shows how well these supporting actions have been accepted and appreciated although they are still at a primary stage.

In the meanwhile, a new project is at the horizon and it will start in 2012. This new project will bridge the G-TRAIN activities towards the word of companies and industries. In addition, it will enable the organisation of other events targeting students and PhD candidates as well as the enlargement of the Satellite navigation University Network and the consolidation of its Working Groups activities.

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