

**TU1208 GPR ROADSHOW: EDUCATIONAL AND PROMOTIONAL
ACTIVITIES CARRIED OUT BY MEMBERS OF COST ACTION TU1208
TO INCREASE PUBLIC AWARENESS ON THE POTENTIAL
AND CAPABILITIES OF THE GPR TECHNIQUE**

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Abstract

Our participation in the COST (European Cooperation in Science and Technology) programme gave us significant insights into the importance of explaining scientific findings to non-scientific audiences. In the framework of COST Action TU1208 “Civil engineering applications of Ground Penetrating Radar” we organised a series of dissemination activities to increase public awareness about ground penetrating radar (GPR) capabilities and applications, as well as to establish a dialogue with stakeholders and end-users of our research. Most of our educational and promotional activities were carried out in less-research intensive countries of the European continent, and we denominated the overall science communication initiative “TU1208 GPR Roadshow”. The purpose of this paper is to present descriptions, principles, and results of our Roadshow. Part of

the Roadshow consisted of a series of non-scientific workshops and practical demonstrations held in Portugal, Italy, Greece, Croatia, Serbia, and the Czech Republic from March 2016 to May 2017. The primary objective of those events was to reach out to GPR stakeholders and potential new end users, at local, regional and national levels; a secondary goal was the education of interested students and citizens. Attendance was always free of charge; talks and explanations were mostly given in native language, with few exceptions. Overall, the Roadshow workshops and demonstrations had 483 participants. In parallel, an amazing series of activities with children and citizens were carried out in Estonia: several lectures were delivered in elementary and secondary schools, practical workshops were held during the Researchers' Nights, communication activities were organized in large events where enterprises were brought together with researchers, some lectures were given in summer schools, and short lectures were transmitted on public TV. All these initiatives have strongly increased public awareness of the potentialities of the GPR technique.

Keywords: Ground penetrating radar; science communication; public knowledge about science and technology; dissemination and outreach; scientific training.

1 Introduction

Researchers are rather confused about what science communication is, and they often underestimate its importance. Science communication mostly is about communicating with nonexperts, whereas many researchers stay in their 'ivory tower' and talk to colleagues within their specialist area, only. The communication strategy of researchers normally includes the presentation of activities and results in scientific conferences, publication of scientific papers in peer-reviewed scientific journals, and publication of scientific books and book chapters; the youngest researchers spread information about their studies on academic social networking sites, as well. If scientists wish to maximize the impact of their activities and receive more funding, it is imperative that they step out of their usual arenas and start communicating science to a broader audience; they need to establish a dialogue with stakeholders and end users of their research, and also with citizens of different ages and education levels. Nowadays there is a huge amount of research going on, on really important topics, that actually never really gets to policymakers, professional groups or commercialization; at the same time, too many citizens do not understand how important science

is for society, how research is crucial for finding concrete solutions to global challenges, and how creating new knowledge and improving education is essential for increasing the quality of our lives.

A contemporary definition of science communication is given by Burns et al. [1] as the employment of proper abilities, actions, media, and dialogue to provide at least one of the following individual reactions to science (with the AEIOU vowel analogy): Awareness, Enjoyment, Interest, Opinion-forming, and Understanding. Science communication is a multifaceted subject which covers a range of issues from dissemination of scientific research to new models of public involvement where lay persons are supported to take part in science discussions and policy; and it attracts increasing consideration from research institutions, policy makers, practitioners and academicians [2].

To encourage science communication initiatives, the European Union (EU) is requiring that a comprehensive communication plan be included in all Horizon 2020 project proposals (as is well known, Horizon 2020 is the EU Framework Programme for Research and Innovation for 2014-2020) [3, 4]. Moreover, Horizon 2020 is launching dedicated calls for communication projects. The EU has recently prepared a “Guide to Science Communication” consisting of a series of short videos about science communication in general, with several tips on ‘how to improve your communication efforts,’ and a 60-minutes video on ‘how to increase the communication impact of your research project’ (all those videos are available on the European Commission “Innovation Union” YouTube channel). Further useful documents published at European level are the “Social media guide for EU funded R&I projects” [5] and the Intellectual Property Rights (IPR) HelpDesk brochure “Making the Most of Your H2020 Project” [6].

Ground Penetrating Radar (GPR) researchers are not different from researchers working in other scientific areas when it comes to science communication behaviour; and yet, given the vast application potential of the GPR technique, there is so much that can be shared with multiple interlocutors and at different levels. Our participation in Horizon 2020 via the COST (European Cooperation in Science and Technology) Action TU1208 “Civil engineering applications of Ground Penetrating Radar” gave us significant insights into the importance of explaining scientific findings to non-scientific audiences. We decided to put efforts into increasing public awareness about GPR capabilities and applications, as well as into establishing a dialogue with stakeholders

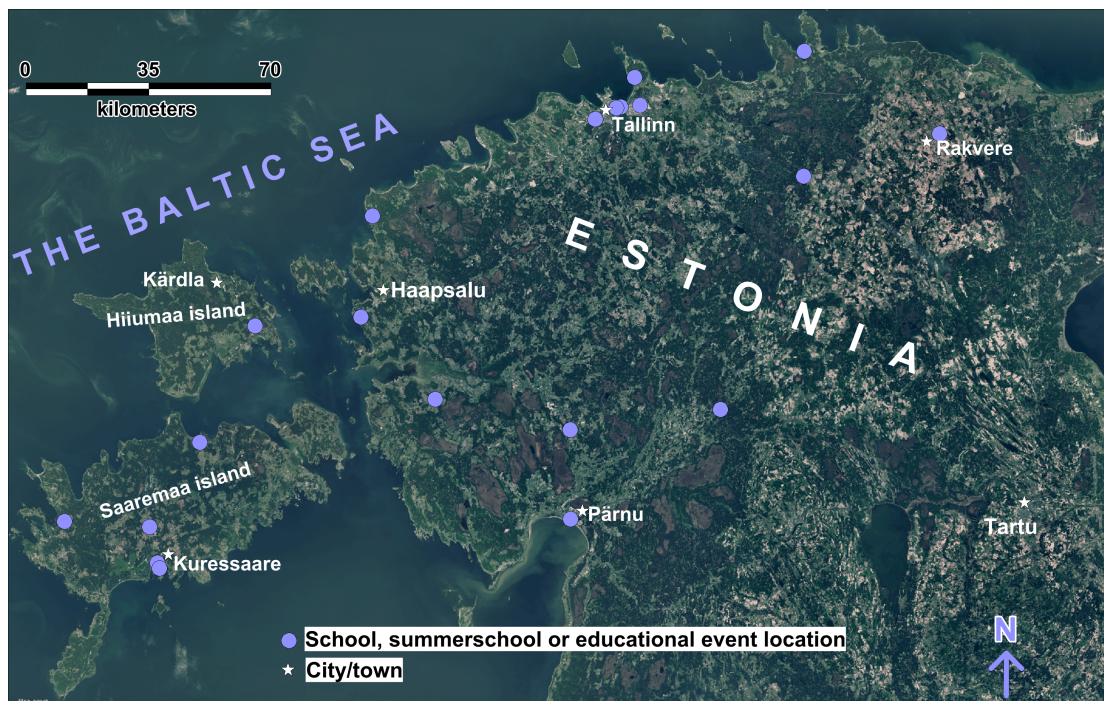
and end-users of our research. We therefore organized a heterogeneous series of educational and promotional activities that were mostly carried out in less-research intensive countries of the European continent (Inclusiveness Target Countries [7]); the overall science communication initiative was denominated “TU1208 GPR Roadshow”.

This paper aims to present some descriptions, principles, and results of our Roadshow. It has to be noted that the Roadshow activities were entirely organized by researchers, sometimes in cooperation with private GPR service providers. When we started, we were totally unaware about science communication methods and strategies, most of us did not even know the meaning of the word ‘stakeholder’ and had never made a serious thought on who the ‘end users’ of their research were [8]. Therefore, the Roadshow activities represented our first steps in the ‘world of science communication.’ Nonetheless, the initiative was undoubtedly a big success; it raised considerable interest in various countries and was a catalyst for a series of new activities.

Part of the Roadshow consisted in a series of communication events held in Portugal, Italy, Greece, Croatia, Serbia, and the Czech Republic from March 2016 to May 2017 [9, 10]; the route of the Roadshow events is illustrated in Figure 1(a). The primary purpose of these events was to reach out to GPR stakeholders and potential new end users, at local, regional and national levels; a secondary goal was the education of interested students and citizens. The events organized in the various countries are presented as separate case studies in Sections 2-7 of this paper. Attendance was always free of charge, for all participants; the talks and explanations were mostly given in native language, with few exceptions. Overall, 483 participants attended the events and had the opportunity to learn what is GPR, how this technique can be used for ‘seeing the unseen,’ and what is the role of GPR in civil engineering works, archaeological investigations, and cultural heritage management (we mainly focused on these fields of application because the COST Action TU1208 project dealt with the use of GPR in civil-engineering). In our events, we also stressed how GPR profiling is a safe, environment-friendly, and non-destructive method of investigation. Feedback was collected after the events; participants expressed strong satisfaction, most often they asked us to organize further dissemination activities if not to establish a regular series of events, to be held annually or every few months, in order to keep the dialogue active and receive regular updates on the GPR research.



(a)



(b)

Figure 1: (a) Route of TU1208 GPR Roadshow communication events. (b) Map of Estonia, with blue dots indicating the locations of our numerous educational activities and events (the base satellite map is taken from the website of the Republic of Estonia Land Board).

In parallel, a series of promotional and educational activities were carried out in Estonia, which brought especially positive and tangible results; these activities are resumed in Section 8 and their numerous locations are shown in Figure 1(b). Estonia is a small and relatively young independent country, where many fields of research are making the first steps; moreover, the profession of the scientific researcher is not much acknowledged and popular among the students. GPR is not very commonly used in Estonia and was an almost unknown tool among Estonian people, until a few years ago. To the best of our knowledge, there were only two GPR systems in Estonia when COST Action TU1208 started, both of them owned by research groups working in the university; those groups were mostly employing GPR in the fields of geology, ecology, and archaeology. Now things are changing: there is an increasing interest in the use of GPR, not only for research but also for practical works in private and public sectors; indeed, the research groups owning GPR systems have reported that they have been recently involved in a growing number of projects ordered by private enterprises or public authorities. We are delighted to say that this phenomenon is most probably the result of the communication efforts made by the researchers from the Institute of Ecology at Tallinn University. A number of lectures delivered in elementary and secondary schools, practical workshops held during the Researchers' Nights, communication activities in large events where enterprises were brought together with researchers, lectures delivered in summer schools, and even short lectures transmitted on public television channels have all increased public awareness on the potentialities of the GPR technique.

2 Roadshow in Portugal

The pilot communication event of COST Action TU1208 was held on 2 March 2016 at the Laboratório Nacional de Engenharia in Lisbon (LNEC), Portugal; the local organiser was Dr Simona Fontul. A full-day non-scientific workshop on GPR basic principles and civil-engineering applications was offered to stakeholders and potential new end-users (namely, representatives from public agencies and private companies providing civil engineering services). The workshop was meant to be a "preliminary experiment" conducted by TU1208 to evaluate the feasibility, raised interest, difficulties, and benefits of this kind of events,

before possibly starting a full-scale dissemination project. The decision to organize the event in Portugal was due to the enthusiasm expressed by the local organiser and to the priority principle of disseminating information about GPR first in countries where this technology is rarely used (and particularly in the less research-intensive countries).

The programme of the workshop is reported in Table 1. As is well known, the penetration of English language is non-uniform across Europe and, even when the penetration of English is sufficient, lectures in native language help Attendees to concentrate on the presented topics, as they don't have to put efforts into decoding a foreign language. For this reason, we decided that most talks had to be given in native language. Nonetheless, lectures given by Action Members coming from abroad were included in the programme, too, to offer a European perspective to Attendees; those talks were of course given in English. Additionally, most slides were written in English to facilitate the foreigners in the comprehension of the presented topics.

In total, 104 persons attended the event, with a high prevalence of local Attendees, as expected (see Figure 2(a)). Figure 2(b) shows the number of Attendees from universities and research institutes, industry, and public agencies (we were pleased by the high number of participants from industry). Figure 2(c) shows gender distribution of Attendees. Based on questions asked by Attendees during the event, we observed that, beyond the civil engineering applications of GPR, there was a significant interest in the use of GPR in geology, water management, and sedimentology.

After the event, we sent an evaluation form to all Portuguese Attendees, via email; the form was sent only once, and we got answers from 48% of the recipients (the feedback was very strong). Questions and answers are reported in Table 2. Some participants asked us to organise further dissemination events in Portugal, and possibly a training course including practical sessions on data acquisition and processing. End-users with previous GPR experience expressed appreciation for the initiative and commented that these events can concretely foster a wider use of GPR, as well as help to demystify subjectivity in GPR data interpretation.

We were glad to learn that, after attending the Lisbon event and discovering the numerous applications and high potential of the GPR technique, a company without previous experience in GPR decided to extend their activities to this area. They tried and contacted various GPR

manufacturers, proposing them to become their national representatives in Portugal, and nowadays they are Portuguese representatives of IDS Georadar srl. The company reported that during the first six months of activity they managed to sell two systems in Portugal and they also started demonstration and rental businesses.

Table 1: Programme of the dissemination event held in Lisbon (Portuguese edition of TU1208 GPR Roadshow).

Seminário Aplicações do Georadar (GPR) em Engenharia Civil (Seminar on Georadar Applications for Civil Engineering)	
Time	Session
09:00-09:30	<i>Receção dos participantes</i>
09:30-09:45	Sessão de abertura
09:45-10:00	“Princípios de funcionamento do Georadar e campos de aplicação,” Doutora Simona Fontul – LNEC, PT
10:00-10:30	“Aplicação do Georadar na avaliação de infraestruturas ferroviárias,” Doutor Eduardo Fortunato & Doutora Simona Fontul – LNEC, PT
10:30-11:00	<i>Intervalo</i>
11:00-11:30	“Avaliação da humidade e presença de fendas em misturas betuminosas,” Prof. Jorge Pais & Prof. Francisco Fernandes – Univ. do Minho, PT
11:30-12:10	“Ground Penetrating Radar inspection of buildings: looking inside advantages and limitations,” Prof. Vega Pérez-Gracia – Univ. Politécnica de Cataluña, ES
12:10-12:30	Debate
12:30-14:15	<i>Almoço (livre)</i>
14:15-14:35	“Aplicação do Georadar em geotecnia e estruturas,” Doutora Maria João Coelho – LNEC, PT
14:35-15:00	“Introduction to the COST programme and to Action TU1208 “Civil engineering applications of Ground Penetrating Radar,” Prof. Lara Pajewski – Universidade “Roma Tre”, IT
15:00-15:20	“Ground Penetrating Radar for bridge inspection,” Prof. Mercedes Solla – Universidade de Vigo, ES
15:20-15:50	<i>Intervalo para café</i>
15:50-16:15	“Aplicação do Georadar na avaliação de infraestruturas rodoviárias e aeroportuárias,” Doutora Simona Fontul & Doutoranda Vânia Marecos – LNEC, PT
16:15-18:00	Painel: Experiências e desafios na aplicação do Georadar – Sessão de encerramento

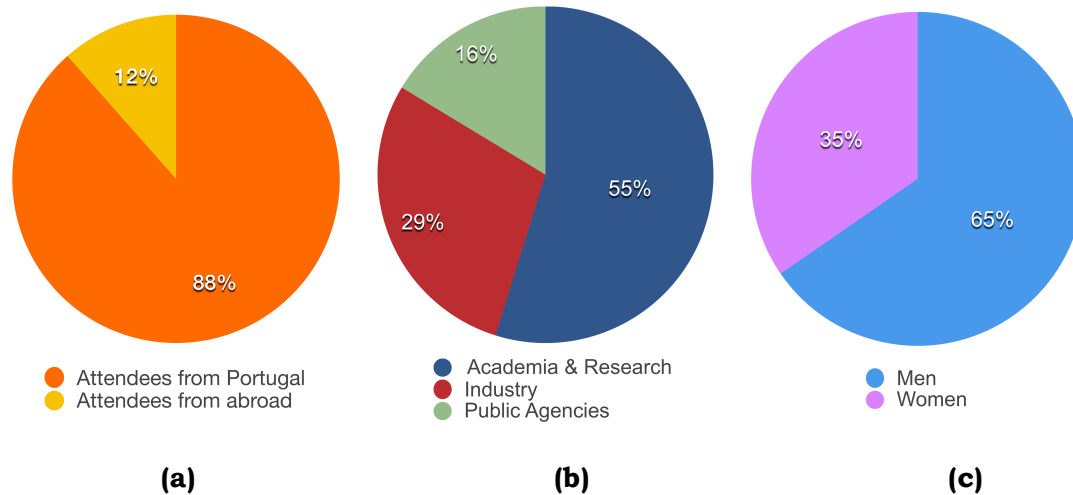


Figure 2: (a) Number of Attendees from Portugal and from other countries; (b) Number of Attendees from universities and research institutes, private companies, and public agencies; (c) Gender distribution of Attendees (Portuguese edition of TU1208 GPR Roadshow).

Table 2: Evaluation form sent to Attendees, with statistics on the received feedback (Portuguese edition of TU1208 GPR Roadshow).

1 - Qual era o conhecimento que detinha sobre o Georadar antes do Seminário? 1 - What was your knowledge about GPR before attending the workshop?	<i>Nunca tinha ouvido</i>	<i>Já tinha ouvido</i>	<i>Utilizei resultado</i>	<i>Sou utilizador</i>
	<i>Never heard about it</i>	<i>Knew about its existence</i>	<i>Saw GPR results before</i>	<i>GPR user</i>
	3%	56%	22%	19%
2 - Utilizava o equipamento Georadar para aplicações na sua área se tivesse a oportunidade? 2 - Will you use GPR in your area, if you will have the opportunity?	<i>Não</i>	<i>Talvez</i>	<i>Sim</i>	<i>Não se aplica</i>
	<i>No</i>	<i>Probably</i>	<i>Yes</i>	<i>Not applicable</i>
	6%	19%	72%	3%
3 - Considerou o Seminário útil para adquirir conhecimentos sobre o funcionamento e a utilização do Georadar? 3 - Do you think that the event was useful to acquire knowledge on GPR basic principles and applications?	<i>Nada</i>	<i>Pouco</i>	<i>Médio</i>	<i>Muito</i>
	<i>Not at all</i>	<i>A little</i>	<i>Fairly</i>	<i>A lot</i>
	0%	3%	34%	63%
4 - Tem sugestões para futuras participações/ colaborações de divulgação nesta área? Quais? 4 - Do you have suggestions for future cooperation / dissemination activities in this area? Which one?	<i>Não</i>	<i>Sim</i>		
	<i>No</i>	<i>Yes</i>		
	75%	25%		

3 Roadshow in Italy

The Lisbon workshop revealed that communication initiatives towards non-scientific audiences were (and still are) strongly needed in the GPR field. Therefore, the Action decided to modify its Work & Budget Plan and organize further dissemination events to be held during the subsequent 15 months in different countries.

The second event was held in Rome on 29 April 2016 and was a great success. The main focus was again on the civil-engineering applications of GPR. The venue was the Department of Engineering of Roma Tre University and the local organiser was Dr Lara Pajewski. The flyer of the event, including the programme (in Italian), is in Figure 3.

The event was attended by 96 participants, with a high prevalence of local Attendees (Figure 4(a)); participants from other Countries were also present since the technical workshop was held right after the 2016 Working Group Progress Meeting of the Action. Most slides were written in English to help foreigners in the comprehension of exposed topics; however, all talks were given in Italian. Figure 4(b) shows the number of Attendees from universities and research institutes, public agencies, and industry. The number of participants from industry was especially high: some private companies attending the event were already working with GPR, other companies did not yet have experience with GPR and were interested in discovering more about this inspection technique; there were also representatives from a manufacturer of radar systems (not GPR) and two telephone companies. Concerning the participation of stakeholders, there were representatives from the Regional Agency for Environmental Protection, the Ministry of Telecommunications, and Carabinieri Corps. It has to be mentioned that this event was organised with short notice (for financial reasons), else attendance would have been stronger; this also explains the low participation of stakeholders, who usually need a longer notice than researchers and companies. Figure 4(c) shows gender distribution of Attendees, which is similar to the Lisbon one. As a general comment, we noticed that the participation of women was stronger at TU1208 dissemination events than at scientific events.

When the event was planned, COST key principles were faithfully followed and young researchers were invited to give most of the lectures, instead of experienced professors; this was also done to stress how, in Italy, young researchers suffer from a strongly hierarchical academic

environment and struggle to have the opportunities and visibility they need and deserve. During some talks, scientific information was intercalated by interesting historical anecdotes. Attendees asked several questions and expressed appreciation for the professionalism and clarity of the Speakers, stating that lectures were one better than the other.

The workshop included a roundtable with companies offering GPR services. Before the event, TU1208 Members from Rome looked on the internet and found 27 Italian companies active in the GPR field: they all were invited to attend the workshop and join the roundtable. Several companies participated in the workshop, and three of them accepted the challenge of the roundtable: GeoLogica from Rome, Geo3D from Rieti, and GRS from Rome. These companies were asked to:

- 1) Introduce themselves and their activities;
- 2) Based on their experience, point out GPR strengths and limits;
- 3) Suggest topics that might be introduced in training programmes at university level, to bridge the gap between industry needs and higher education;
- 4) Tell about their past or ongoing collaborations with Universities and participation in research projects, if any;
- 5) Suggest ideas about how to achieve a stronger involvement of Italian industry in research.

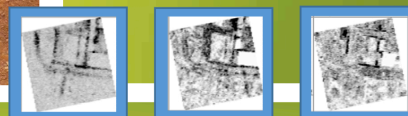
The companies reported that they mainly use GPR in the civil engineering fields of application: assessment of airport runways and reinforced concrete infrastructures, support during construction and renovation works, structural investigations, detection and localization of cavities and utilities (optical fibres being the most frequently sought utilities, as they easily move from their initial position). Moreover, they are sometimes asked to carry out geophysical surveys; sporadically, they use GPR for forensics and archaeological investigations. When needed, GPR is combined with other non-destructive testing techniques to overcome its limits and/or increase the accuracy of results.

Difficulties encountered by the three companies reside more in the wrong reputation of GPR and/or weak awareness of customers about GPR capabilities, rather than in the intrinsic limits of the technique. Sometimes customers request surveys on soils with high conductivity, where good results cannot be obtained (such as clayey soils), or in scenarios where radargrams cannot be easily interpreted due to the presence of too many reflecting structures (such as the basement of a building), or else they wish to reach higher resolution and/or deeper



Le applicazioni del Georadar nell'ingegneria civile

Nell'ambito di un progetto pluriennale finanziato dall'Unione Europea e finalizzato allo sviluppo di una rete di ricerca di eccellenza, si svolge a Roma una giornata divulgativa per ingegneri, professionisti e operatori del settore, o per tutti coloro che vogliono avere una visione generale dello stato dell'arte.



Giornata divulgativa sul Georadar in ingegneria civile

9:00 – Registrazione

9:45 – Saluti di benvenuto, introduzione alla giornata e apertura dei lavori

10:00 – Relazione introduttiva (Andrea Benedetto)
Il Georadar nell'Ingegneria Civile: lo stato dell'arte

10:45 – Il quadro internazionale (Lara Pajewski)
Il contributo della COST Action TU1208

11:20 – Tea & Coffee break

Dalle 11:45 alle 13:00 seguono interventi e discussione su

Le applicazioni del Georadar nel settore stradale (Luca Bianchini Ciampoli)
Le applicazioni del Georadar nel settore ferroviario (Maria Giulia Brancadoro)
Le applicazioni del Georadar nel settore aeroportuale (Fabio Tosti)

Dalle 14:30 alle 16:00

Tavola rotonda con le aziende che operano nel settore

Le applicazioni del Georadar nel settore dell'archeologia (Raffaele Persico)
Le applicazioni del Georadar nel settore del monitoraggio di ponti e viadotti (Fabrizio d'Amico)
L'analisi del segnale e l'interpretazione della misura con Georadar (Francesco Benedetto)
L'esperienza dell'Autorità Nazionale dei Trasporti in Irlanda (Patrizio Simeoni)

Università degli Studi di Roma Tre
Dipartimento di Ingegneria
Sala Conferenze
Via Vito Volterra, 62
29 aprile 2016

COST Action TU1208 "Civil engineering applications of Ground Penetrating Radar"
www.GPRadar.eu - info@GPRadar.eu

Figure 3: Flyer of the technical workshop held in Rome (Italian edition of TU1208 GPR Roadshow).

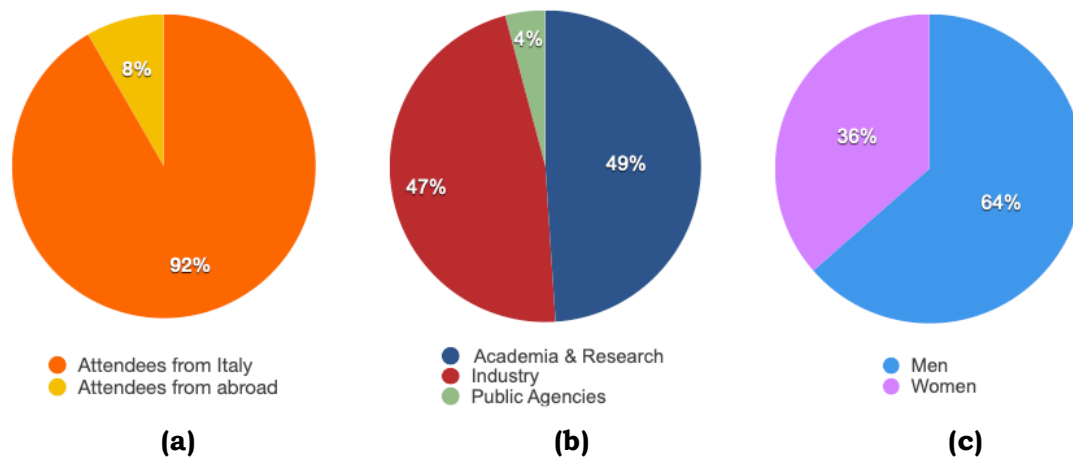


Figure 4: (a) Number of Attendees from Italy and from other countries; (b) Number of Attendees from universities and research institutes, private companies, and public agencies; (c) Gender distribution of Attendees (Italian edition of TU1208 GPR Roadshow).

penetration than possible. In such situations, companies try and explain that, although GPR has recently achieved some spectacular successes, there are environments where it cannot be used to image the subsurface with high resolution, moreover not every kind of target can be detected. Whenever possible, companies propose to customers the use of complementary non-destructive testing approaches in combination with GPR. However, sometimes customers think that companies are recommending to use other techniques to increase their profit and not because of actual necessity.

The companies participating in the Roadshow would gladly welcome the establishment of a license for GPR end-users in Italy and the introduction of national guidelines for the use of GPR in civil engineering and possibly also in other areas. Another issue raised by companies is the absence of GPR training opportunities in Italy: manufacturers organize short and expensive introductory courses, but end-users substantially have to learn how to use their GPR autonomously, and this strongly limits a wider diffusion of the technique. GPR technology and methodology have been evolving fast in the last decades, and nowadays an enormously wide range of applications exist; hence companies believe that it is high time for Italian universities and associations of engineers to start offering GPR courses.

All participating companies stated that they found the workshop very useful. They suggested repeating the experience regularly, for example every six months, to share expertise and foster stronger cooperation between academia and industry. Delegates from academia agreed that frequent meetings between scientists and private end-users are highly desirable; and they observed that such initiatives might be organised by companies, too, not necessarily by universities.

An article resuming this science communication day was published in "Strade & Autostrade," [11] ("Roads & Highways"), an Italian technical bimonthly journal dedicated to issues pertaining to the construction, maintenance, and management of transport networks in Italy.

Among the positive outcomes of the Italian Roadshow, shortly after the event the local organiser was contacted by the Special Operations Department of Carabinieri Corps, to establish a scientific cooperation on the use of GPR for forensic investigations and law enforcement.

4 Roadshow in Greece

The third edition of the Roadshow was held in Athens and spanned over two days (27 and 28 September 2016); the poster of the event is shown in Figure 5. The main focus was on the use of GPR for archaeological investigations and cultural-heritage management, these being the main areas where GPR can be employed in Greece. The local organiser institution was Geoservice, a Greek company funded in 1990 and providing state-of-the-art services, at European level, in the field of non-destructive geophysics. The event was also supported by the Hellenic Ministry of Culture, Education, and Sport, via its Directorate for Conservation of Ancient and Modern Monuments.

The event was attended by 76 participants; two Speakers came from abroad, all other Speakers and Attendees were Greek (Figure 6(a)). Figure 6(b) illustrates the number of participants from universities and research institutes, public agencies, and industry; the local organiser was able to attract the interest of many private companies and stakeholders. The attending companies declared that they did not have any previous experience with GPR. Stakeholders were from the Hellenic Ministry of Culture, Education and Sport, National Archaeological Museum of Athens, Corfu Archaeological Ephorate, Ephorate of Antiquities of West Attiki, Corinth Archaeological Ephorate, and Water Company of Athens. A few participants were unemployed conservators



Figure 5: Flyer of the dissemination event held in Athens, hanging on a wall in the National Gardens of Athens (Greek edition of TU1208 GPR Roadshow).

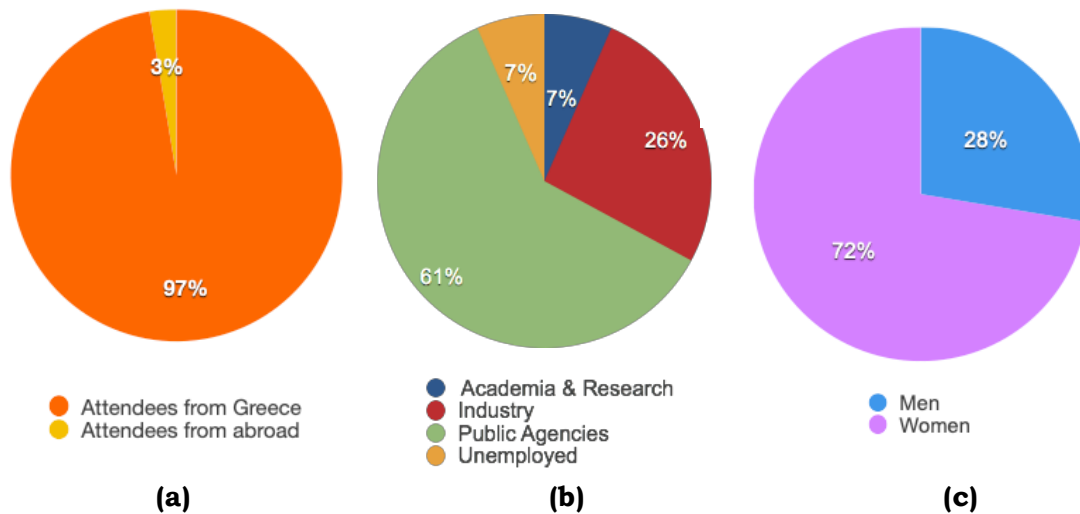


Figure 6: (a) Attendees from Greece and abroad; (b) Attendees from academia and research, industry, public agencies, and unemployed Attendees; (c) Gender distribution of Attendees (Greek edition of TU1208 GPR Roadshow).

and archaeologists. Figure 6(c) shows gender distribution of Attendees: the percentage of women was notably higher than in all other Roadshow editions; this is most probably due to the fact that more women work in the fields of archaeology and cultural-heritage than in civil engineering.

During the first day, the GPR technique was explained to Attendees while performing practical demonstrations in the National Gardens of Athens, a public park in the centre of Athens where ancient ruins, tambourines, Corinthian capitals of columns, mosaics, and other archaeological artifacts, are present. In the morning, an area with mosaics was investigated (Figures 7 and 8(a)-(c). The measured data were plotted, printed, and then interpreted and discussed with Attendees. In the afternoon, we surveyed a 10 m × 10 m flat green area with buried archaeological ruins (Figure 8(d)). These activities required a preparatory work to choose suitable areas and inspect them in advance.

During the second day, a workshop was held in the City of Athens Cultural Centre (Antonis Tritsis Amphitheatre), including a series of technical talks and a final discussion. A photo taken during the workshop is shown in Figure 9; a translation in English of the workshop programme is in Table 3 (the original programme was written in Greek); almost all lectures were given in Greek and slides were in Greek, only the contributions of Dr Lara Pajewski and Dr Fabio Tosti were in English. During the final discussion, the Speakers tried and stimulated ideas in the audience for implementing non-destructive methodologies in the conservation of cultural heritage and starting new projects where GPR could be employed. Moreover, Speakers and audience reflected together about opportunities for the creation of new international synergies in the field of non-destructive assessment by using GPR.



Figure 7: Aerial photo of the mosaics in the National Gardens of Athens, surveyed with GPR during Day 1 (Greek edition of TU1208 GPR Roadshow).

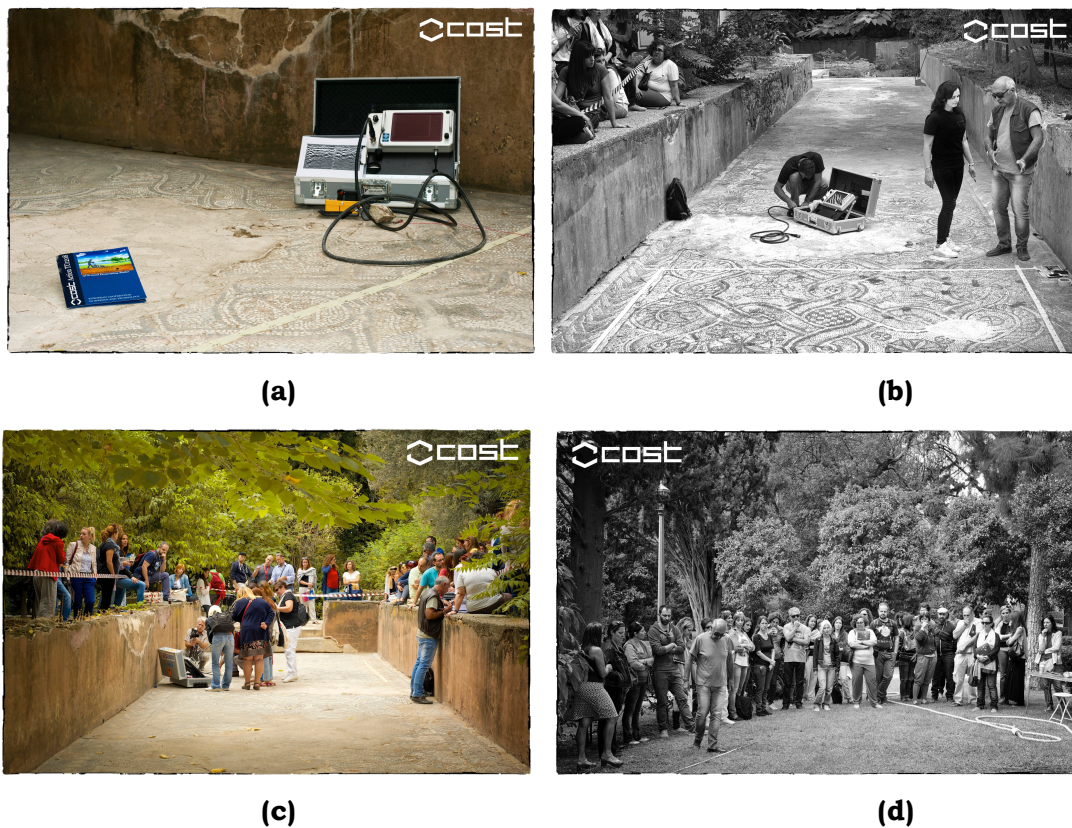


Figure 8: (a) GPR equipment used to inspect the mosaics of the National Gardens of Athens; (b) Morning demonstration on the mosaics; (c) Preparing the acquisition grid on the mosaics; (d) Afternoon demonstration over buried archaeological structures (Greek edition of TU1208 GPR Roadshow).

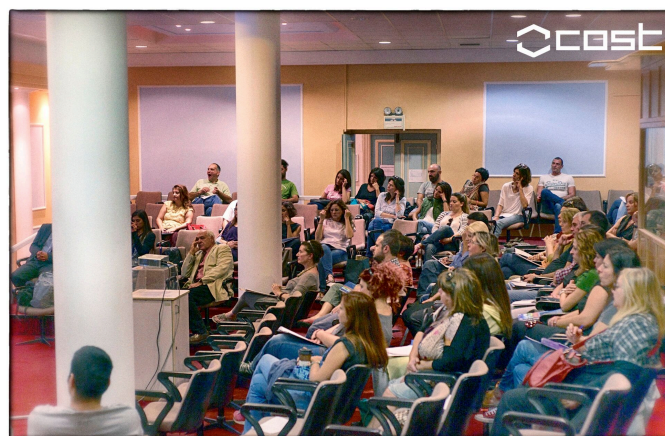


Figure 9: Attendees in the Antonis Tritsis Amphitheatre of the City of Athens Cultural Centre (TU1208 GPR Roadshow – Greek edition).

Table 3: Programme of the workshop held in Athens (TU1208 GPR Roadshow).

Time	Speaker	Activity
10:30 - 10:45	Klisthenis Dimitriadis (President of GEOSERVICE, EL) & Maria Mertzani (Head of Directorate of Conservation of Ancient and Modern Monuments in Greece, Hellenic Ministry of Culture, Education and Sports, EL)	Welcome to participants and introduction to the workshop
10:45 - 11:30	Dr Lara Pajewski (Chair of COST Action TU1208, Roma Tre University, IT)	Introduction to the COST programme and to Action TU1208 "Civil engineering applications of Ground Penetrating Radar"
11:30 - 11:50	Dr Fabio Tosti (Research Fellow, University of West London, UK)	Use of Ground Penetrating Radar (GPR) in archaeological surveys
11:50 - 12:10	Prof. Andreas Loizos (Vice-Chair of COST Action TU1208, National Technical University of Athens, EL)	Overview of GPR applications in transport infrastructure
12:10 - 12:30	Klisthenis Dimitriadis (Geoservice, EL)	An example of non-destructive assessment using GPR, in the Mycenaean Tomb of Acharnon (work supported by COST Action TU1208 with a STSM Grant)
12:30 - 13:00		<i>Buffet at the foyer</i>
13:00 - 13:20	Dr Georgianna Moraitou (Head of Conservation, National Archaeological Museum of Athens, EL)	Non-destructive assessment using GPR, of the Antikythera sculptures
13:20 - 13:50	Maria Mertzani	Non-destructive methods for the conservation of cultural heritage
13:50 - 14:10	Dr Demosthenes Giraud (Emeritus Director, Directorate for Conservation of Ancient and Modern Monuments in Greece, Hellenic Ministry of Culture, Education and Sports, EL)	Non-destructive assessment with GPR in the ancient theater of Megalopolis, in the FP7 EU project STONECORE
14:10 - 15:30	All participants	Open discussion

5 Roadshow in Croatia

The Croatian edition of GPR Roadshow consisted in a technical workshop held on 6 March 2017, prior to a three-day training school organized by COST Action TU1208, too. The event was hosted by the Faculty of Civil Engineering of the University of Osijek and the local organizer was Prof. Damir Varevac. The main focus of this edition was on the use of GPR in civil engineering and especially on the assessment of transport infrastructures. The programme is in Table 4; all talks were given in English, since the local organizer suggested that the level of English is very good in Croatia. Most Speakers were from academia, two were from industry (KB GPR Surveys, United Kingdom, and Murphy Surveys, Ireland). The participation of Speakers from industry is especially useful in GPR communication events, whenever one of the goals is to reach potential new end users.

The workshop was attended by 44 participants: 24 of them were Trainees of the subsequent training school (mostly, they were PhD Students from Inclusiveness Target Countries: the Czech Republic, Croatia, Hungary, Macedonia, Poland, Serbia, Turkey; and one Trainee was a PhD Student from the United Kingdom); the other Attendees were local scientists and students from both scientific and humanistic faculties; the Dean and Vice-Dean of the Faculty of Civil Engineering, Architecture and Geodesy of the University of Split attended the event, too.

The quality of the workshop was very good: Speakers gave excellent talks, interesting discussions took place, and the host institution provided amazing facilities as well as a financial contribution to partially cover the expenses. However, the event was mostly advertised in the academic environment; for that reason, there were no Attendees from public agencies and local private companies, whereas reaching those categories was the main objective of the initiative. The workshop substantially turned into an introductory day to the subsequent training school. The Croatian Roadshow case study highlights and confirms that, when embarking on the first organizational phases of a science communication event, it is crucial to design not only an effective programme of the activities but also an adequate information campaign towards the targeted audiences.

Table 4: Programme of the workshop held in Osijek (Croatian edition of TU1208 GPR Roadshow).

Time	Speaker	Activity
08:30 - 09:00		Registration.
09:00 - 09:15	Local Authorities	Welcome to participants.
09:15 - 10:00	S. Fontul (LNEC, Portugal)	Ground Penetrating Radar (GPR) basic principles, capabilities and limits. Applications of GPR in civil engineering.
10:00 - 10:45	L. Pajewski (Chair of COST Action TU1208, Roma Tre University, Italy)	Introduction to the COST programme and to the Action TU1208 "Civil engineering applications of Ground Penetrating Radar."
10:45 - 11:00	D. Varevac (University of Osijek, Croatia)	GPR activities in the Osijek Faculty of Civil Engineering.
11:00 - 11:30		<i>Tea & Coffee Break</i>
11:30 - 12:30	C. Van Geem (Belgian Road Research Centre, Belgium)	GPR applied to roads and bridges.
12:30 - 13:00	S. Fontul	GPR applied to railways.
13:00 - 14:00		<i>Lunch</i>
14:00 - 14:45	C. Van Geem	Pavement management. Combined use of GPR with complementary non-destructive testing techniques.
14:50 - 15:35	M. Govedarica & A. Ristic (University of Novi Sad, Serbia)	GPR applied to detection and localisation of utilities in urban areas. Guidelines and good practice in Serbia.
15:35 - 16:00	K. Banks (KB GPR Surveys, United Kingdom)	The point of view of a private end-user: Overview on GPR services offered by KB GPR Surveys. Case studies.
16:00 - 16:30		<i>Tea & Coffee Break</i>
16:30 - 16:45	S. Fontul	GPR applied to airports.
16:45 - 17:10	S. Santos Assuncao (Murphy Surveys, Ireland)	The point of view of a private end-user: Overview on GPR services offered by Murphy Surveys. Case studies.
17:10 - 17:30	T. Rukavina (Zagreb University, Croatia)	GPR activities in Zagreb University.
17:30 - 18:00	All	Discussion.

6 GPR Roadshow in Serbia

The fifth Roadshow event of COST Action TU1208 was held on 10 March 2017 at the Faculty of Technical Sciences of the University of Novi Sad, Serbia. The local organizer was the Geoinformatics Laboratory of the Computing and Control Department, coordinated by Prof. Miro Govedarica. The event consisted of a science communication workshop entitled 'GPR Workshop – European experiences, standards and recommendations on the application of Ground Penetrating Radar,' preceded by an exhibition and followed by a practical demonstration. The programme of the event is reported in Table 5, and the flyer is shown in Figure 10.

The targeted audience primarily included public agencies, private companies, and professionals active in the civil engineering field, not only in Serbia but also in Bosnia and Herzegovina, Montenegro, and Macedonia, in consideration of the fact that all these countries share the same language and a similar economic situation.

Lectures started at 10:30, to allow Attendees to reach Novi Sad in the morning (so that it was not necessary for them to spend money on overnight stays). The exhibition entertained those who arrived earlier: it included a showcase of GPR equipment and a poster session. Posters were prepared and presented by selected local students and by Trainees of the TU1208 Training School held in Osijek during the same week (see photos in Figure 11(a)-(b)).

Lectures covered the fundamentals of GPR technology, a general overview on its numerous applications, and then a series of lectures on the use of GPR for utility detection, road and bridge inspection, and railway assessment (see photos in Figure 11(c)-(d)). Various questions asked by the audience regarded the detection of utilities in specific (challenging) conditions; there also was a special interest in the combined use of GPR and complementary technologies.

Taking inspiration from the event held in Rome, a roundtable with companies offering GPR services was organized. Before the event, TU1208 Members from Novi Sad looked on the internet and found five Serbian companies offering GPR services, which were invited to participate in the workshop and in the roundtable. All companies accepted the invitation. They reported that they mainly use GPR for

Table 5: Programme of TU1208 GPR Roadshow held in Novi Sad, Serbia.

Time	Speaker	Activity
9.15 – 10.15	–	<i>Registration & Breakfast.</i> Exhibition of GPR equipment. Poster session.
10:15 – 10:30	Local Authorities	<i>Welcome to participants. (in Serbian)</i>
10:30 – 10:50	Miro Govedarica (Faculty of Techn. Sciences of Novi Sad, RS)	Introduction to the dissemination day. Overview on research and teaching activities at the Faculty of Technical Sciences of Novi Sad. <i>(in Serbian)</i>
10:50 – 11:20	Miro Govedarica & Aleksandar Ristic (Faculty of Techn. Sciences of Novi Sad, RS)	Introduction to Ground Penetrating Radar (GPR): basic principles, capabilities, limits, applications. <i>(in Serbian)</i>
11:20 – 12:00	Simona Fontul (Laboratório Nacional de Engenharia Civil, PT)	GPR applied to roads. Examples. <i>(in English)</i>
12:00 – 12:20		<i>Tea & Coffee Break</i>
12:20 – 13:15	Aleksandar Ristic (")	GPR applied to utility detection. Examples. <i>(in Serbian)</i>
13:15 – 14:15		<i>Lunch</i>
14:15 – 14:45	Simona Fontul (")	GPR applied to railways. Examples. <i>(in English)</i>
14:45 – 15:00	Damir Varevac (Faculty of Civil Engineering of Osijek, HR)	GPR activities in the Faculty of Civil Engineering of Osijek (Croatia). <i>(in English)</i>
15:00 - 15:45	Lara Pajewski (Sapienza Univ. of Rome, IT, TU1208 Chair)	Introduction to the COST programme and to COST Action TU1208 "Civil engineering applications of Ground Penetrating Radar" <i>(in English)</i>
15:45 - 16:15	Coordinated by Miro Govedarica & Lara Pajewski	Roundtable with Stakeholders and private companies <i>(in Serbian and English)</i>
16:15 - 16:30		<i>Tea & Coffee Break</i>
16:30 - 17:30	Coordinated by Milan Vrtunski & Željko Bugarinović (Faculty of Techn. Sciences of Novi Sad, RS)	Practical demonstration of GPR technique (measurements in the vicinity of the meeting venue, with different kinds of equipment)



Figure 10: Flyer of the science communication event held in Novi Sad (Serbian edition of TU1208 GPR Roadshow).



Figure 11: Serbian edition of TU1208 GPR Roadshow. **(a, b):** Poster session before the workshop; **(c)** Prof. Dragan Šešlija, vice-dean of the Faculty of Technical Sciences, opening the event; **(d)** Attendees (this is only a half of a very long room!).

utility detection and localization, other civil engineering works, and geophysical surveys. Sporadically, they had the opportunity to employ GPR in the framework of archaeological investigations. The participating companies also offer Geographic Information System (GIS) and geodetic surveying services. They rarely use GPR in combination with other non-destructive testing techniques.

Attendees were very positive in terms of discovering more about the guidelines for utility detection prepared by COST Action TU1208; they expressed a strong hope that those guidelines would be presented in detail in the future and be used as a basis for developing utility detection standards in Serbia. Indeed, when the guidelines will be finalized and published, we will organize a dedicated event in Novi Sad. Attendees also expressed appreciation about the poster session and were strongly impressed by the significant efforts made by the Faculty of Technical Sciences in educating students about GPR technology and its applications.

An outdoor practical session concluded the event, coordinated by young scientists from the Faculty of Technical Sciences. In the gardens of the University, Attendees were introduced to practical issues commonly faced when using GPR equipment, such as setting the acquisition parameters in different conditions, choosing the most appropriate antennas, and using other non-destructive testing instrumentation along with GPR.

Looking at the number of Attendees, the event was a huge success, with 105 participants (more than in all other Roadshow events). The majority of Attendees was from Serbia, 88 of them; 17 Attendees were from abroad (Figure 12(a)) – in particular, 9 Attendees were from the region of former Yugoslavia (Bosnia and Herzegovina, Croatia) and 8 were from other countries (Italy, Portugal, Turkey, Spain, and the Czech Republic). Figure 12(b) shows the percentages of Attendees from university and research institutes (including professors, researchers, and students), public agencies, and private companies; there was also an unemployed citizen; it is apparent that the local organizer was able to attract the interest of several companies and stakeholders. Concerning gender distribution of Attendees, 77% of them were men and 23% were women (Figure 12(c)); hence the participation of women was lower than in Rome and Athens.

Since the event mainly focused on utility detection and assessment of road and railway infrastructure, it is interesting to analyze in detail

the participation of public agency representatives: statistics are presented in Figure 12(d). Participants belonging to this group typically do not yet own GPR equipment but may be interested in purchasing it, or in ordering GPR scanning services for infrastructure maintenance and development, urban planning, and for the utility and real estate cadaster.

Let us now look more in detail into the participation of private companies (Figure 12(e)). Attendees from companies that work on the detection and mapping of underground utilities usually already have and use GPR equipment, but they are interested in upgrading, as well as in learning about applications in new areas. Attendees from other companies sometimes own GPR equipment, or else they offer different services and are interested in purchasing GPR instrumentation to widen their market.

After the event, a questionnaire was sent to all participants, via email, along with certificates of attendance. The asked questions and some statistics on the received feedback are presented in Table 6. Ideas for future cooperation (question 5) included:

- To organize another GPR communication day, or even better, a communication conference spanning over multiple days where each day would be dedicated to a different GPR application (similar to training schools, but for the public);
- To repeat GPR communication initiatives periodically;
- To establish a national scientific network of cooperation among the companies and researchers that participated in the Roadshow.

Additional comments (question 6) included:

- Strong appreciation for the workshop, compared to previously-attended short courses organised by, e.g., the Serbian Chamber of Engineers or by various associations;
- Participants were happy about the lectures because topics were presented not only theoretically but also professionally, reporting application tips and experiences from practice, and offering a perspective on future GPR applications;
- Participants stressed the need to develop standards and define a legal framework in Serbia for the use of GPR technology;
- Most of the comments were congratulations for the excellent organization and thank you messages.

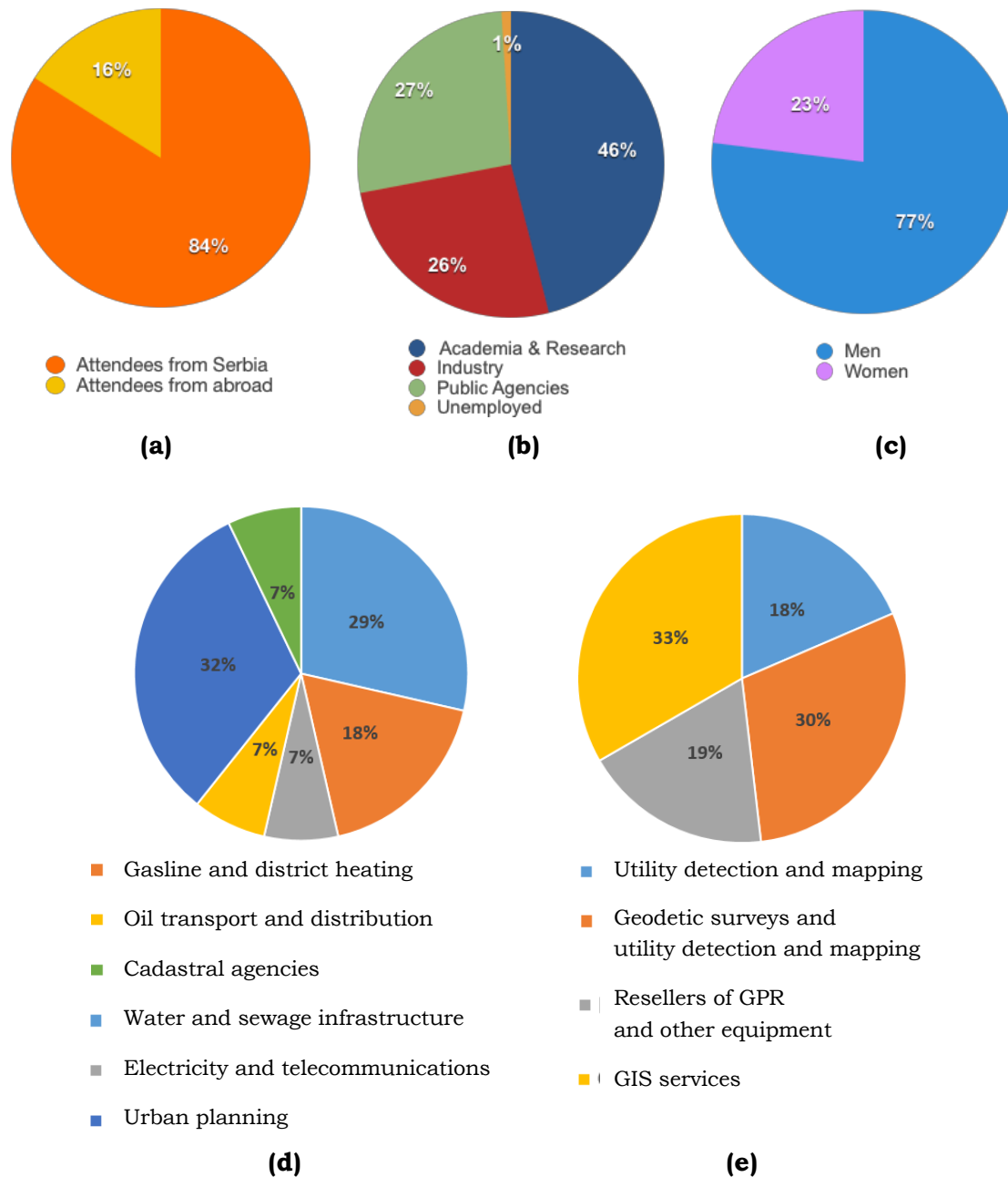


Figure 12: (a) Attendees from Serbia and from other countries; (b) Gender distribution of Attendees; (c) Attendees from academia and research, public agencies, and industry; (d) Representatives from public agencies; (e) Representatives from industry (TU1208 GPR Roadshow, Serbian edition).

Table 6: Questionnaire sent to participants of the Serbian GPR Roadshow and statistics on the received feedback.

1) Kakva su bila Vaša saznanja o COST pre učestvovanja na GPR Workshopu u Novom Sadu?	Nikad nisam čuo/la za COST	Upoznat/a sam ali nikad nisam učestvovao na COST događajima	Prisustvovao/la sam COST događajima ali nikad nisam učestvovao u COST akciji	Učestvovao/la sam u COST akciji / Učestvujem u COST akciji
1) What was your knowledge about COST before attending the Road Show?	Never heard of it	Knew about its existence but never participated to COST events	I already attended a COST event but never participated to a COST Action	I already participated / I am participating to a COST Action
	30%	40%	8%	22%
2) Koliko ste bili upoznati sa tehnologijom skeniranja georadarom pre učešća na GPR Workshopu u Novom Sadu?	Nisam bio/la upoznat	Čuo/la sam da navedena tehnologija postoji	Video/la sam primenu tehnologije, ali je nisam lično primenio	Korisnik sam ove tehnologije
2) What was your knowledge about GPR before attending the Road Show?	Never heard of it	Knew about its existence	I saw GPR results before, but never used it	I am a GPR user
	0%	15%	53%	32%
3) Da li planirate da koristite GPR tehnologiju u budućnosti?	Ne	Možda	Da	Korisnik sam
3) Do you plan to start using GPR in the future?	No	Maybe	Yes	I already use it
	0%	43%	40%	27%
4) Da li smatrate da je GPR Workshop bio koristan u smislu informisanja o osnovnim principima, metodologiji i primeni GPR tehnologije?	Ni najmanje	Malo	Donekle	Prilično
4) Do you think that the Road Show was useful, to gain knowledge about GPR basic principles, methodology and applications?	Not at all	A little	Fairly	A lot
	0%	0%	10%	90%
5) Da li imate ideje o realizaciji buduće saradnje sa članovima COST akcije TU1208, ili predloge za daljnju promociju aktivnosti u oblasti primene GPR tehnologije?	Ne		Da	
5) Do you have ideas for future cooperation with Members of COST Action TU1208 or suggestions for further dissemination activities in the GPR area?	No		Yes	
	85%		15%	
6) Ako imate dodatne komentare u vezi GPR Workshopa, molimo Vas da ih specificirate	Ne		Da	
6) If you have further comments about the Road Show, please write them here.	No		Yes	
	75%		25%	

7 GPR Roadshow in the Czech Republic

The sixth event of TU1208 GPR Roadshow was held in the Faculty of Transport Engineering of the University of Pardubice, in the Czech Republic, on 25 May 2017; Dr Vladislav Borecky coordinated the local organisation. The primary goal of this dissemination day was to introduce the GPR technique and its civil engineering applications to new potential private and public end-users. The intention was not only

to promote the GPR technology but also to point out the pitfalls and limitations of this technique in the various application fields.

The event further highlighted how international research projects, such as COST Action TU1208, can and shall play an important role in bringing private sector and academia together and in establishing an active link between researchers and stakeholders. GPR possibilities were presented to decision makers from regional and national authorities, which may result in support and funding for GPR related projects in the future; they were made aware not only of the cost-effective and time-saving nature of GPR investigations but also of the main outputs of recent and ongoing GPR-related scientific projects. During the lectures and roundtable, new ideas germinated for possible future studies and discussions took place among academicians about starting GPR-related University courses.

A dedicated website was created by the local organizers, prior to the event, with Czech and English versions, for the purposes of advertising the event (georadar.upce.cz). The University of Pardubice announced the event on its website (upce.cz/english/jptf/dts.html) and Facebook page (facebook.com/DFJP.KDS). After the event, a short article was published on the electronic journal of the University of Pardubice (zpravodaj.upce.cz/vzdelavani/2017/georadar-na-dopravni-fakulte/).

The local organizers built on the longstanding cooperation with the local road administrator SÚS Pardubického kraje, which offered financial support to partially cover the expenses.

The programme of the event included lecture sessions, a roundtable, and a practical demonstration (see Table 7 and Figure 13). Lectures were given in Czech and English; most speakers were TU1208 Members, some talks were given by experts not involved in the Action. During the practical demonstration, Attendees got acquainted with GPR systems belonging to the Department of Transport Structures and to the Transport Research Centre v.v.i. (manufactured by IDS Georadar and GSSI, Geophysical Survey Systems, Inc.).

Most participants were from the Czech Republic, there were also some Master and PhD students from abroad (Figure 14(a)). The event had 58 Attendees in total, from industry, academia and research centres, and public agencies; the proportion of these sectors was quite balanced (Figure 14(b)). Figure 14(c) shows the gender distribution of Attendees. Almost a half of Attendees had no knowledge or basic knowledge about GPR (Figure 14(d)).

Table 7: Time schedule of the Roadshow edition held in Pardubice.

Time	Speaker	Activity
8:00 - 9:00		<i>Registration</i>
9:00 - 9:15	Local Authorities	Welcome to participants and presentation of the University of Pardubice (in Czech)
9:15 – 9:25	Özgür Yurdakul (Anadolu University, Turkey)	Introduction to the COST programme
9:25 – 9:55	Vladislav Borecký (University of Pardubice, Czech Republic)	GPR basic principles and applications
9:55 – 10:15	Pavel Lopour (University of Pardubice, Czech Republic)	Civil Engineering Applications of Ground Penetrating Radar: a European perspective. Activities carried out within COST Action TU1208.
10:15– 10:30	Vladislav Borecký (University of Pardubice, Czech Republic)	GPR activities at the Department of Transport Structures UPa (in Czech)
10:30 – 11:00		<i>Tea & Coffee Break</i>
11:00 – 11:40	Radek Matula, Michal Janků (Transport Research Centre, Czech Republic)	GPR applied to roads, bridges and tunnel (in Czech)
11:40 – 12:10	Salih Serkan Artagan (Anadolu University, Turkey)	GPR applied to railways
12:10 – 12:25	Rudolf Tengler (Georadar RTG – Tengler, , Czech Republic)	Presentation of the ROTEG GPR systém (in Czech)
12:25 – 13:25		<i>Lunch</i>
13:25 – 13:55	Jiří Nedvěd (SG Geotechnika a.s.)	GPR in geotechnics (in Czech)
13:55 – 14:25	Dušan Kocur (Technical university of Košice, Slovakia)	Person localization based on detection of their vital signs using Ground Penetrating Radar (in Czech)
14:25 – 15:00		Roundtable with stakeholders and private companies (in Czech & English)
– 15:30		<i>Tea & Coffee Break</i>
15:30 – 17:00		Laboratory tour and GPR practical demonstration in Educational and Research Centre in Transport



Figure 13: Photos taken during the workshop, laboratory tour and GPR practical demonstration (TU1208 GPR Roadshow held in the Czech Republic).

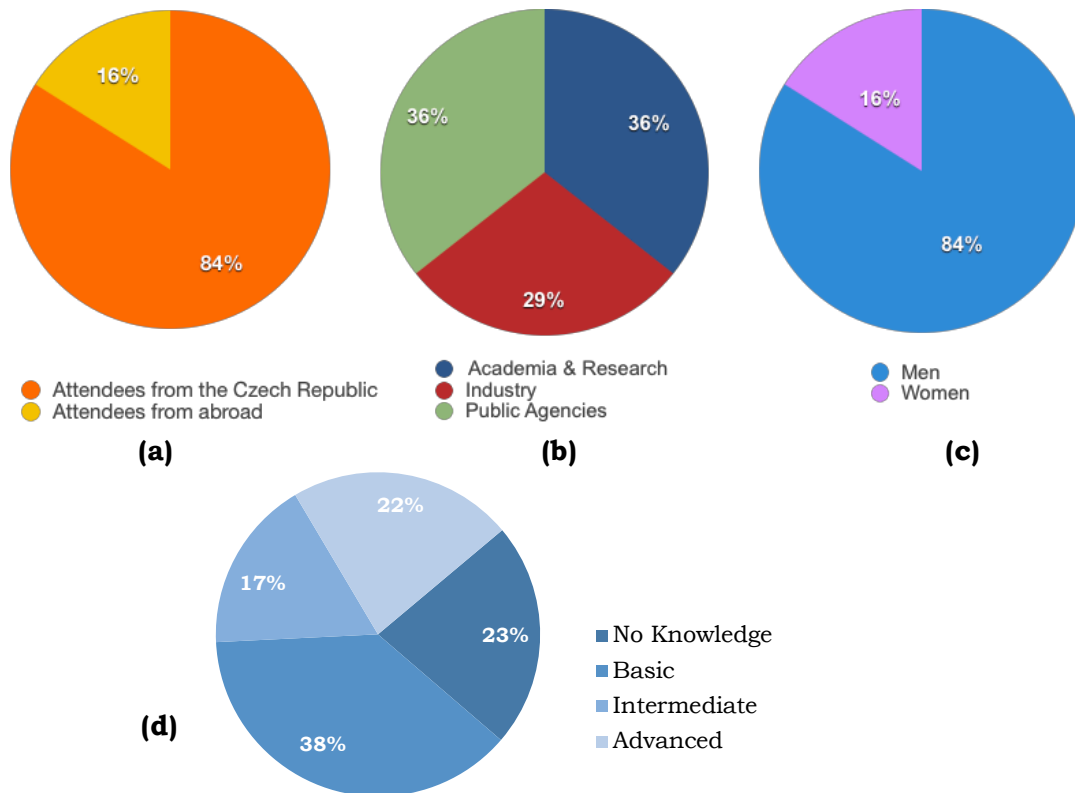


Figure 14: (a) Attendees from the Czech Republic and other Countries; (b) Attendees from academia and research centres, industry, and public agencies; (c) Gender distribution of Attendees; (d) Level of knowledge about GPR declared by Attendees (TU1208 GPR Roadshow held in the Czech Republic).

8 GPR Roadshow in Estonia

This section presents the successful and impactful science communication activities carried out in Estonia by a team of researchers from the Institute of Ecology of Tallinn University.

The Institute of Ecology is a small research unit at Tallinn University. The main research themes include wetland ecosystems – peat bogs, lakes, rivers, coasts, and shore processes. The Estonian coast is located in a region of tectonic uplift, making it possible to investigate the well-preserved ancient beach formations in a few-kilometre wide coastal zone; the ridge-swale complexes with peat bogs and lakes in between the ridges are valuable natural archives of palaeogeographical information. The GPR technique has been used in many occasions, by the researchers of the Institute of Ecology; actually, the GPR profiling is very helpful to detect storm layers in sandy beach formations, measure the thickness of organic layers in lakes and peat bogs, and more. A senior member of the research team started to use GPR already over 20 years ago. The older GPR devices owned by Tallinn University were rather heavy (had to be carried by car), limiting the use of them. A lightweight GPR system, SIR-3000 manufactured by GSSI, was bought in 2011: small size, light weight, and long-lasting batteries make it possible to use it everywhere.

The researchers noticed that several geology-related works carried out by public or private companies in Estonia were done by using destructive methods. It was apparent that most of the geological investigations (digging, drilling, etc.) could have been done by using GPR as a non-destructive, environment-friendly and less-expensive method. The researchers had a hope that they could increase the efficiency of the Estonian economy by educating various age and interest groups about the potential and capabilities of GPR. Therefore, they started devoting some time to dissemination and outreach activities among the ordinary people. As a result of their intensive and enthusiastic promotional work of the GPR technology, the researchers have recently carried out a number of applied projects for different enterprises and local authorities that helped them to include additional resources for their research. The promotional work and the applied projects have also improved their skills in the use of GPR in various geological conditions.

8.1 GPR lessons in secondary schools

Tallinn University is one of the leaders in the field of teacher education and training in Estonia. Many young teachers of geography, biology and natural sciences in schools have recently graduated from Tallinn University, and the researchers of the Institute of Ecology have kept contact with them. So, they offered the young teachers an opportunity to take GPR lessons for the pupils of their schools. The interest in the idea of providing such lessons was enormous. As the Estonian schools, in general, are lacking many needful devices for practical work, all initiatives that help to introduce new technologies and methods are usually very welcome. It was necessary to select a few schools from different regions of Estonia and plan the routes of the lectures, combining them with fieldworks after or before the lessons (in fact, most of the lectures were delivered in the vicinity of areas where the researchers were carrying out some scientific investigations). Lessons were given free of charge and schools were just asked to organize accommodation, if needed (for the most remote places). The researchers were able to visit over 15 schools all over Estonia. Mostly, pupils from grades 6 to 9 were expected to attend the lessons. However, some high schoolers attended the lessons, too. The groups usually consisted of 10 to 20 pupils.

The lessons were simple. During the first 15-20 minutes, there was a theoretical lecture where the basic principles of GPR were described, and some best examples of GPR pictures were illustrated (i.e., radargrams obtained over pipes, cables, caves, buried treasures and other objects). This short lecture helped the pupils to better understand GPR images during the subsequent practical work, which lasted about 30 minutes. The researchers and pupils walked around the school territory and searched for buried artificial objects by using GPR or mapped geologically interesting layers. The locations of heating pipes, power cables and other objects were marked on the ground by using wooden sticks on the grass or chalk on the asphalt. Finally, the pupils could draw the basic schemes of the utilities located on the school.

Once researchers and secondary school students visited a nearby lake, in winter; they measured the thickness of the organic layer on the bottom of the lake and verified the results by using drilling equipment brought by the researchers (Figure 15). Moreover, in one school the ruins of the old school house were found (nearly 100 years old). The

most interesting finding was a cave described in an ancient legend: the researchers and pupils were the first ones who found it and can confirm that the old legend is actually a true story (Figure 16)!

It came out during the lessons that the younger the pupils were the more enthusiastically they took part in the GPR activities. Therefore, it was decided to organize one lesson also for the pupils of grades 1 and 2. It was decided to skip the lecture part with them and carry out the entire experience on the beach. A few “treasures” were buried in the sand to make the study more attractive. Moreover, several simple skills were needed to reach the final “treasure” (the initial finding was just the first clue to the real treasure), including the use of a compass, reading the distance from the measuring tape, etc (Figure 17). The lesson with such young pupils was a huge success. They were really enthusiastic and proud to find the “treasure” (candies, some lemonade and a book for the school library), and to hand over the book to the school library. The lesson needed a little more preparatory work, but the outcome was worth it. Moreover, the researchers were pleased to discover (from the feedback) that the parents of the pupils were very well informed by their children, after the lesson, on what GPR is and how it can be used in different tasks.



Figure 15: Educational event. GPR was used to detect the thickness of the organic layer on the bottom of a lake. Drilling was used to verify GPR results.



Figure 16: GPR lessons at school. The pupils were intensively working in the school's parking lot (left); An old legend describing secret caves from the local church to manor was confirmed (right)!?

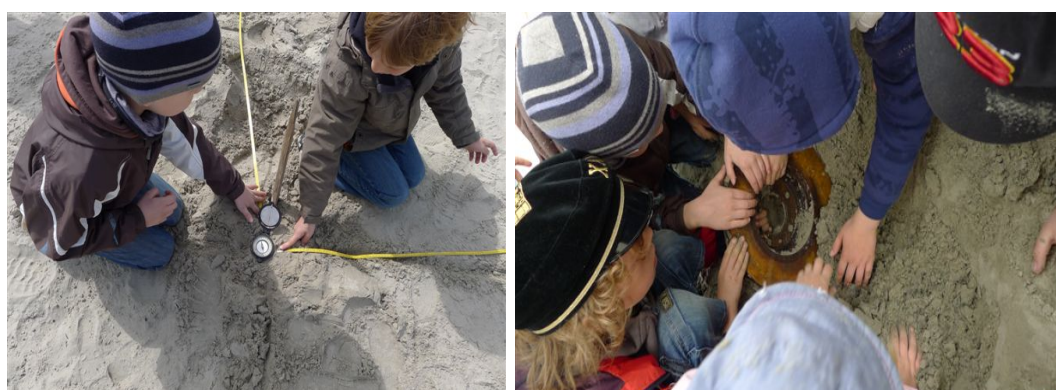


Figure 17: Second grade pupils in Tallinn during a lesson on the beach.

8.2 Investigations during the Researcher Night

The researchers from the Institute of Ecology of Tallinn University were discovered by several interest groups, as a result of their lessons in schools. They were invited to present their GPR equipment in the frames of the Estonian edition of the European Researchers' Nights for three consecutive years. The innovative and popular concept of the Researchers' Night was introduced several years ago in Estonia; during these open science events, science and the work of scientists are presented to non-scientific audiences all over Europe. Over the course of the day and throughout the night, children, adolescents, adults, older people, students, and entrepreneurs can get to know more about science through workshops, meetings with researchers, lectures and laboratory visits. In Estonia, the Researchers' Night is normally held in

public spaces, in the city centre of Tallinn; numerous researchers introduce their studies, equipment and most recent findings to hundreds of interested people.

Tallinn city center is located just beside the medieval old town, and many archeologically significant features can be found below the contemporary ground surface. Therefore, the researchers from the Institute of Ecology of Tallinn University had the chance to organize very impactful GPR demonstrations, where GPR was used to show the presence of buried archeological objects to local people. The researchers got extremely positive feedback: the citizens understood the importance of non-destructive technologies and several new users of GPR services stemmed from those events. The audience attending GPR demonstrations during the Researchers' Nights was rather diverse – from kids to retired citizens (Figure 18).

8.3 Festivals with enterprises

Estonian universities have created a system called “Adapter.” All services offered by the universities are registered there, and one can search the desired service by entering keywords. The GPR-services are also registered there. However, this is not all. In September 2016, an annual co-operation festival was held in the Estonian National Museum with the aim of bringing the entrepreneurs and researchers together. The researchers of the Institute of Ecology of Tallinn University were invited to introduce the GPR technology and its applications in civil

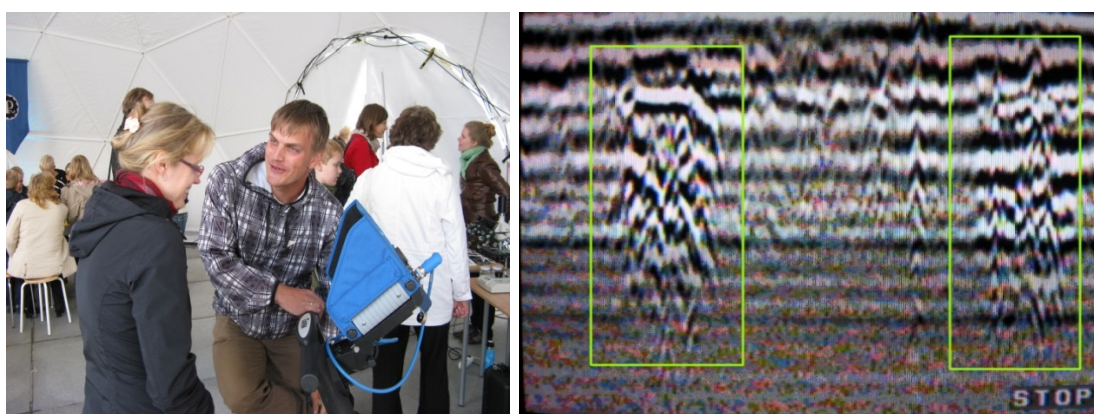


Figure 18: Researchers Night organized in the city centre of Tallinn. GPR was demonstrated and tested among other activities (left); the ruins of the buried medieval city walls were shown on the GPR screen (right).

engineering, archaeology and geological research. Each topic was presented in a 3- minute lecture. This presentation scheme is called “elevator pitch:” a brief, persuasive speech is given to spark interest in what an organization does, in a project, idea, or product – or in a person! A good elevator pitch should last no longer than an elevator ride, hence the name. As a result of the evaluation, the GPR service presented by Tallinn University was elected the most useful service of 2016. The best “elevator pitch” talk award was also received by Hannes Tonisson (www.youtube.com/watch?v=OzvKsmfE3yk).

8.4 Joint fieldworks with archaeologists and TV crew

The educational work presented in the previous subsections brought the researchers of the Institute of Ecology in contact with a lot of different interest groups, and several job offers arrived; the researchers also established new connections with other research teams.

A team of archaeologists had preliminary information about a buried Viking ship near Salme village, on Saaremaa Island. The site was investigated by using an older version of GPR, and the Viking ship was found (Figure 19). A pile of stones placed on top of the buried ship generated the strongest reflected signal and helped the researchers to locate the vessel. The archaeology students filmed the whole investigation process; an educational movie was realized, for future (archaeology) students.

8.5 Cooperation with Tallinn Harbor

As already mentioned, the voluntary promotional events led to several successful cooperation projects among the researchers of the Institute of Ecology and private enterprises, local authorities and state-financed companies. Another successful example is presented in this subsection.

Tallinn is known for its fully restored medieval Old Town (UNESCO World Heritage Site). Tallinn is also a seaside city where the signs of human activities date back to Stone Age when seal hunters and fishers were using the city center as their temporary camp [12]. Therefore, many archeologically essential findings can be found below the current surface (as stated in subsection 8.2), including old walls, water systems, tools, shipwrecks, etc. In cooperation with Tallinn City, the researchers of the Institute of Ecology have been investigating several sites where major buildings or new roads are planned. It must be highlighted that

currently local authorities are recommending the developers to carry out GPR studies even before the planning phase, to avoid unwanted disruptions during the construction phase!

In this framework, the most successful cooperation took place with Tallinn Harbor, a state-owned company. The archaeologists of Tallinn suggested that there might be a major shipwreck in their territory, but the exact location, state (preserved or not) and size were unknown. They recommended carrying out a GPR survey. Hence, Tallinn Harbor ordered a GPR study from the Institute of Ecology. As a result of the investigation, an anomaly was found that might be the ship. The anomaly was over 50 m long, around 10 m wide and approximately 1 m below the current surface.



Figure 19: Searching for ancient Viking ship on Saaremaa Island. Search is in progress (top), ship was found (lower left) and archaeologists expose the ship remains (lower right). A special movie was realized for educational purposes.

The archeologists carried out test excavations in a 2×1-m pit and confirmed that the finding was the historically valuable shipwreck (Figure 20). This information assisted Tallinn Harbor to change the development project in such a way that the ship area will be used as a parking lot and no buildings or utilities are any more planned there. The ship will be preserved for future generations and for archaeologists with more efficient excavation methods/technologies. So the state-owned company didn't suffer any losses, and the archaeologically valuable object was preserved.

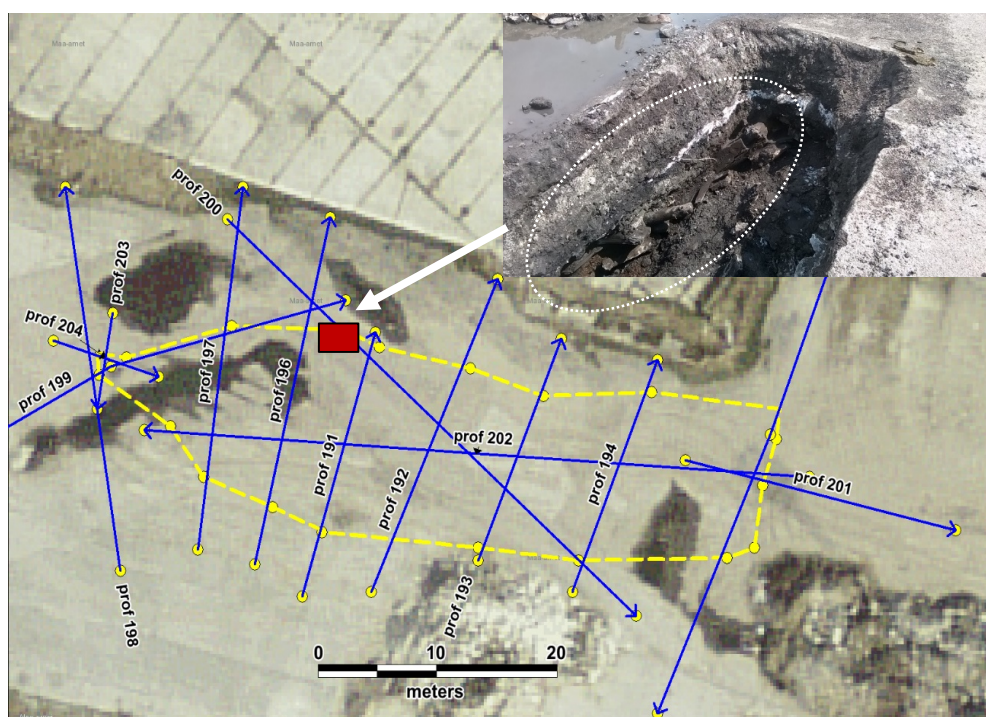


Figure 20: Blue arrows: locations of GPR profiles; yellow dashed contour: expected location of the shipwreck; red box: location and size of the excavation pit; top-right photo: excavation pit (a white-dashed oval indicates fragments of the shipwreck).

8.6 One-minute lecture on national TV channel

The final educational and also a little bit promotional product was a video lecture about GPR. Tallinn University was involved in a project called “one-minute lectures.” These are short, easy to understand and high-quality lectures introducing scientific problems or new scientific

methods/equipment. The one-minute lecture about GPR, given by Dr Kaarel Orviku, was on air on the biggest national TV channel. A lecture with a longer introduction to GPR is still visible on the website of the national TV channel - Estonian TV; the one-minute lecture, instead, has been uploaded on the YouTube channel of Tallinn University and can be seen here: www.youtube.com/watch?v=vMCm0Qk8fUo

Finally, with this initiative the researchers managed to reach every Estonian's home!

9 Conclusions

Science communication is the public communication of science-related topics to non-experts. Science communication is increasingly essential in today's society, although its importance is often underestimated by researchers. In this paper, we have presented descriptions, principles, and results of a very successful series of science communication initiatives about the Ground Penetrating Radar (GPR) technique, recently carried out by Members of COST Action TU1208 "Civil engineering applications of Ground Penetrating Radar" and overall denominated "TU1208 GPR Roadshow."

Part of TU1208 GPR Roadshow consisted of a series of six non-scientific workshops and practical demonstrations held in Portugal (National Laboratory of Civil Engineering), Italy (Roma Tre University), Greece (Geoservice), Croatia (University of Osijek), Serbia (University of Novi Sad), and the Czech Republic (University of Pardubice), from March 2016 to May 2017. Audiences went well beyond the GPR scientific community and primarily included representatives from public agencies and private companies, as well as interested citizens. The workshops were attended by almost 500 participants in total and were a huge success; we were able to raise considerable interest in various countries and our events were catalysts for a series of new activities.

Another significant part of the Roadshow consisted of a series of promotional and educational initiatives carried out in Estonia. Before these initiatives, very few people in Estonia knew what GPR was and how it could be used in different application fields. The researchers from the Institute of Ecology of the University of Tallinn were able to spread the knowledge to a significant number of people without the need of a GPR-related project devoted explicitly to this (i.e., without dedicated funding). They delivered several lectures in schools, practical

workshops during the Researchers' Nights and during other large communication events, and even short lectures on TV. In this way, they have increased public awareness on the potential and capabilities of the GPR technique; Estonian companies have learnt about the possibility of using GPR to conduct more efficient business activities. The feedback was very positive and currently the Estonian researchers have a long pre-order list of schools who are expecting their visit!

As is shown by the map in Figure 21, our science communication project involved eighteen countries. In particular, the various initiatives took place in the seven countries coloured in yellow, while speakers, trainers, and attendees were from both the yellow and orange countries. The primary purpose of our project was to reach out to the public at local, regional, and national levels; however, the Roadshow had an international perspective and impact.

The authors of this paper hope to improve their science communication skills and continue with GPR communication, training, promotion, dissemination, and outreach initiatives in the future. We would like to put efforts into both "one-way" and "two-way" communication exchanges, where one-way exchanges may include preparing webpages with non-scientific explanation about GPR, brochures, posters, blog posts, and even videos, whereas two-way exchanges may include technical workshops of various kinds, exhibitions, visits of school pupils in research centres, lectures in schools, summer schools, and internet debates. There is a high potential in citizen science, too, i.e., public and societal engagement in research. For information about our future activities, please visit the dedicated webpage: gpradar.eu/events-dissemination/roadshow.html.

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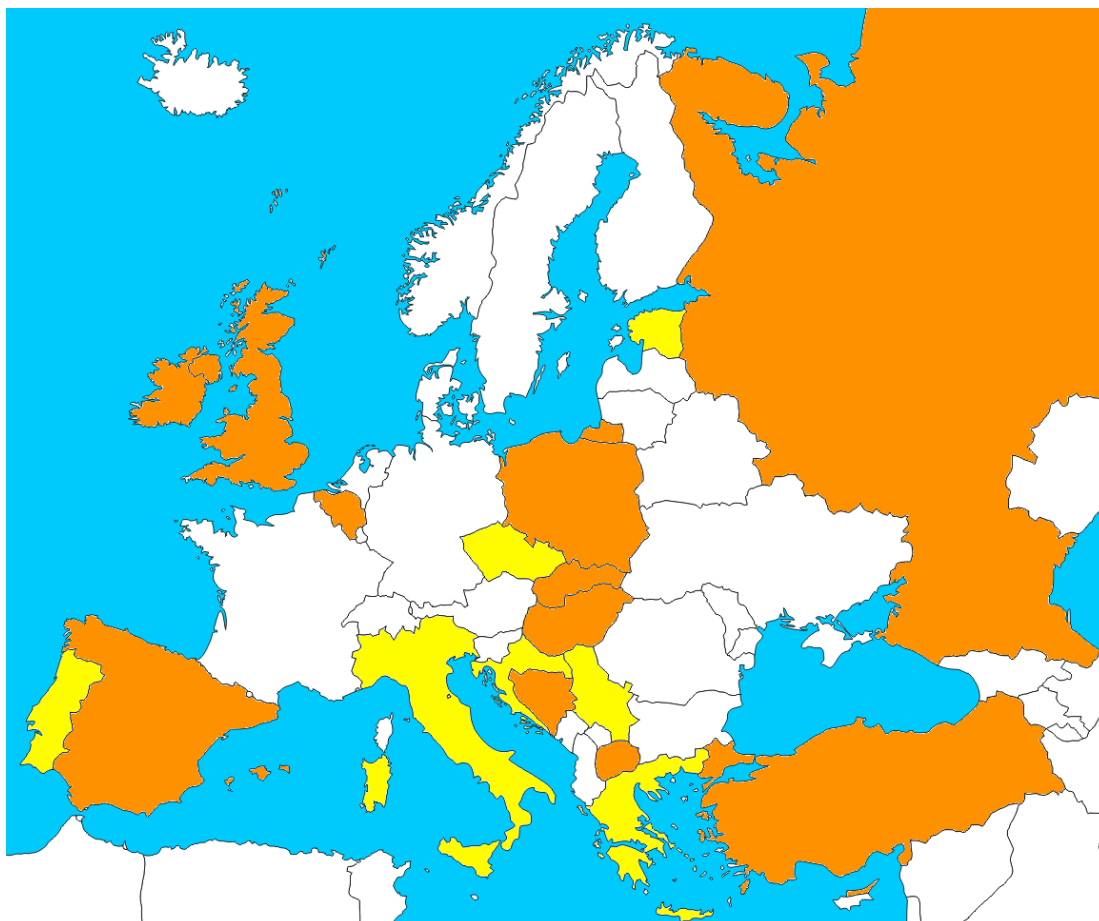


Figure 21: Countries involved in TU1208 GPR Roadshow. The initiatives took place in the yellow-coloured countries; participants were from both the yellow- and orange-coloured countries.

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