

COST

Domain Committee "Transport and Urban Development"

COST Action TU1208

Start Date: 4th of April, 2013

Civil Engineering Applications of Ground Penetrating Radar

MONITORING PROGRESS REPORT

Reporting Period:

from the 4th of April, 2013, to the 25th of February, 2014.

This Report is presented to the relevant Domain Committee.
It contains three parts:

- I. Management Report** prepared by the COST Office/Grant Holder
- II. Scientific Report** prepared by the Chair of the Management Committee of the Action
- III. Previous versions of the Scientific Report; i.e., part II of past reporting periods**

The report is a "cumulative" report, i.e. it is updated annually and covers the entire period of the Action.

Confidentiality: the documents will be made available to the public via the COST Action web page except for chapter *II.D. Self evaluation*.

Based on the monitoring results, the COST Office will decide on the following year's budget allocation.

Executive summary (max.250 words):

COST Action TU1208 focuses on the exchange of scientific-technical knowledge and experience of Ground Penetrating Radar (GPR) techniques in civil engineering. At present, the Action is in month 11 of its lifetime, month 9 of the first financial period. The starting phase of the Action was devoted to organise its WGs and Projects, collect information about available resources, Members' experience, interests and skills, create the Action's website and set up the communication tools. The First General Meeting was held on 22-24 July 2013 (Rome, IT); a WG Progress Meeting was held on 24-25 February 2014 (Nantes, FR); both meetings were positive and fruitful. Four STSMs took place. A TS is going to be held on 24-28 March 2014 (Madonna di Campiglio, IT). The Second General Meeting is going to be held on 30 April-2 May 2014 (Vienna, AT). During these months, Members collected and shared information about state-of-the-art and open issues on the Action's topics. Test sites were identified, for the comparison of different GPR systems and inspection procedures. Test scenarios were defined, for the comparison of different modelling/imaging/data-processing methods. In addition to this, several original results have been obtained within the Projects composing the WGs. All this work is attested by a high number of publications. The Action is disseminating and promoting its activities in international conferences related to GPR. The Action is highly interdisciplinary. The number of involved Partners is increasing: at present, we have 24 COST Countries, 2 NNCs, 6 IPCs, 99 Institutions, 203 Members.

I. Management Report

I.A. COST Action Fact Sheet

- **COST Action** TU1208 - *Civil Engineering Applications of Ground Penetrating Radar*
- **Domain** *Transport and Urban Development (TUD)*

- **Action details:**

CSO Approval: (21/11/2012)

End date: (03/04/2017)

Entry into force: (04/04/2013)

Extension: (day/month/year)

- **Objectives**

This Action focuses on the exchange of scientific-technical knowledge and experience of Ground Penetrating Radar (GPR) techniques in Civil Engineering (CE). The project will be developed within the frame of a unique approach based on the integrated contribution of University researchers, software developers, geophysics experts, Non-Destructive Testing equipment designers and producers, end users from private companies and public agencies. In this interdisciplinary Action, advantages and limitations of GPR will be highlighted leading to the identification of gaps in knowledge and technology. Protocols and guidelines for EU Standards will be developed, for effective application of GPR in CE. A novel GPR will be designed and realized: a multi-static system, with dedicated software and calibration procedures, able to construct real-time lane 3D high-resolution images of investigated areas. Advanced electromagnetic-scattering and data-processing techniques will be developed. The understanding of relationships between geophysical parameters and CE needs will be improved. Freeware software will be released, for inspection and monitoring of structures and infrastructures, buried-object localization, shape reconstruction and estimation of useful parameters. A high level training program will be organized. Mobility of early career researchers will be encouraged. The project has already received the interest of key end users and excellent EU Institutions.

Parties:

Austria (11/01/2013)	FYR of Macedonia (22/05/2013)	Poland (14/12/2012)
Belgium (16/01/2013)	Germany (21/01/2013)	Portugal (28/03/2013)
Croatia (10/01/2013)	Greece (04/02/2013)	Slovakia (20/01/2014)
Czech Rep. (28/02/2013)	Italy (12/12/2012)	Slovenia (14/11/2013)
Denmark (22/10/2013)	Latvia (29/05/2013)	Spain (18/12/2012)
Estonia (20/01/2014)	Malta (27/07/2013)	Switzerland (01/03/2013)
Finland (29/05/2013)	Netherlands (21/02/2013)	Turkey (28/01/2013)
France (26/02/2013)	Norway (05/12/2013)	United Kingdom (29/11/2012)

- **Intentions to accept:** *list of countries and date*

Romania

- **Other participants:** *(Institution Name, Country, Town)*

State Engineering University of Armenia, Armenia (NNC)
Usikov Institute for Radiophysics and Electronics of the National Academy of Sciences of Ukraine, Ukraine (NNC)
Department of Transport and Main Roads, Australia (IPC)
University of Mississippi, United States of America (IPC)
University of New Mexico, United States of America (IPC)
University of Texas, United States of America (IPC)
Washington State Department of Transportation, United States of America (IPC)
National University of Rwanda, Rwanda (IPC)

Chair:

*Dr Lara Pajewski
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*Dr Mickael Pero
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Administrative Officer:

*Ms Carmencita Malimban
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- **Action Web site:** <http://www.GPRadar.eu>

- **Grant Holder Representatives:**

*Legal Representative: Dr Paolo Atzeni, paolo.atzeni@uniroma3.it
Financial Representative: Ms Laura Grossi, amm.ingegneria@uniroma3.it
Scientific Representative: Dr Lara Pajewski, lara.pajewski@uniroma3.it*

- **Working Groups** (*list of WGs and names and affiliations of participants*)

The Action is organised in 4 WGs and each WG includes various Projects, as described below.

WORKING GROUP 1**NOVEL GPR INSTRUMENTATION**

- **Project 1.1** *Design, realization and optimisation of innovative GPR equipment for the monitoring of critical transport infrastructures and buildings, and for the sensing of underground utilities and voids.*
- **Project 1.2** *Development and definition of advanced testing, calibration and stability procedures and protocols, for GPR equipment.*
- **Project 1.3** *Design and optimisation of innovative GPR antennas.*

WORKING GROUP 2**GPR SURVEYING OF PAVEMENTS, BRIDGES, TUNNELS AND BUILDINGS; UNDERGROUND UTILITY AND VOID SENSING**

- **Project 2.1** *Innovative inspection procedures for effective GPR surveying of critical transport infrastructures (pavements, bridges and tunnels).*
 - Task I. Pavements*
 - Task II. Bridges*
 - Task III. Tunnels*
 - Task IV. Retaining walls*
 - Task V. Railway tracks*

- **Project 2.2** *Innovative inspection procedures for effective GPR surveying of buildings.*
- **Project 2.3** *Innovative inspection procedures for effective GPR sensing and mapping of underground utilities and voids, with a focus to urban areas.*
- **Project 2.4** *Innovative procedures for effective GPR inspection of construction materials and structures.*
- **Project 2.5** *Determination, by using GPR, of the volumetric water content in structures, sub-structures, foundations and soil.*

WORKING GROUP 3

ELECTROMAGNETIC METHODS FOR NEAR-FIELD SCATTERING PROBLEMS BY BURIED STRUCTURES; DATA PROCESSING TECHNIQUES

- **Project 3.1** *Development of new methods for the solution of forward electromagnetic scattering problems by buried structures.*
- **Project 3.2** *Development of new methods for the solution of inverse electromagnetic scattering problems by buried structures.*
- **Project 3.3** *Development of intrinsic models for describing near-field antenna effects, including antenna-medium coupling, for improved radar data processing using full-wave inversion.*
- **Project 3.4** *Shape-reconstruction and quantitative estimation of electromagnetic and physical properties from GPR data.*
- **Project 3.5** *Development of advanced GPR data processing techniques.*
- **Project 3.6** *Development of advanced methods for joint processing of data collected by GPR and other non-destructive testing techniques.*

WORKING GROUP 4

DIFFERENT APPLICATIONS OF GPR AND OTHER NON-DESTRUCTIVE TESTING TECHNOLOGIES IN CIVIL ENGINEERING

- **Project 4.1** *Applications of GPR and other non-destructive testing methods in archaeological prospecting and cultural heritage diagnostics.*
- **Project 4.2** *Advanced application of GPR to vital signs detection and to the localization of buried and trapped people.*
- **Project 4.3** *Applications of GPR in association with other non-destructive testing methods in surveying of transport infrastructures.*
- **Project 4.4** *Applications of GPR in association with other non-destructive testing methods in building assessment and in geological/geotechnical tasks.*
- **Project 4.5** *Development of other advanced electric and electromagnetic methods for the characterization of construction materials and structures.*
- **Project 4.6** *Applications of GPR in association with other non-destructive testing methods in the management and protection of water resources.*

The following Table resumes the number of participants involved in each WG and Project.

Working Group	Project	Number of Participants
1	1.1	23
	1.2	9
	1.3	5
Number of participants in WG1: 24		
2	2.1	50
	2.2	28
	2.3	31
	2.4	30
	2.5	43
Number of participants in WG2: 69		
3	3.1	35
	3.2	34
	3.3	25
	3.4	32
	3.5	42
	3.6	12
Number of participants in WG3: 75		
4	4.1	46
	4.2	35
	4.3	57
	4.4	41
	4.5	38
	4.6	17
Number of participants in WG4: 97		

The total number of WG Members is 203 (192 from COST Member Countries, 11 from NNCs and IPCs). The total number of Institutions is 99 (91 from COST Member Countries, 8 from NNCs and IPCs). The complete list of WG Members and Institutions is given below.

COST Member Countries

AUSTRIA (2 Institutions, 4 Members)

1. Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology, Vienna
 1. Immo Trinks (MC Member)
 2. Wolfgang Neubauer (MC Substitute Member)
 3. Alois Hinterleitner
2. Zentralanstalt für Meteorologie und Geodynamik, Vienna
 1. Sirri Seren

BELGIUM (5 Institutions, 14 Members)

3. Université Catholique de Louvain, Louvain-la-Neuve
 1. Sebastián Lambot (MC Member)
 2. Christophe Craeye (MC Substitute Member)
 3. Albéric De Coster
 4. Laurence Mertens
 5. Denis Tihon
4. Belgian Road Research Centre, Brussels

1. Colette Grégoire
2. Carl Van Geem
5. Ghent University, Ghent
 1. Marc Van Meirvenne (MC Member)
 2. Samuel Delefortrie
 3. Jan De Pue
 4. Philippe De Smedt
 5. Ellen Van De Vijver
6. University of Liège, Liège
 1. Frédéric Nguyen
7. Vrije Universiteit Brussels, Brussels
 1. Hichem Sahli

CROATIA (2 Institutions, 6 Members)

8. University of Zagreb, Zagreb
 1. Mario Bacic (MC Member; TU1202 MC Substitute Member and TU1206 MC Member)
 2. Danijela Marcic (MC Member; TU1202 MC Substitute Member and TU1206 MC Member)
 3. Lovorka Libric (MC Substitute Member; TU1202 MC Member)
 4. Josipa Domitrović
 5. Tatjana Rukavina
9. University of Split, Split
 1. Dragan Poljak (MC Substitute Member; BM1309 MC Member)

CZECH REPUBLIC (6 Institutions, 7 Members)

10. Transport Research Centre, Brno
 1. Josef Stryk (MC Member)
 2. Radek Matula (MC Substitute Member)
11. GF Instruments, Ltd
 1. Vit Gregor
12. Arcadis Geotechnika
 1. Jiri Nedved
13. Inset, Ltd
 1. Roman Smolik
14. Brno University of Technology
 1. Michal Varaus
15. Czech Technical University in Prague
 1. Ludvik Vebr

DENMARK (1 Institution, 2 Members)

16. Ramboll Denmark, Copenhagen
 1. Jørgen Ringgaard (MC Member)
 2. Roger Wisén (MC Substitute Member)

ESTONIA (1 Institution, 2 Members)

17. Institute of Ecology, Tallinn
 1. Hannes Tonisson (MC Member)
 2. Kadri Vilumaa (MC Member)

FINLAND (2 Institutions, 3 Members)

18. Aalto University, Aalto Espoo
 1. Tehri Pellinen (MC Member)
19. Geological Survey of Finland, Espoo

1. Pekka Hänninen (MC Member)
2. Taija Huotari-Halkosaari (MC Substitute Member)

The FORMER YUGOSLAV REPUBLIC of MACEDONIA (1 Institution, 2 Members)

20. Ss. Cyril and Methodius University, Skopje
1. Borislav Popovski (MC Member)
 2. Pero Latkoski (MC Substitute Member)

FRANCE (13 Institutions, 22 Members)

21. Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR), Bouguenais Cedex
1. Xavier Derobert (MC Member)
 2. Vincent Baltazart
 3. Jean Domoulin
 4. Géraldine Villain
22. University of Toulouse, Toulouse Cedex
1. Jean-Paul Balayssac (MC Member)
23. Alyotech Technologies, Nantes
1. Nicolas Pinel
24. Université Bordeaux, Bordeaux
1. Z. Mehdi Sbartai
25. Centres d'Etudes Techniques de l'Équipement (CETE), Angers – Blois – Les Ponts de Cé
1. Amine Ihamouten
 2. Cyrille Fauchard
 3. Cédric Le Bastard
26. Clermont-Ferrand University - Blaise Pascal Institute, Clermont-Ferrand cedex
1. Khalil El Khamlichi Drissi
27. École supérieure d'électricité (SUPELEC), Gif sur Yvette
1. M. Mohammed Serhir (MC Substitute Member)
 2. Marc Lambert
 3. Dominique Lesselier
28. Institut Fresnel, Marseille
1. Christelle Eyraud
 2. Amélie Litman (TD1301 MC Member)
 3. Hervé Tortel
29. Institut National des Sciences Appliquées (INSA), Toulouse
1. Gilles Klysz
30. Strasbourg University, Strasbourg
1. Maksim Bano
31. University of Nantes, Nantes
1. Cristophe Bourlier
32. University Nice Sophia Antipolis, Sophia Antipolis
1. Christian Pichot du Mezeray (MC Substitute Member; TD1301 MC Member)
33. Laboratoire d'Études et de Recherches sur les Matériaux (LERM), Arles Cedex
1. Jean-Luc Garciaz

GERMANY (5 Institutions, 9 Members)

34. Federal Institute for Material Research and Testing (BAM), Berlin
1. Christiane Trela (MC Member)
 2. Thomas Kind (MC Member)
 3. Christian Kopp (MC Substitute Member)
35. DMT GmbH & Co. KG, Exploration & Geosurvey, Hamburg
1. Joerg Endom (MC Substitute Member)
36. Institute of Bio and Geosciences, Forschungszentrum Jülich, Jülich
1. Jan van der Kruk
37. Technische Universität Ilmenau, Ilmenau

1. Jürgen Sachs (TD1301 MC Member)
 2. Rudolf Zetik
38. Ruhr-Universität Bochum, Bochum
1. Miomir Miljkovic
 2. Martin Radenberg

GREECE (5 Institutions, 12 Members)

39. National Technical University of Athens, Athens
1. Andreas Loizos (MC Member)
 2. Christina Plati (MC Member)
40. Aristotle University of Thessaloniki, Thessaloniki
1. Nectaria Diamanti
41. Geoservice, Athens
1. Klisthenis Dimitriadis
 2. Yannis Konstantakis
 3. Michael Styllas
42. Technical University of Crete, Crete
1. Nikos Economou
 2. Nikolaos Andronikidis
 3. George Kritikakis
 4. Nikos Spanoudakis
 5. Antonis Vafidis
43. Geoterra, Athens
1. Dimitrios Xirouchakis

ITALY (13 Institutions, 47 Members)

44. "Roma Tre" University, Rome
1. Lara Pajewski (MC Chair)
 2. Andrea Benedetto (MC Substitute Member)
 3. Saba Adabi
 4. Francesco Benedetto
 5. Fabrizio D'Amico
 6. Maria Rosaria De Blasiis
 7. Gaetano Giunta
 8. Wolfgang Kusayanagi
 9. Cristina Ponti
 10. Giuseppe Schettini
 11. Fabio Tosti
45. ELEDIA Research Center, Trento
1. Andrea Massa (MC Member)
 2. Luca Manica
 3. Giacomo Oliveri
 4. Lorenzo Poli
 5. Paolo Rocca
 6. Marco Salucci
 7. Federico Viani
46. IDS Ingegneria dei Sistemi, Pisa
1. Guido Manacorda (MC Member)
47. Consiglio Nazionale delle Ricerche (CNR), Istituto per i Beni Archeologici e Monumentali (IBAM), Naples
1. Nicola Masini
 2. Raffaele Persico
48. Consiglio Nazionale delle Ricerche (CNR), Istituto per il Rilevamento Elettromagnetico dell'Ambiente (IREA), Naples
1. Ilaria Catapano
 2. Lorenzo Crocco (TD1301 MC Member)
 3. Francesco Soldovieri

49. "La Sapienza" University, Rome
 1. Fabrizio Frezza (MC Substitute Member)
 2. Vincenzo Ferrara
 3. Fabio Mangini
 4. Santo Prontera
50. Seconda Università di Napoli, Napoli
 1. Giovanni Leone
 2. Raffaele Solimene (TD1301 MC Substitute Member)
51. Università Mediterranea di Reggio Calabria, Reggio Calabria
 1. Tommaso Isernia
52. University of Genoa, Genoa
 1. Matteo Pastorino
 2. Andrea Randazzo
53. University of Naples "Federico II", Naples
 1. Salvatore Capozziello
 2. Mariafelicia De Laurentis
 3. Giuseppe Longo
 4. Maurizio Paolillo
54. Provincia di Roma, Rome
 1. Francesco F. Valeri
55. Provincia di Rieti, Rome
 1. Carmelo Tulumello
56. University of Napoli "Parthenope"
 1. Fabio Baselice
 2. Giampaolo Ferraioli
 3. Ferdinando Nunziata
 4. Vito Pascazio
 5. Gilda Schirinzi
 6. Roberta Autieri
 7. Michele Ambrosiano
 8. Gianfranco Matuozzo

LATVIA (1 Institution, 2 Members)

57. Transport and Telecommunication Institute, Riga
 1. Valerijs Kutevs (MC Member)
 2. Daniil Opolchenov

MALTA (1 Institution, 1 Member)

58. University of Malta, Msida
 1. Sebastiano D'Amico (MC Member)

NETHERLAND (1 Institution, 1 Member)

59. Technical University of Delft, Delft
 1. Evert Slob (MC Member)

NORWAY (3 Institutions, 4 Members)

60. Norwegian University of Science and Technology, Trondheim
 1. Inge Hoff (MC Member)
61. SINTEF, Trondheim
 1. Anna Lalague (MC Member)
62. 3d-Radar AS, Trondheim
 1. Egil Eide (MC Substitute Member)
 2. Jacopo Sala (MC Substitute Member)

POLAND (3 Institutions, 5 Members)

63. National Institute of Telecommunications, Warsaw
 1. Marian Marciniak (MC Member; MP0702 MC Chair; IC1004 and MP1204 MC Substitute Member, IC1101 and MP1302 MC Member)
64. Road and Bridge Research Institute, Warsaw
 1. Lech Krysiński (MC Member)
 2. Jacek Sudyka (MC Substitute Member)
65. University of Science and Technology – Akademia Górniczo-Hutnicza im. Stanisława Staszica, Kraków
 1. Tomisław Gołebiowski (MC Substitute Member)
 2. Jerzy Karczewski

PORTUGAL (3 Institutions, 5 Members)

66. Instituto Politécnico de Leiria, Leiria
 1. Luisa Maria da Silva Gonçalves (MC Member)
67. University of Minho, Guimarães
 1. Jorge Pais (MC Member)
 2. Francisco M. Fernandes (MC Substitute Member)
68. National Laboratory for Civil Engineering (LNEC), Lisbon
 1. Simona Fontul
 2. Vânia Marecos

SLOVAKIA (1 Institution, 2 Members)

69. Technical University of Kosice, Kosice
 1. Dusan Kocur (MC Member)
 2. Jana Fortes Rovnakova (MC Member)

SLOVENIA (1 Institution, 1 Member)

70. University of Ljubljana, Ljubljana
 1. Andrej Gosar (MC Member; IC1301 and IC1303 MC Member)

SPAIN (5 Institutions, 16 Members)

71. Geofisica Consultores, Santiago de Surgo
 1. Alfredo Garcia (MC Member)
 2. Raúl Mínguez
72. Universidade de Vigo, Pontevedra
 1. Henrique Lorenzo (MC Member)
 2. Mercedes Solla (MC Substitute Member)
 3. Pedro Arias
 4. Xavier Nunez Nieto
73. Universidad Politécnica de Catalunya, Barcelona
 1. Gracia Vega-Pérez (MC Substitute Member)
 2. José A. Canas
 3. Oriol Caselles
 4. Jaime Clapés
 5. Lluís G. Pujades
 6. Victor Salinas Naval
 7. Sonia Santos Assunção
74. Polytechnic University of Valencia, Valencia
 1. Joaquin Andreu
 2. Luis Pallarés
75. Public University of Navarra, Pamplona
 1. Belén Larumbe Gonzalo

SWITZERLAND (4 Institutions, 7 Members)

- 76. Hochschule Rapperswil, Rapperswil
 - 1. Johannes Hugenschmidt (MC Member)
- 77. Scuola Universitaria Professionale della Svizzera Italiana, Lugano-Manno
 - 1. Luca Gamma (MC Member)
 - 2. Manuel Luescher
 - 3. Samuel Poretti
 - 4. Andrea Salvadè
- 78. Smartec, Lugano-Manno
 - 1. Daniele Inaudi
- 79. Meet Electronic Engineering
 - 1. Riccardo Monleone

TURKEY (2 Institutions, 6 Members)

- 80. Ankara University, Ankara
 - 1. Selma Kadioglu (MC Member)
 - 2. Yusuf Kagan Kadioglu
 - 3. Kiyimet Deniz
 - 4. Cuhmur Ozcan Kilic
- 81. Suleyman Demirel University, Isparta
 - 1. Serdal Terzi (MC Member)
 - 2. Mehmet Saltan (MC Substitute Member)

UNITED KINGDOM (10 Institutions, 13 Members)

- 82. The University of Edinburgh, Edinburgh
 - 1. Antonis Giannopoulos (MC Member)
 - 2. Iraklis Giannakis
- 83. The University of Greenwich, Chatham Maritime
 - 1. Amir Morteza Alani (MC Member)
 - 2. Morteza Aboutalebi
 - 3. Gokhan Kilic
- 84. Atlas Geophysical Limited, Powys
 - 1. Alex Birtwisle
- 85. British Geological Survey, Edinburgh
 - 1. Dr. Seumas Campbell (MC Substitute Member; TU1206 MC Chair; TU1204 MC Substitute Member)
- 86. Edinburgh Napier University, Edinburgh
 - 1. Craig Warren
- 87. GM RADAR Solutions, London
 - 1. Christopher Stefas
- 88. Infrastructure Services - Mouchel, Glasgow
 - 1. Michael Gordon
- 89. Queen Mary University of London, London
 - 1. Lei Li
- 90. The University of Nottingham, Nottingham
 - 1. Trevor Benson (MC Substitute Member)
- 91. Keele University, Keele
 - 1. Nigel Cassidy

Near Neighbour Countries**ARMENIA** (1 Institution, 1 Member)

- 92. State Engineering University of Armenia, Yerevan
 - 1. Hovik Baghdasaryan

UKRAINE (1 Institution, 2 Members)

93. Usikov Institute for Radiophysics and Electronics of the National Academy of Sciences of Ukraine

1. Gennadiy P. Pochanin
2. Sergey A. Masalov

International Partner Countries**AUSTRALIA** (1 Institution, 1 Member)

- Department of Transport and Main Roads
Wayne Muller

RWANDA (1 Institution, 1 Member)

- National University of Rwanda
Dr. Celestin Twizere

UNITED STATES OF AMERICA (4 Institutions, 6 Members)

- University of Mississippi
Paul Goggans
Waheed Uddin
- University of New Mexico
Rafiqul A. Tarefder
Mesbah Ahmed
- University of Texas
A. T. Papagiannakis
- Washington State Department of Transportation
David R. Luhr

For each Working Group, a Chair and a Vice Chair have been nominated. Each Project has a Leader or two Co-Leaders. Below, the following information is provided for each WG: Chair, Vice-Chair, Project Leaders and WG Members participating to the various Projects (with affiliations and email addresses).

WORKING GROUP 1 - NOVEL GPR INSTRUMENTATION (24 Members)**WG1 Chair:**

Guido MANACORDA, IDS Ingegneria dei Sistemi, Pisa, Italy, g.manacorda@idscorporation.com

WG1 Vice-Chair:

Luca GAMMA, Scuola Universitaria Professionale della Svizzera Italiana (SUPSI), Lugano-Manno, Switzerland, luca.gamma@supsi.ch

Project 1.1 – *Design, realization and optimization of innovative GPR equipment for the monitoring of critical transport infrastructures and buildings, and for the sensing of underground utilities and voids.*

Leader:

Raffaele Persico, Consiglio Nazionale delle Ricerche (CNR) - IBAM, Naples, Italy, r.persico@ibam.cnr.it

Participants:

1. Vincent Baltazart, Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFFSTAR), Bouguenais Cedex, France, vincent.baltazart@ifsttar.fr
2. Alex Birtwisle, Atlas Geophysical Limited, Ystradgynlais, Powys, United Kingdom, alex@atlasgeo.co.uk
3. Egil Eide, 3d-Radar AS, Trondheim, Norway, egil@3d-radar.com

4. Christelle Eyraud, Institut Fresnel, AMU-CNRS-ECM, Marseille, France, christelle.eyraud@fresnel.fr
5. Luca Gamma, Scuola Universitaria Professionale Svizzera Italiana (SUPSI), Lugano-Manno, Switzerland, luca.gamma@supsi.ch
6. Iraklis Giannakis, The University of Edinburgh, Edinburgh, United Kingdom, i.giannakis@ed.ac.uk
7. Antonis Giannopoulos, University of Edinburgh, Edinburgh, United Kingdom, a.giannopoulos@ed.ac.uk
8. Belén Larumbe Gonzalo, Public University of Navarra, Pamplona, Spain, belen.larumbe@unavarra.es
9. Cédric Le Bastard, CETE de l'Ouest, DLRCA, Les ponts de Cé, France, cedric.lebastard@developpement-durable.gouv.fr
10. Manuel Luescher, Scuola Universitaria Professionale Svizzera Italiana (SUPSI), Lugano-Manno, Switzerland, manuel.luescher@supsi.ch
11. Guido Manacorda, IDS Ingegneria dei Sistemi, Pisa, Italy, g.manacorda@idscorporation.com
12. Vânia Marecos, LNEC - National Laboratory for Civil Engineering, Lisbon, Portugal, vmarecos@lnec.pt
13. Luis Pallarés, Polytechnic University of Valencia, Valencia, Spain, luipalru@cst.upv.es
14. Raffaele Persico, Consiglio Nazionale delle Ricerche (CNR) - IBAM, Italy, r.persico@ibam.cnr.it
15. Christian Pichot du Mezeray, LEAT, UNS-CNRS, University Nice Sophia Antipolis, Sophia Antipolis, France, christian.pichot@unice.fr
16. Nicolas Pinel, Alyotech Technologies, Nantes, France, nicolas.pinel@alyotech.fr
17. Samuel Poretti, Scuola Universitaria Professionale Svizzera Italiana (SUPSI), Lugano-Manno, Switzerland, samuel.poretti@supsi.ch
18. Jürgen Sachs, Technische Universität Ilmenau, Ilmenau, juergen.sachs@tu-ilmenau.de
19. Andrea Salvadè, Scuola Universitaria Professionale Svizzera Italiana (SUPSI), Lugano-Manno, Switzerland, asalvade@supsi.ch
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Project 1.2 – *Development and definition of advanced testing, calibration and stability procedures and protocols, for GPR equipment*

Temporary Leader:

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Project 1.3 – *Design, modelling and optimisation of Ground Penetrating Radar antennas.*

Leader:

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WORKING GROUP 2 - GPR SURVEYING OF PAVEMENTS, BRIDGES, TUNNELS AND BUILDINGS; UNDERGROUND UTILITY AND VOID SENSING (69 Members)

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Project 2.1 – Innovative inspection procedures for effective GPR surveying of critical transport infrastructures (pavements, bridges and tunnels)

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Project 2.2 – Innovative inspection procedures for effective GPR surveying of buildings

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Project 2.3 – Innovative inspection procedures for effective GPR sensing and mapping of

underground utilities and voids, with a focus to urban areas

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Project 2.4 – Innovative procedures for effective GPR inspection of construction materials and structures

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Project 2.5 – *Determination, by using GPR, of the volumetric water content in structures, sub-structures, foundations and soil*

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WORKING GROUP 3 - ELECTROMAGNETIC METHODS FOR NEAR-FIELD SCATTERING PROBLEMS BY BURIED STRUCTURES; DATA PROCESSING TECHNIQUES (75 Members)

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Project 3.1 – Development of new methods for the solution of forward electromagnetic scattering problems by buried structures

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Project 3.2 – *Development of new methods for the solution of inverse electromagnetic scattering problems by buried structures*

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Project 3.3 – *Development of intrinsic models for describing near-field antenna effects, including antenna-medium coupling, for improved radar data processing using full-wave inversion*

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Project 3.4 – *Shape-reconstruction and quantitative estimation of electromagnetic and physical properties from GPR data*

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Project 3.5 – Development of advanced GPR data processing techniques

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Project 3.6 – *Development of advanced methods for joint processing of data collected by GPR and other non-destructive testing techniques*

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WORKING GROUP 4 - DIFFERENT APPLICATIONS OF GPR AND OTHER NON-DESTRUCTIVE TESTING TECHNOLOGIES IN CIVIL ENGINEERING (97 Members)

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Project 4.1 – Applications of GPR and other non-destructive testing methods in archaeological prospecting and cultural heritage diagnostics

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Project 4.2 – *Advanced application of GPR to the localization and vital signs detection of buried and trapped people*

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Project 4.3 – *Applications of GPR in association with other non-destructive testing methods in surveying of transport infrastructures*

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Project 4.4 – *Applications of GPR in association with other non-destructive testing methods in building assessment and in geological/geotechnical tasks*

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Project 4.5 – Development of other advanced electric and electromagnetic methods for the characterization of construction materials and structures

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Project 4.6 – *Applications of GPR in association with other non-destructive testing methods in the management and protection of water resources*

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I.C. Overview activities and expenditure

Year 1 Budget

Total Action Budget:
EUR 151.000,00

Meetings

Meeting Type	Date	Place	Cost	Total
MC+WG+CG Meetings (First Action's General Meeting)	22 – 25 July 2013	“Roma Tre” University, Rome, IT	EUR 34.100,79	
WG Meeting & Workshop (2014 Working Group Progress Meeting)	24 – 25 February 2014	Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR), Nantes, FR Local Host: Dr Xavier Derobert	EUR 23.499,21 (estimated)	
MC+WG+CG Meetings & Conference (Second Action's General Meeting)	30 April – 2 May 2014	Austria Center Vienna (ACV), Vienna, AT	EUR 53.900,00 (estimated)	
				EUR 111.500,00

STSM Grants

Beneficiary	Date	Place and STSM Title	Cost	Total
Lara Pajewski, “Roma Tre” University, Rome, IT	21 October – 20 December 2013	The University of Edinburgh, Edinburgh, UK “Electromagnetic modelling of GPR responses to complex targets”	EUR 2.500,00	
Philippe De Smedt, University of Ghent, Ghent, BE	1 February – 31 March 2014	Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology, Vienna, AT “Reconstructing prehistoric environments at Stonehenge with multiple EM methods”	EUR 2.500,00	
Sonia Santos Assunção, Polytechnic University of Catalonia, ES	15 January – 15 February 2014	Geoservice, Athens, EL “The preservation of the Tholos Tomb of Acharnon”	EUR 850,00	
Iraklis Giannakis, The University of Edinburgh, Edinburgh, UK	20 January – 21 March 2014	“Roma Tre” University, Rome, IT “Numerical modelling of GPR antennas”	EUR 2.500,00	

Further Beneficiaries	?	?	EUR 3.950,00	
				EUR 8.350,00+ 3.950,00= 12.300,00

TS Grants

Beneficiary	Date	School	Cost	Total
Saba Adabi, "Roma Tre" University, Rome, IT	24 – 28 March 2014	Microwave Imaging and Diagnostics, co-organised with COST Action TD1301 and ESoA	EUR 650,00	
Albéric De Coster, Université catholique de Louvain, Louvain-La- Neuve, BE	24 – 28 March 2014	Microwave Imaging and Diagnostics, co-organised with COST Action TD1301 and ESoA	EUR 650,00	
Iraklis Giannakis The University of Edinburgh, Edinburgh, UK	24 – 28 March 2014	Microwave Imaging and Diagnostics, co-organised with COST Action TD1301 and ESoA	EUR 650,00	
Belén Larumbe Gonzalo, Public University of Navarra, Pamplona, ES	24 – 28 March 2014	Microwave Imaging and Diagnostics, co-organised with COST Action TD1301 and ESoA	EUR 650,00	
Fabio Mangini, "La Sapienza" University, Rome, IT	24 – 28 March 2014	Microwave Imaging and Diagnostics, co-organised with COST Action TD1301 and ESoA	EUR 650,00	
Laurence Mertens, Université catholique de Louvain, Louvain-La- Neuve, BE	24 – 28 March 2014	Microwave Imaging and Diagnostics, co-organised with COST Action TD1301 and ESoA	EUR 650,00	
				EUR 3.900,00

Dissemination

Title	Date	Beneficiary	Cost	Total
Website realisation and maintenance	1	"Roma Tre" University	EUR 4.100,00	
				EUR 4.100,00

Total Science Expenditure: **EUR 131.800,00**

Financial and Scientific Administration and Coordination: **EUR 19.200,00**

Annexes to the Scientific Report:

The following Annexes are submitted together with the APM Scientific Report:

- Annex 1 is the list of publications by Action's Members, on the Action's topics and explicitly acknowledging COST Action TU1208.
- Annex 2 includes the Programme, Scientific Report and MC Minutes (with Annexes) relevant to the First Action's General Meeting (22 – 24 July 2013, Rome, Italy).
- Annex 3 consists of the Proceedings of the First Action's General Meeting. Editors: L. Pajewski and A. Benedetto; Publishing House: Aracne; Rome, July 2013; 194 pp.; ISBN 978-88-548-6191-6; o.o. 978-88-548-6190-9.
- Annex 4 is the Booklet of Action's Participants and Institutions. Editors: L. Pajewski and A. Benedetto; Publishing House: Aracne; Rome, July 2013; 127 pp.; ISBN 978-88-548-6192-3; o.o. 978-88-548-6190-9.
- Annex 5 includes the Programme, Scientific Report and Provisional Proceedings of the 2014 Working Group Progress Meeting (24 – 25 February 2014, Nantes, France).
- Annex 6 is the Programme of the Training School on Microwave Imaging and Diagnostics (24 – 28 March 2014, Madonna di Campiglio, Italy).
- Annex 7 is the Provisional Programme of the Second Action's General Meeting (30 April – 2 May 2014, Vienna, Austria).
- Annex 8 includes book chapters written by Action's Members and listed in Annex 1, as well as documents relevant to a Springer book that is going to be published by the Action in 2014.
- Annex 9 is a collection of papers published by the Action's Members on international peer-reviewed scientific journals and listed in Annex 1.
- Annex 10 is a collection of papers published by the Action's Members on international peer-reviewed conference proceedings and listed in Annex 1.
- Annex 11 includes reports, papers on national conference proceedings, technical journals, magazines and newsletters, published by the Action's Members and listed in Annex 1; it also includes additional documents relevant to few seminars and oral talks given by the Action's Members.

II. Scientific Report

II.A. Innovative networking

The starting phase of the Action was devoted to organise its WGs and Projects, as described in Section I.A, to nominate WG Chairs and Vice-Chairs, Project Leaders, the Editorial Coordinator, and the STSM and TS Managers. Moreover, efforts were devoted to creating the Action's website and setting up the communication tools. In addition to this, all the Members were asked to prepare a personal page (including: full contact details, a biographical sketch, main experience and recent publications on the Action's topics, possible participation to other Actions, role in TU1208) and a page about their Institution (including: research activities on the Action's topics, available equipment and software useful for the Action). This information was collected in a volume, constituting a census of the Action's resources and Member's experience, skills and interests. Furthermore, each Project Leader was asked to take contact with the participants of her/his Project, in order to prepare together a state-of-the-art report and identify open issues/research priorities. We were proud to have all this work done before the First General Meeting, so that the state-of-the-art reports and the Book of Participants and Institutions could be published [b1, b2; Annexes 3 and 4]; 100 copies of both volumes were printed and given to the Participants attending the First General Meeting, in July 2013. Thanks to these preliminary networking activities, a spirit of partnership, motivation and commitment was established from the beginning, and we were able to have a fruitful and positive First General Meeting.

Concerning the website, its public part was completed on 2 July 2013 and is regularly kept up-to-date. It includes: (i) a *home page*, with information relevant to recent and next Action's events, how to join the Action and main networking opportunities, top news; (ii) a section *about* the Action, providing general information on COST, TUD, and on our Action; (iii) a section devoted to the *activities* of the Action, presenting in detail the WGs and Projects, meetings, workshops, TSs, STSMs; (iv) a section collecting *resources* produced by the Action, as papers, reports, books, software, and additional material; (v) a section about *people* involved in the Action; (vi) the *links* section. Two complete versions of the website exist, optimised for desktop and mobile view. The website is registered in appropriate portals, in order to increase traffic flow, give the Action maximum visibility and reach as wide an audience as possible. More recently, the *Members Area* was set aside. Action's pages were created on Facebook and LinkedIn. A network of mailing lists is active: one is for MC Members; another one is for all the Members and external experts; finally, there is a specific mailing list for each WG and Project.

The First General Meeting was a 3-days event held in "Roma Tre" University, Rome, IT, on 22-24 July 2013; 95 participants attended this meeting, from 19 European Countries; the Science Officer was present. Overall, the event included the Action's MC and SG Meeting as well as the Meetings of the four WGs composing the general pattern of the scientific program of the Action. Several promising discussions and a wide exchange of knowledge and experience related to the use of GPR in civil engineering problems took place. The meeting was mainly devoted to address the state of the art, ongoing studies and open problems, in the fields of GPR technologies and methodologies, inspection strategies and practices, electromagnetic (EM) methods for the modelling of GPR scenarios, and numerical algorithms for the processing of GPR data. Although the Action is mainly focused on the use of GPR in civil engineering, information and ideas were shared with experts employing GPR in different fields of application, or exploiting other Non-Destructive Testing techniques in civil engineering. A representative from each partner Institution gave a short talk presenting its research team. We were honoured to have Dr. D.J. Daniels with us (who in our scientific community is recognised as the world's best leading expert on GPR), giving a talk on GPR design challenges; he provided an overview of GPR system design issues for the various modulation techniques and suggested what improvements in subsystems - such as antennas, receivers and transmitters - are needed to increase overall GPR performance. A long paper by Daniels is included in the Proceedings of the meeting [b1.2]. We were honoured by the presence of Dr. E. Utsi as well, presenting EuroGPR activities and discussing with us ideas and proposals concerning possible joint initiatives between EuroGPR and our Action [b1.3]. We were also delighted by the exciting plenary talk given by Prof. A. Giannopoulos, Chair of WG3, about the well-known simulation tool GprMax that he has developed: he presented an overview on the progress reached by FDTD modelling over the last 20 years, also providing instructions on developments to be pursued in the next future [b1.4]. It was a great pleasure to have Dr. I. Trinks, Chair of WG4, giving a plenary talk about large-scale archaeological prospection using GPR array systems: he presented extraordinary results collected by his research team at the Roman town of Carnuntum, AT, representing an excellent example of how high-resolution GPR measurements

are of fundamental importance for the mapping, documentation and investigation of buried cultural heritage in 3D [b1.5]. Each Project Leader presented the state-of-the-art and open issues relevant to her/his Project [b1.6-b1.21]. We discussed preliminary ideas about the definition of test sites and scenarios for an effective comparison between different GPR systems, inspection procedures, EM methods and data-processing algorithms. Prof. M. Marciniak presented the STSM mechanism. We discussed Marie Curie ITN and NATO SPS programmes. For more details, please see Annexes 2-4.

The second event organised by the Action was the 2014 WG Progress Meeting, held in IFSTTAR, Nantes, FR, on 24-25 Feb. 2014; 34 delegates from 12 Countries, from both academia and industry, actively participated to the meeting, being engaged in a series of presentations, discussions and brainstorming sessions. Topics of the meeting were: inspection procedures for effective surveying of transport infrastructures and buildings, mapping of underground utilities and voids in urban areas, monitoring of construction materials; determination of water content in structures, foundations and soil; advanced techniques for the solution of EM near-field scattering problems; data-processing. We were honoured to have Prof. A. Giannopoulos and Dr. C. Warren holding a workshop on “Computational Electromagnetics with the FDTD technique.” During the workshop, the theory beyond the FDTD approach was resumed; practical suggestions on the use of GprMax were given; advanced topics were faced, as the modelling of complex structures and of inhomogeneous media with stochastically distributed parameters, for a realistic EM representation of GPR antennas, materials and soils. We were delighted as well by two keynote lectures, by Prof. A. Tzanis and Dr. J. Poikajarvi. Tzanis presented the well-known MatGpr software that he has developed, providing a wide range of tools for the analysis of GPR data; he also gave an overview on GPR data processing, suggesting open issues and possible future developments in this area. Poikajarvi presented the Mara Nord Project, recently carried out in Finland, Sweden and Norway, aiming at demonstrating the potential of GPR in road-condition measurement and rehabilitation planning, and at creating and harmonising Scandinavian recommendations. An interesting visit to the IFSTTAR Geophysical Test Site (GTS) and Accelerated Pavement Testing (APT) facility took place, representing the perfect location for the comparison of different GPR systems and surveying procedures. Project Leaders presented progress reports concerning their Projects. New Members provided their experience and point of view on the Action’s topics and gave talks on their research activities. For more details, please see Annex 5.

The next events organised by the Action during its 1st financial year are: a TS on Microwave Imaging and Diagnostics (24-28 March 2014, Madonna di Campiglio, IT); the Second General Meeting (30 April -2 May, Austria Center Vienna, Vienna, AT). For the TS, please see Annex 6 and Section II.B. Concerning the Second General Meeting, it is organised jointly with the European Geosciences Union General Assembly (EGU-GA) and will include: the EGU-GA Session “Civil Engineering Applications of GPR” (30 April), the MC, SG and WGs Meetings (1-2 May). The provisional programme is in Annex 7. The EGU-GA is a very important conference, bringing together about 12.000 geoscientists from all over the world and providing a high-level forum where researchers can discuss their work and ideas. The MC agrees unanimously that the co-organisation of the Second General Meeting and EGU-GA represents a big success of our Action; this joint event is going to give huge visibility to COST and to the Action.

The state-of-the-art works published in [b1] are being improved and extended; a book on “Civil Engineering Applications of GPR” is going to be published by Springer (see Annex 8). A second (more complete) edition of [b2] and a catalogue of European GPR test sites are being prepared. Innovative knowledge is also resulting from 4 completed/ongoing STSMs (see Section I.C, r3, c45, r7, c69, c46).

In addition to the scientific progress described so far, further original results have been obtained by the Action, as attested by the large number of publications listed in Annex 1 and provided in Annexes 8-11. The Action is disseminating and promoting its activities and results in prestigious international conferences related to GPR, as the 2013 EGU-GA [c1, c2], the 2013 International Workshop on GPR [c3 (invited)], the 2013 European Microwave Week [c4], of course the 2014 EGU-GA, and the 15th International Conference on GPR [c6]. The Action has been also presented in [j1, t1-t3, o1-o9].

The expected societal and economical benefits of the Action are evident; they mainly derive from the wider and more effective application of GPR that will take place thanks to the Action. Many structures/infrastructures are affected, all over Europe and throughout the world, by diffused poor condition which influences the safety of citizens. Where structural rehabilitation is weak or absent, or sub-standard management planning is adopted and ineffective traditional tools are used, the cost of maintenance dramatically increases. A socio-economic impact is expected also outside from the civil engineering area, as in archaeology and cultural-heritage preservation, water management

and agriculture, inspection of natural/manmade materials, landmine detection, planetary exploration. Due to the short lifetime of the Action and recent launch of Horizon 2020, it's too soon to already have new proposals/funded projects in the EC RTD FP. A spin-off from EL, D, IT, PL, UK is writing a proposal for NMP-21/2014. A wider spin-off is writing a proposal for a Marie Skłodowska-Curie ITN. Concerning new National Programme projects, few examples of projects strictly related to the achievement of the Action's objectives and began after the Action's start date is provided in the following. *BE*: "Etude de prénormalisation: Développement de la technique géoradar en auscultation de routes" (Nov.2013-Nov.2015; funded by Federal Public Service Economy and Belgian Bureau for Standardisation). *CZ*: LD14029 "Civil Engineering Applications of GPR in Czech Republic" (Apr.2014–Apr.2017, funded by Ministry of Education, Youth and Sports). *Italy*: "CLARA - CCloud pAtform and smart underground imaging for natural Risk Assessment" (March 2014–June 2016; 12 Mln EUR; funded by Ministry of Education, Univ. and Research). *PL*: PW.S-647 "Permittivity Measurements of Road Construction Materials" (June 2013–Apr. 2014; funded by Road&Bridge Research Institute). *UKR*: "Radar monitoring of the technical condition of subsurface parts of engineering constructions" (Apr.2013-Dec.2015, Ukranian Programme "Safety problems of constructions, buildings and machines").

II.B. Inter-disciplinary networking

This Action is beyond a shadow of a doubt highly interdisciplinary and is being developed within the frame of a unique approach, based on the integrated contribution of University researchers from different scientific disciplines (civil and electronic engineers, architects, geophysics experts, archaeologists, ...), NDT equipment designers and producers, end users from private companies and some public agencies. Such a high level of inter-disciplinarity has a huge potential of providing technological, scientific and socio-economic impacts. Outside of the TUD Domain, the Action is of great interest for the COST ICT and ESSEM Domains, and also for BMBS, FA, FPBS, ISCH and MPNS Domains.

Cooperation has been established with Actions TU1206, TD1301, and IC1102. The TU1208 Action was presented during a TU1206 MC Meeting [o5] and TU1206 is going to be presented during the TU1208 Second General Meeting [c7]; key areas of common interest and potential collaboration have been identified, as the non-destructive characterisation of the near urban subsurface, the surveying of anthropogenic deposits, the management of water resources [b6]. A TS on Microwave Imaging and Diagnostics has been organised jointly with TD1301 and ESoA; it is going to be held on 24-28 March in Madonna di Campiglio, IT and the programme is in Annex 6; both Actions assigned 6 TS Grants to ESRs; 35 Trainees are going to attend the school; the Granted Trainees have been requested to coordinate between themselves to write a joint report, presenting in detail the techniques they will have learnt during the school. Finally, TU1208 is going to be presented during the next IC1102 MC&WG Meeting [o9]; points of potential cooperation are being identified, as the design of GPR antennas, EM modelling and microwave imaging, through-wall applications.

II.C. New networking

Several new Members joined the Action since the Kick-Off Meeting. The number of participating COST Countries increased from 14 to 24 (+1 intention to participate); 2 NNCs and 1 additional IPC joined the Action. The number of MC Members increased from 41 to 65 (+2 subject to MC permission), the number of Institutions from 64 to 99, WG Members from 116 to 203 (WG1: 11→24; WG2: 35→69; WG3: 34→75; WG4: 44→94). At present, 18% of Members are women and 32% are ESRs. The Action assigned 100% of STSM and TS grants to ESRs, 50% to women. At the First General Meeting, 30% participants were women and 52% ESRs. At the WG Progress Meeting, 29% participants were women and 41% ESRs. From outside of COST Countries, 11 participants are involved in the Action (27% from NNCs); the main benefit of their participation should be the possibility to disseminate Action's results and activities outside of COST Countries, as well as to collect information concerning the use of GPR in the participating IPCs and NNCs. Participants from Armenia and Ukraine joined recently and are expected to significantly contribute to WG1 and WG3. The Action published 2 ISBN volumes (+1 ISBN volume and 1 Springer book in progress), 1 additional book chapter (+2 in progress), 5 papers on international peer-reviewed scientific journals, 76 papers on peer-reviewed conference proceedings, 8 reports, 3 papers on technical national journals; furthermore, 8 oral communications have been given (+1 planned). Only works strictly related to the Action activities, explicitly mentioning and acknowledging it, are counted here. The complete list is in Annex 1. Concerning activities and projects carried out by COST colleagues within the network, see I.A. The capacity of Action's members to raise research funds is good, as

attested by the high number of ongoing national and international projects, few examples are in II.B.

