Curricula Enrichment for Sri Lankan Universities Delivered Through the Application of Location-based Services to Intelligent Transport Systems

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Key words: Location-based Services (LBS), transportation systems, geomatics, transportation sciences, University education

SUMMARY

Sri Lanka faces many transportation challenges. Constraints such as timely access to modern technology and the lack of appropriately trained personnel have contributed to increasing social, economic and environmental concerns around road safety, pollution and transport inefficiencies. The project LBS2ITS will address these issues through enrichment of the University curricula; specifically, the integration of LBS (Location-based Services) into ITS (Intelligent Transport Systems). LBS deliver information based on the location of objects. Smart transportation is therefore an ideal LBS application since it is based on locating people (e.g. using smartphones) and objects (e.g. cars, trains, etc.). As LBS evolve rapidly, there is an increasing need to train the next generation of skilled professionals who can leverage these new capabilities. This is important for Sri Lanka, where population growth and resource constraints demand the urgent use of emerging technologies to secure the safety and sustainability of their society. This level of education is in its infancy and cannot rapidly deliver the knowledge inputs required to change transport management decision-making. The Erasmus+ project LBS2ITS aims at a fully immersive and integrated teaching and learning experience. The outcome will be a digital learning environment supporting synthetic and real-world learning experiences encouraging self-paced learning modules for both teacher and students. It will contain digital resource kits for interaction with modern equipment, continuous assessment and two-way feedback. Webinars and virtual experiences will underpin real-world Problem-based Learning (PBL) scenarios. A key novelty will be inclusion of industry representatives and external experts in the advisory groups. These will support our dissemination and quality control initiatives, the relevance of the PBL and student learning outcomes. Mentorship and a focus on cultural awareness, gender equity and social parity will govern our principles for curricula enrichment.

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1. INTRODUCTION

Location-based Services (LBS) can be defined as computer applications (especially mobile computing applications) that deliver information tailored to the location and context of the device and the user (Huang et al., 2018). An increasing demand in expanding LBS is seen from outdoors to indoors, and from navigation systems and mobile guides to more diverse applications (e.g. healthcare, transportation and gaming). More and more LBS are entering into the general public's daily lives, which greatly influence how people interact with each other and their behaviours in different environments. With the integration of information and communication technologies (ICT), especially mobile ICT in every aspect of our daily lives, 4A (anytime, anywhere, for anyone and anything) 'services' are being developed to benefit our human society and environment. It also brings many opportunities (e.g. for traffic management and urban planning) and challenges (e.g. privacy, ethical, and legal issues) to our environment and human society.

Transport has been one of the main application fields of LBS. Applications include those for driver assistance, passenger information, and vehicle management. Car navigation systems are probably the most popular LBS applications, which provide wayfinding assistance for drivers, and are still being improved with new features, such as real-time traffic information. Crowdsourced traffic and road information is used to provide, for instance, drivers with real-time navigation supports. LBS and tracking techniques have now been extensively used for vehicle management and logistic tracking. In recent years, applications beyond car navigation and vehicle management have been emerging. For example, for driver assistance and passenger guidance, applications for finding available on-street parking spaces, safety warning, and multi-modal routing have appeared. There are also studies using LBS to promote more healthy, greener (lower CO2 emission), and more active mobility behaviours. Sustainable personal mobility in multi-modal traffic scenarios is a necessity in our modern life. Thus, pedestrian navigation and guidance is a major focus in the courses of LBS education.

The Erasmus+ project LBS2ITS deals with the modernization of curricula modules and courses in the field of LBS and smart transportation in the partner country Sri Lanka. LBS deliver information depending on the location of a mobile device and user play a key role in this mobile information era. To motivate further LBS development and stimulate collective efforts, modern curricula in the geomatics and transportation sector need highly qualified graduates. In addition, transportation systems need be changed in the partner country to enable safer and more environmental friendly sustainable personal mobility. Using cooperation with industry the employability of graduates shall be increased and training of employees enabled. In the start of the project the current traffic situation in Sri Lanka is analyzed in detail to be able to adapt the curricula at the four partner Universities to the needs of the society. This will also include comparative analyses of the situations in the region to derive synergies with other possible partners for education.

2. LBS FOR TRANSPORTATION ISSUES

Major applications in LBS include (Huang et al., 2018):

- Navigation (car and pedestrian);
- Mobile guides;
- Fitness monitoring and healthcare;
- Assistive systems;
- Social networking;
- Location-based gaming; and
- Other emerging applications (e.g. advertisement, education, safety).

Transportation overlaps to the other categories listed above. Some examples for the overlap are:

- Location based gaming is widely applied in transport, see e.g. the Vienna Wien zu Fuß-App[1] or cycling Apps[2];
- The transition to social networking is fluent as one might think of using social networks for competitions that are facilitated by location based gaming;
- The transition to fitness monitoring is also fluent as physical activity is always one important part of fitness – and physical activity is generated by walking and cycling trips – this is again transport. For example, in the Switch project[3], people are motivated to increase their transport-related physical activities (minutes walking and cycling in transport) for health reasons, and the health arguments can be found in all the above listed location based gaming Apps;
- Assistive systems deliver a great potential for applications in the transport domain, there might be an overlap with navigation;
- Navigation is a transport application (that should be developed in a multi-modal approach including all relevant transport modes (also cycling, shared services, parking garages, public transport etc.). It may be difficult in separating it from mobile guides (these include probably more the description of relevant destinations and less the navigation to these destinations).

Therefore the project LBS2ITS developed the following suggestions for possible categories in education of students in the geodetic and transportation sciences:

- Understanding travel behavior: LBS have a great potential for collecting better data on travel behavoiur at potentially lower cost, they could potentially replace traditional

[1] https://www.wienzufuss.at/app/
[2] https://www.cycling4trees.com/, https://changers.com/de/, https://www.mit-dem-rad-zur-arbeit.de
[3] https://www.switchtravel.eu/

methods for data collection, see e.g. the strategies of the Austrian ministry for transportation[4];

- Modelling: LBS-based data could be far more detailed and recent than currently used data; it opens completely new opportunities for modelling transport;
- Navigation and mobile guides;
- Assistive systems: non-navigation, e.g. automatic calls when geofenced areas are left or other pre-defined things happen, warning of car drivers when bicycles approach, all driver assistance systems such as warnings when lanes are left, adaptive cruise control, etc. – this will substantially gain in importance with higher automation in transport;
- Optimization of traffic flows / transport demand management: road authorities purchase already today floating car / vehicle data, e.g. from INRIX[5], cars sending data to other cars / transport users in the road or to road authorities in the future, this opens completely new opportunities for transport demand management as this is done e.g. by ITS Vienna Region[6] or VMZ Berlin[7];
- Location based gaming: subsume fitness monitoring here;
- Other emerging applications such as advertisement, education, logistics goods transportation: this might even be an own category.

LBS are also being used as assistive technology to enable visually impaired people, and disabled and elderly people to perform their daily living activities independently and to experience an improved quality of life. These assistive systems provide assisted-living functions, such as personalized navigation and wayfinding, obstacle detection, space perception (Shen et al. 2008), and independent shopping. With the increasingly aging population, one can expect that more and more location-based assistive systems will be developed and employed in the future. Recent years have also seen the application domains of LBS being expanded into disaster and emergency, supporting citizens' involvements in society (e.g. for crime mapping, reporting urban problems), education (learning in the field), entertainment (e.g. music), insurance, billing, and supporting production processes in factories. While most LBS applications are developed primarily for supporting individual users, some researchers have started to develop LBS applications to support groups of users for collaborative task solving, such as wayfinding.

3. LBS SCIENTIFIC RESEARCH AGENDA

To motivate further LBS research and stimulate collective efforts in our rapidly evolving mobile information society, a cross-cutting research agenda, identifying the key research questions and challenges that are essential to meet the increasing societal demands of LBS was developed by Huang et al. (2018) as a joint activity of the LBS research community, which mainly consists of experts from GIScience, cartography, geomatics, surveying, computer science, and social sciences. Based on proposals of researchers, and the feedback

[4] https://www.bmvit.gv.at/verkehr/gesamtverkehr/statistik/oesterreich_unterwegs/
[5] http://inrix.com/
[6] https://www.its-viennaregion.at/
[7] https://www.vmzberlin.com/

and results of a workshop and conference session, a list of ‘key research challenges’ were identified that have to be addressed to bring LBS to a higher level to better benefit our human society and environment. These research challenges can be classified into seven broad areas: (1) positioning; (2) modelling; (3) communication; (4) evaluation; (5) applications; (6) analysis of LBS-generated data; and (7) social and behavioural implications of LBS. The first three areas (the inner groups) represent the core of LBS (‘How to make it work’), as every LBS application needs to handle the main tasks of positioning, data modelling, and information communication. ‘Evaluation’ is important to ensure that a developed LBS meets users’ needs. Sufficiently addressing these four aspects would prepare LBS to be ready for different kinds of applications, such as navigation, mobile guides, transportation, healthcare, and entertainment. These LBS applications not only help to facilitate people’s daily activities and decision-making in space, but also generate a lot of data about how people use, travel, and interact with each other in the environment. ‘Analysis of LBS-generated data’ (e.g. location-based tracking data, social media data, and crowdsourced geographic information) helps to better understand people’s behaviours in different environments, which enables various innovative applications (e.g. transport, urban planning, and smart city), as well as provides insights to further improve these LBS applications. Beyond these, ‘social and behavioural implications of LBS’ raise as LBS enter into people’s daily lives.

The unique approach of this project is the direct involvement of researchers from the transport domain as one of the most relevant application fields for LBS. Transport researchers in the consortium directly support in evaluating user needs in the transport domain. The term ‘transport user’ in this context covers not only the travelling persons and goods but also the experts working on modelling and optimizing transport systems. LBS applications have a great potential for supporting the work of transport planners and engineers in municipalities, higher level administrations, private consultancies, academic and further institutions. Based on the analysis of these various users’ needs and in direct collaboration with the transport community, tailor-made LBS services/applications are developed that fully meet users’ needs. In the direct collaboration of providers / developers and (potential) users of LBS services, the project spans the whole research cycle: (1) users’ needs are investigated as the basis for developing new LBS services; (2) the uptake of these services is evaluated; (3) the results feed into their advancement in the next round of the research cycle.

4. UBIQUITOUS POSITIONING, NAVIGATION AND TIMING (PNT)

To provide services and content relevant to the location, LBS need to determine where the user is. Therefore, positioning or location determination is a crucial technology for LBS. As LBS become increasingly important and pervasive in our daily life, ubiquitous positioning is needed to provide an accurate and timely estimate of a user’s or an object’s location at all times and in all environments. GNSS, i.e., GPS, GLONASS, Galileo, and BeiDou, as well as regional systems, such as the Indian Navigation Constellation (NavIC) or the Japanese Quasi Zenith Satellite System (QZSS), are available in outdoor environments. Especially the Indian sub-continent and Sri Lanka as well as South-east Asia are covered nowadays with the highest number of visible satellites in the world which brings challenging research questions which need to be addressed and dealt with in the education of students.

GNSS positioning accuracy, however, varies, and often gets worse in dense urban environments (due to urban canyon effects). For indoor environments, while other positioning methods and technologies start to appear, such as using signals-of-opportunities, such as Wi-Fi-based positioning and Bluetooth beacons, achieving accurate and reliable positioning is still a long way to go. Sensor fusion is a major topic which needs to be addressed in this context. Apart from the aforementioned technologies and techniques, modern smartphones and other mobile devices have embedded sensors. These inertial sensors, i.e., accelerometers and gyroscopes, can be employed together with a digital compass (i.e., magnetometer) as well as barometric pressure sensor (altimeter) for determination of the distance travelled, heading of the user and altitude. If these sensors are used for localization of pedestrian users, the technique for obtaining the relative positions from a given start position is referred to as Pedestrian Dead Reckoning (PDR). Then it is possible to locate and navigate a user continuously in combination with GNSS and / or other absolute positioning technologies, such as Wi-Fi.

Ubiquitous Positioning, Navigation and Timing therefore requires the following two major aspects: (1) to deliver GNSS-like performance anywhere, anytime, under any operating conditions, and (2) to exceed the performance levels of GNSS for safety and liability critical applications (Retscher et al., 2020).

5. PNT APPLICATION REQUIREMENTS

As identified by Retscher et al. (2020) the PNT requirements can be categorized in four different classes which are (1) positioning; (2) cost; (3) security and legal as well as (4) interface requirements. Thereby the most relevant positioning requirements are apart from positioning accuracy also integrity, availability and coverage, latency and continuity as well as sampling and update rate. Furthermore, operational and maintenance costs, for instance, are very important too when designing a low-cost positioning system. If these key requirements and performance parameters are applied, for instance, for Wi-Fi positioning, a similar statement or meaning can be formulated. Regarding availability the number of transmitters (i.e., Wi-Fi Access Points) replaces the number of satellites. Especially integrity is often neglected and not paid full attention. It can be seen as a very important key parameter. The way that integrity is ensured and assessed, and the means of delivering integrity related information to the user are highly application dependent. Time-to-First-Fix (TTFF) in the case of RSSI-based (Received Signal Strength Indicator Based) Wi-Fi positioning using location fingerprinting is highly correlated to the RSSI scan duration of a certain mobile device (Retscher, 2020). This is especially important in kinematic positioning as the appearing scan durations can vary significantly for different smartphones which results in a different level of achievable positioning accuracy in dependence of the walking speed in the case of pedestrian navigation (Retscher and Leb, 2019). For different users robustness may have a different meaning, such as the ability of the solution to respond following a severe shadowing event. Robustness can also be defined as the ability of the solution to mitigate interference. Other requirements and performance parameters are power consumption, resiliency, connectivity, interoperability and traceability. Especially in the case of mobile devices power consumption is still very critical to provide a long-term solution possibility. Resiliency is the ability to prepare for and adapt to changing conditions, such as it is the case for Wi-Fi RSSI signal variations and fluctuations. To encounter for their influence new robust schemes are necessary and need to be developed.

6. COOPERATIVE LOCALIZATION OF LBS USER GROUPS

For many applications ubiquitous positioning of not only a single user but a group of users to be navigated within a neighbourhood is required. A solution is referred to as Cooperative Localization (CL) or Cooperative Positioning (CP). CL follows from the multi-sensory approach developed over the past years, where GNSS augmentation was provided for each user individually by additional sensors. The definition states that an integrated positioning solution termed 'CL' employs multiple location sensors with different accuracy on different platforms for sharing of their absolute and relative localizations. Thus, CL is an integrated positioning solution of a group of users or platforms, for example, pedestrians, vehicles, and bicyclists (see e.g. Kealy et al., 2019). They can be equipped with different sensors and share their absolute and relative localizations. The main two principles can be summarized as:

- Ubiquitous positioning requirement in applications where a group of users has to be navigated;
- Integrated positioning solution employing multiple location sensors with different accuracy on different platforms for sharing of their absolute and relative localizations.

The ultimate and crucial research goals are to enable robust multi-sensory CL, seamless transition between different environments and optimal estimation of all users or platforms using sensor fusion of all currently available measurements. The need for CL navigation and guidance in GNSS-challenged environments started with the positioning of dismounted soldiers and emergency crews, which is now extended to different sensor platforms also for swarms of Unmanned Aerial Vehicles (UAVs) as well as team of robots. Thereby sensor augmentation of GNSS is based on the use of INS (Inertial Navigation Systems), accelerometers and gyroscopes, magnetometers and compass, and in the case of vehicles on odometers, as well as barometers which nowadays can also be found embedded in smartphones, and optical systems for vision-based positioning, etc., for applications ranging from pedestrian navigation, to georegistration of remote sensing sensors in land-based and airborne platforms.

7. MAJOR AIMS OF EDUCATION IN THE LBS DOMAIN

The above addressed issues and key points can be seen as major aims for modernized state-of-the-art education in the LBS domain. They should be addressed either in modernized and new curricula course modules and courses. Thereby the education of the students in the undergraduate and master up to PhD level should not only consist of theoretical lectures but also on practical work and hands-on experience with state-of-the-art equipment and sensor platforms. A selection of the main topics in the broader LBS and transportation domains are given in the following.

(1) Smart (urban) mobility / transportation

The suggestions below are based on the assumption that the overall education concept is to enable students to develop LBS applications on their own with a particular focus on the transport domain. It is proposed that the fundamentals of transport planning and traffic engineering are taught; in each of the courses, LBS applications are prominently incorporated. For example, a course 'Understanding Travel Behaviour' puts much weight on LBS-based tools for collecting data on travel behaviour. At the same time, students learn about alternative methods for collecting data on travel behaviour, they learn about where the collected data will be used in transport planning, they analyse the data and actually learn how people behave / how they travel and why.

Possible courses:

- Mobility Concepts and Evaluation (current status/challenges and opportunities in transport (e.g. climate change, air pollution, noise, capacity problems/congestion etc.), strategies and policy measures for shaping future transport systems, processes and institutions);
- Understanding Travel Behaviour (methods for data collection, methods for processing and analyzing the data, results – how do people behave in transport / how do they travel and why);
- Use of PNT data for the calibration of transportation models (this is part of a general course 'Modelling in Transport'. Students learn about how we model transport systems today and about how PNT data could improve transport models);
- Road Design and Infrastructure (basic principles of designing streets and roads that meet all the different user groups' needs, including place functions and curbside activities such as parking, loading etc.);
- Traffic Engineering (traffic quality, road safety management, intelligent transport systems, transport demand management);
- Possible further candidates: Applied Statistics in Transport, Transport Economics and Logistics, Public Transport Planning and Management.

(2) Localization concepts and solutions

- PNT concepts and their realization in the context of smart transportation and geomatics;
- Novel estimation theory approaches for optimal user localization;
- Personal mobility for sustainable transport using GNSS and other complementary and augmented localization technologies and techniques;
- Enhanced solutions concerning the four key parameters positioning accuracy, connectivity, ubiquity and security;
- PNT applications in challenging GNSS-denied environments with a special emphasis on indoor and hybrid environment localization;
- Ubiquitous localization techniques for individuals and groups of end users (including users with special needs) – e.g., using a smartphone App;

- Sensor fusion techniques for robust position estimation of all available signals-of-opportunities and sensors in smartphones and other mobile devices.

(3) GIS, Cartography and Geoinformatics

- GIS technologies / architectures and their relationship and importance to the field of LBS and smart mobility;
- Multi-media cartography for state-of-the-art presentation of LBS contents;
- Urban and indoor environment 3D spatial modelling;
- Virtual and augmented reality applications;
- Use of emerging mobile devices, such as smart watches, smart glasses, etc.;
- Standardization of LBS interfaces of ubiquitous PNT solutions; and
- Coverage of all aspects in the LBS domain.

The main three pillars can be seen as: (1) Geomatics / Geodesy dealing with PNT and sensors; (2) LBS including cartography and GIS and (3) smart transportation and mobility. To summarize, the main catchwords are as follows:

- Personal mobility – part of understanding travel behaviour;
- Sustainable transport – part of mobility concepts and evaluation;
- Public transport – part of mobility concepts and evaluation;
- Transportation in smart cities – part of mobility concepts and evaluation;
- Transportation management – part of traffic engineering (safety and traffic quality management);
- Traffic flow monitoring and guidance – part of traffic engineering;
- Traveler information systems – part of traffic engineering/transport demand management;
- Crowd monitoring and guidance part of understanding travel behaviour, might also be part of traffic engineering/transport demand management;
- Ubiquitous PNT for LBS;
- GNSS and its augmentation;
- Pedestrian localization in challenging environments;
- Cooperative solutions; and
- Sensor fusion and estimation techniques.

8. DEVELOPMENT OF SIX TRAIN-THE-TEACHERS COURSES

Competent teaching staff is a necessary guarantee for quality of teaching and learning in Universities. Many Universities, however, do not have enough competent teachers, especially on modern technologies related to LBS and smart transportation, such as ubiquitous PNT, GNSS, multi-media cartography and geovisualization, GIS, transportation system planning, data and models in transportation, etc. Therefore, the project LBS2ITS intends to upgrade staff's competences through six one-week intensive training courses. Emphasis will be put on new technologies (for example LBS, PNT, GNSS, GIS, smartphone user localization, urban planning for transportation, smart transportation services for personal mobility, environmental monitoring and protection in transportation services) and applications in related fields which are important in the partner country Sri Lanka.

Teaching staff from each partner Higher Education Institutions (HEIs) will receive training through six intensive courses on the following topics:

- Transportation system planning for smart cities;
- Alternative PNT technologies;
- Estimation theory and processing of spatial data;
- Data and models in transportation;
- Smartphone positioning techniques for in- and outdoor localization; and
- LBS and multi-media cartography.

Thereby major aims are to modernize current and construct new courses with focus on competences and learning outcomes. Concerning academic course modernization, at first a selection of the courses to be modified will be performed. This aims to align the course content with the level of education to be delivered. In parallel, the necessary resources for teaching will be identified. Further tasks concern updating current teaching material for six major subject areas. A major task in this activity includes designing the new curriculum course modules under consideration of a survey carried out. In a curriculum development workshop competencies needed by the industry and labour market will be defined. Accordingly, the core curriculum course modules with a list of courses will be developed. The workshop will also discuss course syllabi including a complete list of lesson topics and learning outcomes. For the latter we will use the active verbs used in Bloom's taxonomy (i.e., remembering, understanding, applying, analysing, evaluating and creating), which emphasize the six levels of thinking and the active nature of learning. Teaching materials for 20 major subject areas will be developed and e-published as open access following a review and revision process. Furthermore an emphasis will be led to build and implement Problem-based Learning (PBL) modules. This activity will start at an early stage with a workshop. Its content will focus on e-learning using the web platform MOODLE, basic philosophy on PBL and paradigms of their use. The workshop will also develop a work plan for a PBL pilot course. To save costs and resources between the partner HEIs also video recording and live-streaming of lectures will be prepared.

9. CONCRETE TANGIBLE RESULTS OF THE LBS2ITS EDUCATIONAL PROJECT

The results expected from the completion of the project comply with the objectives of the action of the European Union Erasmus+ Capacity Building in Higher Education (CBHE) programme. These are listed in three generic categories as follows:

(1) Results and outcomes concerning knowledge-gain and teaching skills in the partner country;
(2) Results and outcomes that concern with the educational curriculum / teaching material and equipment; and
(3) Management, quality, dissemination and other results.

Ad (1):

(i) New / improved knowledge on LBS and transportation education obtained through six intensive courses;
(ii) New / improved knowledge on LBS and transportation education obtained through knowledge transfer. The trained staff members (step (i)) to transfer knowledge to colleagues in their HEI unit (Dept. / Faculty);
(iii) New / improved knowledge on LBS and transportation education for the students attending the relevant courses in the last year of the project. Student feedback will be used to assess the outcomes of the project;
(iv) New / improved teaching skills on e-learning and PBL acquired through continuing practicing at HEI level and a joint workshop for a limited number of participants. This activity is addressed to the teaching staff for each HEI unit (Dept. / Faculty) participating in the project; and
(v) New knowledge acquired by the stakeholders.

Ad (2):

(i) Training material (e.g., lectures, practicals, e-learning) for six intensive courses in LBS and transportation prepared to train a limited number of the teaching staff from the participating HEIs;
(ii) A portfolio of teaching material (e.g., lectures, practicals, e-learning) for six fully modernized subject areas that focus on LBS and transportation;
(ii) A portfolio of teaching material (e.g., lectures, practicals, e-learning) for 20 newly developed core course modules on LBS / geomatics and transportation / smart mobility;
(iv) A portfolio of workshop material including material on: “core curriculum course modules development”, “e-learning and PBL”, “quality assurance (QA) in teaching”, etc.;
(vi) Digital resource kits for e-learning and student interaction (e.g., MOODLE web server, App-based course evaluation), and video recording tools for archiving lectures, practical training, etc.; and
(vii) A wide range of fully tested and functioning scientific equipment ranging from low-cost localization / data transfer systems (e.g. PDAs) to high-grade positioning units

(e.g. GNSS receivers) to act as core infrastructure for LBS and for validating low-cost ones.

Ad (3):

(i) The project's webpage to act as a central point hosting: (a) core information about the project (scope, objectives, activities, etc.); (b) open access teaching and training material on LBS and transportation / smart mobility; (c) links to stakeholders on LBS in Sri Lanka, Asia and internationally. The project webpage will serve as a live hub connecting HEIs and stakeholders on LBS and transportation in Sri Lanka and abroad;

(ii) A fully functioning educational database hosting information for the main stakeholders (HEIs, public and private organizations, professional bodies, industrial partners, etc.) in Sri Lanka that are concerned with the LBS sector for transportation. The database will take the form of an open access, dynamic tool easy to retrieve key information for the listed members (type of activity, focus areas, etc.) and having the possibility to host relevant announcements to the community;

(iii) Branches established in professional / non-governmental associations, institutions (e.g. transportation, geomatics, GIS,) to promote LBS to transportation. Priority will be given to Associated Partners participating in the project;

(iv) Cooperation agreements signed among the Depts. / Faculties of the participating HEIs and stakeholders. Priority will be given to Associated Partners in the project;

(v) Active participation of HEIs to international scientific and professional organizations (e.g., hEART, IAG, FIG, ICA, etc.);

(vi) An Activity Monitoring Manual (AMM).

10. IMPACT AND SUSTAINABLITY OF LBS2ITS

Table 1 summarizes the expected impact and Table 2 the sustainability of the project LBS2ITS.

11. CONCLUSIONS AND OUTLOOK

To sumamarize it can be said that LBS2ITS addresses the major aims and objectives through:

- Survey geomatics and transportation sciences stakeholders to identify society's needs and define competences which are needed;
- Develop LBS core course modules with definition of learning outcomes at lesson level;
- Introduce or modernize e-learning as a tool;
- Introduce PBL pedagogy to foster active learning;
- Implement quality assurance mechanism;
- Develop new teaching materials; and
- Promote regional cooperation.

#	Project results	Who will they impact at national, regional level?	How?
1	Examination of current and implementation of novel LBS education	Teachers and technicians at partner Universities	Better understanding of industry needs for graduates; teachers know better which topics to address in their lectures
2	Survey of all relevant stakeholders and employees	Teachers and technicians at partner Universities and national and regional level	Development and analyses of a questionaire sent to professional organizations and related industry
3	Proposal for modification of the national standards in education	Teachers and technicians at partner Universities	Development of a catalogue of generic research competences and field-specific research competences in engineering, natural sciences and IT
4	Mentoring implementation in the moderinzed and new course modules and courses	Teachers and technicians at partner Universities and EU Universities	For each courses the syllabus (competences, learning outcomes, course content, assessment methods and professional literature) is developed, tested and published
5	Guidelines for the development and implementation of courses in the partner countries	Teachers and technicians on the national level	Support of teachers and technicians with the developed guidelines
6	Trained partner countries teaching staff for the course development in the thematic fields	Teachers on the national and regional level	Teaching University staff delivering appropriate courses
7	e-learning and PBL approaches development and implementation	Students at partner Universities	Development of new course teaching materials for a student centered approach
8	Video recording and live-streaming of lectures	Students at partner Universities and national, regional and international	Sharing of resources at partner country Universities and enabling remote long-distance learning
9	Establishment of branches of LBS education in national professional organizations	Teachers and students from at partner Universities and other national Universities	Increase of visibility for the need on LBS education
10	Membership and participation in international scientific and professional organizations	Teachers on the national level	Joining international scientific and professional organizations on education in geomatics and transportation sciences, such as the International Federation of Surveyors (FIG) Commission 2, International Association of Geodesy (IAG), International Association of Cartography (ICA), hEART (European Association for Research in Transportation) and TRB (Transportation Research Board)

Table 1: Impact of the project

Sustainable Outcomes	Strategy to ensure their sustainability	Resources necessary to achieve this	Where will these resources be obtained?
Presentation of project outcomes	Publications in journals and at international conferences	Funding from follow-up educational and research projects	National and international funding schemes
Technology transfer networks	Open to other additional partners	Staff participation and willingness	Future joint project applications
Maintenance of websites and other communication channels	Assignment of maintenance responsibilities to HEI	Adminstrative staff partcipation	HEI
Cooperation aggreements between HEIs	Long-term relationship continued	Staff participation and willingness	Future joint project applications
Cooperation aggreements between HEIs and enterprises	Established relationship continued	Staff participation and willingness	Future collaboration with funding from enterprises
Closer cooperations for business relationships between HEI and enterprises	Established relationship continued and new partner acquisition	Staff participation and willingness	Future collaboration with funding from enterprises
New equipment update and acquisition	Adoption of EU standards	Funding from follow-up research projects	National and international funding schemes
Offering new life-long learning modules	Close cooperation with relevant partners in industry and governmental sectors	Usual teaching resources	Tuition fees from participants
Internationalisation of education	Attraction of more students from abroad using e.g. reduction of tuition fees, summer schools	Usual teaching resources	Tuition fees from participants
Integration of PhD students	Incentives for participation at HEIs	Scholarships	Funding from HEI and tuition fees
Pilot projects	Best-practice examples serving as references and benchmarks	Usual teaching resources	Funding from HEI

Table 2: Sustainability of the project

The project just started and runs in the coming three years and its impact and sustainability should be guaranteed beyond the lifetime of the project. Further information will be provided on the project website lbs2its.net.

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