ANNEX 2: PERIODIC REPORT

Marie Curie Actions – International Fellowships

Project n°: 269157

Project Acronym: AMISS

Project Full Name: Active and Passive MIcrowaves for Security and Subsurface imaging

AMISS

Active and Passive MIcrowaves for Security and Subsurface imaging

Marie Curie Actions

IRSES Periodic Report

Period covered: from 01/04/2013 **to** 30/09/2014

Period number: 2nd

Start date of project: 01/10/2011

Project coordinator name: Francesco Soldovieri

Project coordinator organisation name: Consiglio nazionale delle Ricerche

Duration: 36 Months

1. PUBLISHABLE SUMMARY

Project Objectives

The project aimed at fostering the collaboration between the Western and Eastern European Countries and between the European Countries and Brazilian partner, with the aim of sharing and exachanging knowledge and achieving theoretical and applicative advances in the areas of the passive and active microwave imaging systems and characterization techniques. Specifically, the research objectives of the proposal were:

1) Development/improvement and characterization of new sensors and systems for active and passive microwave imaging;
2) Set up, analysis and validation of state of art/novel data processing approach for GPR in critical infrastructure and subsurface imaging;
3) Integration of state of art and novel imaging hardware and characterization approaches to tackle realistic situations in security, safety and subsurface prospecting applications;
4) Development and feasibility study of bioradar technology (system and data processing) for vital signs detection and detection/characterization of human beings in complex scenarios

Work performed since the beginning of the project

The activities of the project were organized in four work packages, three regarding technical activities and the last one aimed at the management. The scientific activities for this second period are briefly summarised.

For “WP1 Microwave and Millimetre wave imaging systems for security”, the first activity has regarded the design, realization and integration of several UWB antennas within the GPR systems available at the partners (differential GPR systems, Through wall imaging systems, radar systems for concealed object detection, radiometric systems), enabling different applications not only in security and safety, but even in civil applications as road monitoring. The development of a full holographic radar system (amplitude and phase measurements of the field) has been achieved for the detection of concealed objects; this system has been equipped with advanced data processing and has been also used in a configuration not originally expected, as for subsurface imaging. The other main activity has regarded the development and use in real situations of millimeter passive radiometric systems for applications ranging from security to civil applications: the performances of these radiometric system have been improved enhanced by means of advanced data processing for clutter mitigation and high resolution images.

For “WP2 Development of GPR technologies for subsurface sensing and critical infrastructure monitoring”, the first activity has regarded hardware development: in particular, the design and realization of loaded ridged horn and reflector antennas was carried out and the designed radar systems were deployed also in unconventional configuration as the Forward Looking one, of interest for landmine and Improvised Explosive Devices (IED) detection. For the hardware development, another main activity has regarded the development of novel impulse generators, whose performances have been thoroughly investigated in laboratory.

The second main WP2 activity has regarded the development of data processing ion order to improve the performance of the differential GPR system and of the holographic (based on the only amplitude measurement) system deployed for subsurface imaging: both the systems are relevant to different applications as cultural heritage and infrastructures monitoring, non-destructive testing, buried pipes detection and localization. In WP2, a significant attention has been devoted to the forward modeling of the electromagnetic scattering in complex scenarios; this activity

was also necessary for the development and performance analysis of linear and nonlinear inverse scattering approaches aiming to a qualitative and quantitative characterization of buried and hidden objects. These inverse scattering approaches have been validated in real conditions for different application domains ranging from the archeological prospection, to forensics, to soil moisture monitoring to oil spill monitoring. All these applications have a significant impact in environmental monitoring and exploitation of the subsurface resources.
“WP3 Radar technologies for remote detection and registration of vital signs” was completed with success. Three bioradar systems, whose development was started in the first period, were completed and equipped with advanced data processing. The complex of the three systems covers an overall band ranging from 2 GHz to 14 GHz and permit to detect and characterize vital signs and movements in several applications as detection of buried persons and through obstacles and medical applications. In this frame, a good attention was focused on the use of bioradar for the signal breathing patterns for noncontact screening of sleep Apnea syndromes. The activity carried out in this WP make us confident about the use of bioradar in real situations for biomedical applications.

AMISS activities have led to significant scientific and technological outcome, as listed below.

WP1 Microwave and Millimetre wave imaging systems for security

- Development and performance analysis of a novel 2.5D ARM algorithm for fast and reliable analysis of parabolic reflector antennas at millimetre frequencies (YTU).
- Design, realization and validation of a novel ultra-wide band Vivaldi shaped TEM fed dielectric loaded ridged horn and integration as antenna head of the Ground Penetrating Impulse Radar designed by IRE (YTU-IRE).
- Design of a novel compact UWB antenna called “partial dielectric loaded ridged horn” for ultra-wide band (UWB) microwave through-wall imaging system available at BMSTU (YTU-BMSTU).
- Development and performance analysis of an adaptive UWB SAR algorithm and TWI SAR laboratory test measurements for human-like targets at the distance of 2-3 meters from the radar platform (YTU-BMSTU).
- Design and realization of a fully holographic system (hardware + software) for concealed targets detection. The system has been extended also to the case of buried target detection (YTU-BMSTU).
- Development of a 3-Dimensional Analytical Regularization Method (ARM) to perform fast and accurate design and analysis of waveguide array feeder of a parabolic reflector for radiometric passive millimetre wave imaging systems at SRC (YTU-SRC).
- System design knowledge of 35 GHz passive radiometric imaging system and its sub-modules (i.e. antennas, receiver and image processing) were transferred from SRC to YTU.
- Performance analysis of the two radiometric passive imaging systems available at SRC (33 GHz and 94 GHz) thanks to the data processing developed at CNR.

WP2 Development of GPR technologies for subsurface sensing and critical infrastructure monitoring

- Integration of the dielectric loaded compact ridged horn antenna, reflector antenna in the GPR prototype available at IRE and successful validation of the

integrated GPR system under a Forward Looking GPR configuration. (YTU-IRE).

- Design, manufacturing and testing of a new digital delay line with low jitter and extended range. Moreover, the stability performance of the system sampling has been improved (IRE-YTU).
- 3 GHz impulse generator based on RF switch-transistor (2N2222 model switch-transistor) has been designed and realized by YTU group in cooperation with IRE. Tests and measurements have been done successfully at YTU Microwave Laboratory (YTU-IRE).
- Design realization and preliminary testing of two low-cost high voltage impulse generators for GPR (YTU-IRE).
- Improvement of the differential transmitting and receiving antenna system for GPR. The Transmitting/Receiving antenna decoupling exceeds up to – 65 dB over the operating frequency band of 0.8÷1.6 GHz (IRE-YTU).
- Development, performance analysis and validation of microwave tomographic approach for GPR data processing under the differential configuration in 2D and 3D geometry (CNR-IRE).
- Validation of a novel data processing for holographic GPR in controlled and real conditions (CNR-BMSTU).
- Improvement of 2D modelling with possibility to include frequency dependent loss models (TUDELFT, USP).
- Development of modelling VRP data from surface reflection data (TUDELFT).
- Improvement of 2D linear inverse scattering approaches in view of their application in real situations (CNR).
- Development, performance analysis and validation of microwave tomographic approach for GPR data processing under the reflection configuration (CNR-IRE) in 3D geometry
- Development of a novel approach based on the use of a periodic lattice to improve the performances of a microwave tomographic approach in terms of resolution limits (CNR).
- Development, performance analysis and validation of full inverse scattering approach in 1D geometry for quantitative estimation from GPR traces (USP-CNR).
- Development and performance analysis of data-driven 2D and 3D full waveform inversion schemes based on three linear steps (TUDELFT).
- Development and performance analysis of a full waveform inversion scheme based on three linear steps (TUDELFT).
- Validation of linear and non-linear inversion approaches thanks to experimental data collected in controlled and real situations (USP-CNR-TUDELFT).

WP3 Radar technologies for remote detection and registration of vital signs

- Design and realization of three bioradar prototypes. In particular, two systems have been realised at BMSTU working in two different frequency bands, centred at 4 and 15 GHz, respectively. The third system has been realized at CNR and operates in a lower band as compared to the ones of BMSTU, i.e., at about 2 GHz (CNR- BMSTU-YTU).
- Development of specific data processing developed by BMSTU and CNR. The different data processing codes have been compared by means of the validation via experimental data collected at the two institutions. Moreover, the path for their integration has been traced, as they provide different, and complementary ways, to process the radar traces (BMSTU-CNR).

- Extensive analysis of the performance of the bioradar systems. In particular, potential of the device for medical applications has been investigated, with a focus on the monitoring of patients for sleep syndromes analysis (BMSTU-CNR).
- Definition of measurement protocols and processing strategies for medical applications (BMSTU-CNR).

As outcome transversal with respect to the technical activities, we stress the dissemination activity of the project, amounting to the 14 papers on international journals 1 chapter book and more than 30 conference presentations, among which three invited presentations.
In this second period, a very good knowledge sharing/exchange and training activity was performed and significant outcomes were achieved in establishing new cooperation and improving the already present collaborations between the partners. AMISS partners have now an assessed cooperation, which will enable the joint involvement in proposals responding to H2020 calls.
Summarising, the activities carried out in AMISS were successful in achieving two main outcomes. The first one was a significant knowledge exchange/sharing among partners with assessed expertise in all the fields (electronics, microwaves, inverse scattering, electromagnetic modeling) necessary for the development of passive and active radar systems. As second outcome, AMISS scientific and technological outcomes has been shown to have significant impact in many security and civil sectors of the society such as: physical security, forensics, civil engineering diagnostics, critical infrastructures monitoring; environmental monitoring; subsurface prospecting, archaeology and cultural heritage diagnostics; demining and explosive detection, just to mention few fields.

2. GENERAL PROGRESS OF THE PROJECT

In the second reporting period, the activities have been performed according to the expected plan and all the milestones have been achieved.

The milestones achieved in this second reporting period are reported below.

M1.2 Prototype of a novel holographic system for the detection of concealed objects in charge of BMSTU and expected on month 24. The prototype has been designed and realized and a preliminary evaluation of the performances has been carried out. Achievement of Deliverable D1.4.

M1.3 Prototype of a radiometric imaging method and system for concealed weapon detection, in charge of SRC and expected on month 30. Two prototypes of the system, working at different frequency bands, have been developed and a performance evaluation has been carried out. Achievement of deliverable D1.5.

M2.1 Design of UWB antennas, impulse generators and electronic devices for UWB, multichannel array mode GPR, in charge of YTU and expected on month 21. The design of novel antennas, generators and electronics for GPR systems has been finalised. Achievement of Deliverables D2.1 and 2.2.

M2.2 Inversion approaches for differential GPR and holographic radar, in charge of CNR and expected on month 24. The inversion approaches have been finalised for both the GPR systems and the reconstruction performances have been investigated with both synthetic and experimental data. Achievement of Deliverable D2.5.

M2.3 Linear and non-linear imaging approaches for UWB, multichannel array mode GPR, in charge of TUDELFT and expected on month 24. Several linear and non-linear inversion approaches have been implemented and their performances have been evaluated in the frame of qualitative and quantitative subsurface reconstruction. Achievement of Deliverable D2.7.

M2.4 Multichannel and array mode GPR prototypes, in charge of YTU and expected on month 30. The multi-channel and array based GPR configurations have been implemented and validated. Achievement of Deliverable 2.4.

M2.5 Experimental validation of GPR systems in controlled conditions, in charge of USP and expected on month 33. The experimental validation has been performed thanks to measurements collected for different scenarios at the test sites of University of Sao Paulo. Achievement of Deliverable 2.8.

M3.1 Prototypes of bioradar, in charge of BMSTU and expected on month 21. Two prototypes of bioradar systems have been designed and realized at BMSTU and an additional prototype has been realized at CNR in a frequency intermediate as compared to BMSTU systems. The performances of the bioradar systems have been evaluated and compared by processing real data. Achievement of Deliverable D3.1.

M3.2 Feasibility study on the bioradar integrated with data processing, in charge of CNR/BMSTU and expected month 33. A feasibility study of the bioradar systems has been performed, thanks to experiments in controlled conditions. In particular, bioradar data processing algorithms have been developed and used to process experimental data gathered in laboratory conditions by means of both the BMSTU

and the CNR bioradar prototypes. Achievement of Deliverable D3.3.

M4.3 Yearly project meeting, in charge of the Coordinator (CNR) and expected on month 24. Definition of the annual plan of exchange/activities and updating of the secondments, according to the evaluation outcomes of the periodic report at month 18.

M4.3 Final project meeting in charge of the Coordinator (CNR). Definition of the actions in view of the final periodic reporting and drawing of the possible cooperation activities beyond the project's lifetime.

About technical activities, the details of the progress towards the achievements of deliverables and milestones in this second period are described below for each Work-package.

WP1 Microwave and Millimetre wave imaging systems for security

The activities of the second part of the project have been performed according to the planned roadmap with a full technical cooperation between all WP1 partners.

Task 1.1: Horn, parabolic reflector and array antenna preliminary designs in microwave and MMwave bands.

YTU and IRE cooperated in the analysis of UWB impulse GPR design, YTU developed UWB horn and reflector antennas, impulse generator with IRE.

YTU developed 2.5D ARM algorithm for fast and reliable analysis of parabolic reflector antennas for millimetre-wave systems. The outcome of this activity is in

O.M. Yücedag, A.S. Türk, Design of horn fed offset parabolic reflector antennas with analytical regularization method", Journal of Electromagnetic Waves and Applications, 28(12), pp. 1502-1511, 2014 DOI:10.1080/09205071.2014.932056

In addition, a journal paper *A.S.Turk et al. "Development of 2.5D Analytical Regularization Method for reflector antenna analysis" is under preparation for the submission to IEEE Trans. Antennas and Propagation.*

A novel ultra-wide band Vivaldi shaped TEM fed dielectric loaded ridged horn design has been implemented by YTU and integrated as antenna head for Ground Penetrating Impulse Radar designed by IRE. The technological aim of this study is to achieve high antenna gain, narrow beam and low input reflection characteristics over an ultra-wide band for high resolution impulse radar systems. The antenna has been after integrated into the radar system designed by IRE and measurements have been carried out for this UWB antenna. Finally, the design of this antenna for GPR differential system has been tested in real conditions for road diagnostics and monitoring.

The scientific outcomes of this activity are presented in

G.P. Pochanin, V.P. Ruban, P.V. Kholod, A.A. Shuba, A.G. Pochanin, A.A Orlenko "Enlarging of power budget of ultrawideband radar" (Proc. of the 6th International Conference on "Recent Advances in Space Technologies-RAST2013", pp. 213-216, June 12 14, 2013. Istanbul (Turkey).

Pochanin G.P., Ruban V.P., Batrakova A.G., Urdzik S.N., Batrakov D.O. "Measuring of thickness of asphalt pavement with use of GPR", 15th International radar symposium proceedings, pp. 452-455. Gdansk, Poland, June 16-18, 2014. ISBN 978-83-931525-3-7.

Pochanin G.P., Ruban V.P., Kholod P.V., Shuba O.A., Pochanina I.Ye., Batrakova A.G., Urdzik S.N., Batrakov D.O., Golovin D.V. "Advances in Ground Penetrating Radars for Road Surveying", Proceedings of 7th International Conference on Ultra Wideband and Ultra Short Impulse Signals (UWBUSIS), pp. 13-18. September 15-19, 2014, Kharkiv, Ukraine.

Task 1.2: Active microwave tomographic system design for through wall imaging.

The dielectric loaded compact ridged horn antenna was designed at YTU for ultra-wide band (UWB) microwave through-wall imaging system, in order to provide adaptive ranging and better resolution performance for the TWI RASCAN system developed by BMSTU group.

An adaptive UWB SAR algorithm has been developed by YTU group and TWI SAR laboratory test measurements have been performed for human-like targets at the distance of 2-3 meters from the radar platform. *The performance analysis has been presented at 15th International Radar Symposium, Gdansk, Poland, June 16-18, 2014.*

Task 1.3: Active Microwave holographic system design for detection of concealed objects under clothes on human body.

A full holographic system was realized at BMSTU, using two measurement channels with the aim to acquire in-phase and quadrature signals. The data processing tools have been developed for this kind of system and results have been presented in

Zhuravlev, A.V., S.I. Ivashov, V.V. Razevig, I.A. Vasiliev, A.S. Bugaev (2013b), "Holographic Subsurface Radar RASCAN-5", Proceedings of the International Workshop on Advanced Ground Penetrating Radar, (IWAGPR2013), pp. 289-294, Nantes, France, July 2-5, 2013.

Further studies have been jointly carried out by YTU and BMSTU to improve the holographic GPR system at BMSTU. As not expected outcome of the project, the full holographic system has been characterised also for buried target detection.

Zhuravlev, A.V., S.I. Ivashov, V.V. Razevig, I.A. Vasiliev, A.S. Türk, and A. Kizilay, "Holographic Microwave Imaging Radar for Applications In Civil Engineering", Proceedings of the IET International Radar Conference, paper A0065. 14-16 April 2013, Xi'an, China.

Ivashov, S.I., A.S. Bugaev, A.S. Turk, A.V. Zhuravlev (2013), "An Algorithm for Detection of Hidden Objects by Passive/Active Radiometer", paper D0121, Proceedings of the IET International Radar Conference, 14-16 April 2013, Xi'an, China.

Task 1.4: Radiometric passive imaging for concealed weapon detection.

YTU, in cooperation with SRC, has completed the numerical design of waveguide

and horn array fed parabolic reflector antenna for the radiometric passive millimetre wave imaging system developed by SRC. In particular, a 3-Dimensional Analytical Regularization Method (ARM) has been developed by YTU to perform fast and accurate design and analysis of waveguide array feeder of the parabolic reflector of SRC system. The main aim of this design is to obtain desired radiation characteristics for air and coastal microwave surveillance radars and radiometric passive millimetre wave imaging.

The system design knowledge of 35 GHz passive radiometric imaging system and its sub-modules (i.e. antennas, receiver and image processing) were transferred from SRC to YTU. As future activity, it is expected to realize a laboratory prototype of this system in YTU laboratory.

The performance of the two radiometric passive imaging systems available at SRC (33 GHz and 94 GHz) have been enhanced thanks to the data processing developed at CNR. The aims of the data processing are the mitigation of clutter and improvement of spatial resolution for the achieved radiometric images. The data processing approach performances have been evaluated thanks to the data collected by the two systems at 33 and 94 GHz.

The scientific outcomes of this activity are collected in

F. Soldovieri, A. Natale, V. Gorishnyak, A. Pavluchenko, A. Denisov, and L. Chen, "Radiometric Imaging for Monitoring and Surveillance Issues," International Journal of Antennas and Propagation, vol. 2013, Article ID 272561, 8 pages, 2013. doi:10.1155/2013/272561

F. Soldovieri, A. Denisov, V. Speziale, "A novel solution for car traffic control based on radiometric microwave devices", Vol. 16, EGU2014-13903, 2014 EGU General Assembly 2014.

As an unexpected result of the project, an activity has been started between SRC and CNR regarding the study of a novel single-block UWB device, operating in TeraHertz band. The system combines a super-wide band frequency-meter with a sensitive super-wide band panoramic receiver. The outcome of this scientific activity is presented in the conference paper

A.Denisov, F.Soldovieri, J.Qiu, "Best candidate for the receiving and frequency measuring in the future analogue of "Agilent" in Terahertz band is Josephson junction", submitted to IEEE International Microwave Symposium, USA, May 2015.

WP2 Development of GPR technologies for subsurface sensing and critical infrastructure monitoring

During the second part of the project, WP2 has achieved the objectives and technical goals expected in the AMISS workplan and, in several cases, unexpected results have been obtained.

Task 2.1: Ultra-wide band (UWB) planar, TEM horn and array antenna designs for GPR systems.

It is worth noting that the activities of tasks 1.1, 2.1 and 2.2 were strictly related, so that they should be seen under a unified framework.

YTU and IRE have integrated the designed dielectric loaded compact ridged horn antenna, the reflector antenna and the prototype available at IRE. The validation of such an integrated GPR system has been performed for a Forward Looking GPR configuration, aiming at detecting buried metal and dielectric objects in the area ahead of a vehicle. The study yielded positive results. Experimental results were published in the proceedings of UWBUSIS 2014 conference:

Turk, A.S., A.K. Keskin, M. Dagcan Senturk, A. Magat, M.B. Ozakin, S. Aksoy,"Ultra wide band TEM horn and reflector antenna designs for down and forward looking ground penetrating radars", Proceedings of the International Workshop on Advanced Ground Penetrating Radar (IWAGPR2013), Nantes, France, July 2-5, 2013.

Ruban V.P., Shuba O.O., Pochanin O.G., Pochanin G.P., Turk A.S., Keskin A.K., Dagcan S.M., Caliskan A.T., "Analog Signal Processing for UWB Sounding", Proc. Of 7th International Conference on Ultra Wideband and Ultra Short Impulse Signals (UWBUSIS), pp. 55-58. September 15-19, 2014, Kharkiv, Ukraine.

The design of a new digital delay line with low jitter and extended range of delay was discussed during a visit of YTU at IRE. The prototype of the delay line was manufactured and tested during 2 visits to the YTU.

Task 2.2: Wide band impulse generator designs for multi-band GPR.

A 3GHz impulse generator based on RF switch-transistor has been designed and realized by YTU group in cooperation with IRE. Tests and measurements have been successfully carried out at YTU Microwave Laboratory.
Low cost high voltage impulse generators have been designed and realized for GPR transmitters. In particular, two short pulse generators have been designed by 2N2222 with its avalanche mode. The first one is realized with a single stage, whereas the second one is realized under a cascade modality, by using cascaded multi-stage to get higher voltage. Measurements have shown the effectiveness of the proposed solution for the two generators.
The outcomes of this activity are gathered in:

A.K. Keskin, M. D. Senturk, A. A. Orlenko, G.P. Pochanin, and A.S. Turk, "Low Cost High Voltage Impulse Generator for GPR", Proc. of 30th Annual Review of Progress in Applied Computational Electromagnetics, ACES 2014 Conference, March 23-27, 2014, Jacksonville, USA.

Ruban V.P., Shuba O.O., Pochanin O.G., Pochanin G.P., Turk A.S., Keskin, A.K., Dagcan S.M., Caliskan A.T., "Analog Signal Processing for UWB Sounding", Proc. of 7th International Conference on Ultra Wideband and Ultra Short Impulse Signals (UWBUSIS), pp. 55-58, September 15-19, 2014, Kharkiv, Ukraine.

Task 2.3: Novel GPR system based on differential configuration for clutter mitigation

YTU has cooperated with IRE on the hardware development of the novel differential GPR system of IRE. In particular, YTU has developed novel ultra-wide band TEM horn antenna pair, which have been connected to the GPR system designed by IRE.
Part of the experimentation of the integrated GPR systems in controlled conditions has been presented in the conference paper:

Ruban V.P., Shuba O.O., Pochanin O.G., Pochanin G.P., Turk A.S., Keskin, A.K.,

Dagcan S.M., Caliskan A.T., "Analog Signal Processing for UWB Sounding", Proc. of 7th International Conference on Ultra Wideband and Ultra Short Impulse Signals (UWBUSIS), pp. 55-58, September 15-19, 2014, Kharkiv, Ukraine.

Large attention was given to the development of advanced and specifically devoted data processing for the differential configuration, which is a non-conventional configuration for GPR surveys. The development of data processing and its integration in the GPR system of IRE was the topic of a cooperation between CNR and IRE. A detailed description of the radar image reconstruction based on differential GPR data and tomographic inversion approaches are going to be presented in a journal paper, which is in preparation.

Persico R., Pochanin G., Ruban V., Orlenko A., Catapano I., and Soldovieri F., "High decoupled antenna and microwave tomography in GPR" under submission.

The above paper summarises the results of the activity detailed below.
First, a reconstruction approach was developed in a 2D geometry, both for free space and half-space (buried targets) scenarios. The GPR system in combination with tomographic radar data processing allows to retrieve the shape of the objects from radar measurements carried out using this antenna system. The effectiveness of the proposed inversion scheme has been tested by processing synthetic and experimental data and main scientific outcomes are gathered in

Persico, R.; Soldovieri, F.; Catapano, I.; Pochanin, G.; Ruban, V.; Orlenko, O., "Experimental results of a microwave tomography approach applied to a differential measurement configuration", Proceedings of the International Workshop on Advanced Ground Penetrating Radar, (IWAGPR2013), 2-5 July 2013,Nantes, France.

Afterwards, the more general case of a 3D scenario has been considered; theoretical investigations have been performed on three differential antenna systems and experiments clarifying the characteristics of the differential antenna systems were performed. The activity dealt with the comparison of three systems where receiving antennas are symmetrically displaced with respect to the transmitting antenna along three orthogonal directions for imaging of 3D-targets located in free-space. To this end, synthetic radargrams were generated by a finite-difference time-domain forward solver, for each measurement set-up. Finally, a microwave tomographic approach has been developed and applied to process the scattered field differential data and obtain images, in order to the compare the three systems. The scientific outcomes of these investigations have been published in

Varianytsia-Roshchupkina L.A., Gennarelli G., Soldovieri F., Pochanin G.P., "Comparative Analysis of Three RTR-Differential GPR Systems for Subsurface Object Imaging" Radiophysics and Electronics. 2014, vol. 4, (in press).

Varianytsia-Roshchupkina L.A., Soldovieri F., Pochanin G.P., Gennarelli G.,"Full 3D Imaging by Differential GPR Systems", Proc. of 7th International Conference on Ultra Wideband and Ultra Short Impulse Signals (UWBUSIS), pp. 120-123. September 15-19, 2014, Kharkiv, Ukraine.

Varianytsia-Roshchupkina L.A., Gennarelli G., Soldovieri F., "Comparison of Two Differential GPR Systems for Imaging Objects under a Reflection Configuration", proc. of 15th International Radar Symposium, Gdansk, Poland, June 16-18, 2014.

Task 2.4: Holographic radar for shallower subsurface imaging

CNR-IREA and BMSTU have continued to work on the integration of a novel data processing algorithm to localize and characterize the geometry of buried objects via holographic radar. Deliverable D.2.6 addressing this topic has been successfully issued. CNR-IREA has been in charge of the development of the inversion approach and its validation through surveys carried out by means of the holographic radar RASCAN 4-4000 designed by BMSTU.

The main outcome of this activity is in

I. Catapano, L. Crocco, A. Affinito, G. Gennarelli, V. Razevig, I. A. Vasiliev, S. I. Ivashov, F. Soldovieri, "On the holographic radar as a tool for structural monitoring", Proc. of 33rd EARSeL Symposium, Matera, 6-7 June 2013.

I. Catapano, L. Crocco, A. Affinito, G. Gennarelli, F. Soldovieri, "Monitoring by holographic radar systems" Proc. of EGU General Assembly, Vienna, 7-12 April 2013.

Task 2.5: Application of GPR systems to several domains: geophysical, archeology, NDT applications.

This task had the aim of validating the use of GPR systems in different application fields, ranging from geophysics, to archaeology, non-destructive testing and monitoring. This task together with all the following ones of this WP should be seen under a unified framework. In particular, the approaches based on a linear model of the electromagnetic scattering have been validated in several applications. Here, we list several publications where this activity has been reported. The other main activities regarding the validation of the developed reconstruction approaches are in task 2.9, with a specific focus on the datasets collected at test sites of USP.
A microwave tomographic approach developed by CNR has been validated in real conditions for an archaeological prospecting aimed to inspect a prehistoric site in a cave of the Southern Italy.

Catapano I, Loperte A., Satriani A., Larocca F., Affinito A., Soldovieri F., Amato M., "Three-dimensional ground penetrating radar surveys at Grotte dell'Angelo, Pertosa, (SA), Southern Italy", Rendiconti Online Societa' Geologica Italiana, 2013

Catapano I, Affinito A., Gennarelli G., di Maio F., Loperte A., Soldovieri F., "Full three-dimensional imaging via ground penetrating radar: assessment in controlled conditions and on field for archaeological prospecting", Applied Physics A, vol. 115, pp. 1415-1422, 2014

Task 2.6: Electromagnetic modeling of subsurface wave propagation and scattering from sub-layers and buried objects.

A fast time domain finite difference code has been developed by TUDELFT to model 2D TE-mode GPR data: this code has been used by USP to model several scenarios necessary for achieving Task 2.9. A novel modelling method based on electromagnetic reciprocity and scattering formulations has been developed: this method can transform measured reflection data into new data. These new data corresponds to a set of virtual measurements where the sources are in the same location as those of the measurements, but the user can place the receivers at any desired depth level thereby creating a vertical radar profile data set. The resulting

data contains true amplitude information and includes all propagation and scattering of the actual subsurface situation. This approach forms the basis for a game changer in terms of full waveform inversion strategies. Results can be found in

Slob E. and K. Wapenaar, "GPR wave field decomposition, synthesis, and imaging for lossless layered vertically transverse isotropic media", Proceedings of the International Workshop on Advanced Ground-Penetrating Radar (IWAGPR2013), pp. 21-26. Nantes, France, July 2-5, 2013.

Slob, E. and K. Wapenaar, "Coupled Marchenko equations for electromagnetic Green's function retrieval and imaging", Proc. of SEG 83rd Annual Meeting, pp. 1863-1867. Houston, USA, September 2013.

Slob, E. , J. Hünziker, J. Torbecke, and K. Wapneaar, "Creating virtual vertical radar profiles from surface reflection Ground Penetrating Radar data", Proceedings of the 15th International Conference on GPR2014, Bruxelles, Belgium, June 2014.

Task 2.7 Fast single and multi-component linear inversion algorithms using the imaging principle.

CNR and USP have cooperated to improve the linear inversion approaches already available at CNR, with the aim to adapt them to the forensics archaeology applications. The developed approach has been after used in real conditions thanks to the processing of data collected at an experimental site at USP: this latter activity is presented in task 2.9, with the related scientific outcomes.

Another activity has regarded the development of an advanced scattering model capable of accounting for the 3D and vector nature of the scattering phenomenon, used to design a novel imaging approach capable of providing full 3D images of buried targets. This approach has been validated experimentally thanks to the activities in Tasks 2.5 and 2.9

Catapano I., Affinito A., Crocco L., Gennarell, G., Soldovieri, F., "Full 3-D electromagnetic subsurface imaging using ground penetrating radar," Proc. of Workshop on Advanced Ground Penetrating Radar (IWAGPR2013), 2-5 July 2013, Nantes, France.

As an unexpected result, a new approach has been developed and analysed in which the reconstruction capabilities of microwave data processing are improved in terms of achievable resolution by using a periodic lattice between the antenna system and the targets, This activity has led to the following publication on a very prestigious Journal

Gianluca Gennarelli, Raffaele Persico, and Francesco Soldovieri. "Effective imaging systems based on periodic lattices." Applied Physics Letters, vol. 104.19 (2014): 194103.

Task 2.8: Full waveform non-linear inversion

This task was devoted to develop and analyse inverse scattering approaches able to perform a quantitative description of the targets in terms of electromagnetic properties (dielectric permittivity, electrical conductivity and magnetic permeability). The approaches here developed are characterized by further mathematical difficulties compared to the ones (linear imaging) presented in Task 2.7. In fact, in

this case, we are concerned with the non-linearity of the relationships between the scattered/reflected field data and the unknown electromagnetic properties of the targets, so that a problem of the reliability of the achieved solutions arises (false solution occurrence).
Different geometries (1D, 2D..) and background scenarios have been considered.

For the 1D geometry, an inverse modelling has been developed in order to perform a quantitative analysis regarding the estimation of the electromagnetic properties of a layered medium starting from a GPR trace (A scan). The problem is solved by using the Ant Colony Optimization as a global random search method to minimize a cost function representing the distance between measurements and model data. The quantitative analysis was performed over a simple 1D model in order to better evaluate the performance of the proposed methodology with respect to the reliability and the accuracy of the results. The study was focussed on this canonical case starting from data acquired in a fixed-offset, off-ground configuration with the aim to retrieve the properties of a slab in free space. After several statistical analyses, the optimization was able to provide very accurate results, in terms of estimation of relative permittivity, conductivity and thickness of the slab. An experimental validation of the approach has been performed with real data acquired at CNR-IREA laboratory, by using two kind of antenna systems: a 2GHz GPR antenna from IDS Corporation and a laboratory system using two ridged horn antennas. This quantitative analysis was possible thanks to the cooperation between USP and CNR and is the subject of a journal paper to be soon submitted.

A potential breakthrough in full waveform inversion was achieved by TUDELFT rendering the full-waveform inversion a linear problem unlike what is commonly assumed. The developed scheme carries out full waveform inversion in three linear steps. The first step reorganized the measured reflection data such that receivers are placed from the original measurement surface to any user-desired depth level. In this step, surface reflection data are transformed into a virtual vertical radar profile where the sources remain at their original locations while the receivers are placed in the subsurface. This step is a linear filter step that requires as input the emitted source time signature and the time to first arrival from all sources to the subsurface receiver location. A smooth subsurface model suffices to achieve this step and such model can be obtained through velocity analysis carried out on the measured data. After this first step the upgoing and downgoing wavefields are known separately at the receiver level. The second step carries out a multidimensional deconvolution, effectively placing the sources at the receiver depth level, and obtains the local reflection response at the receiver depth level. The reflection response is true-amplitude and forms the data on which Amplitude Versus Angle AVA analysis can be carried out. This analysis forms the actual inversion and is the third step in the method. Theoretical developments and numerical results can be found in:

Slob, E., "Non-destructive monitoring of layered infrastructure using GPR data", Proc. of EGU General Assembly, Vienna, 7-12 April 2013.

Slob E. and K. Wapenaar, "GPR wave field decomposition, synthesis, and imaging for lossless layered vertically transverse isotropic media", Proceedings of the International Workshop on Advanced Ground-Penetrating Radar (IWAGPR2013), pp. 21-26. Nantes, France, July 2-5, 2013.

Slob, E. and K. Wapenaar, "Data-driven inversion of GPR surface reflection data for lossless layered media", Proceedings of the 8th European Conference on Antennas and Propagation, April 2014.

Task 2.9: Experimental validation of the GPR systems at the USP geophysical test site.

This task was devoted at carrying out the experimental validation of the inversion approaches developed in the tasks above (mainly Tasks 2.7 and 2.8), by using data collected in experiments/measurements performed at a full scale and in different operative contexts thanks to the USP facilities The different datasets were made available by USP to all the partners to make a performance analysis of the reconstruction approaches.

First case

GPR data were acquired at the IAG Controlled Site of Shallow Geophysics. GPR pseudo-3D profiles (2D parallel profiles) was collected by employing 200, 270 and 400MHz antennas for mapping interferences (pipelines, metallic and plastic drums).
During the secondment of Prado (USP) at TUDelft, data processing was carried out for GPR measurements collected at the field sites Campos de Jordão and São José dos Campos (Sao Paulo State – Brazil), with the aim of monitoring geotechnical and climatic variables at support of the deployment of early warning systems for landslides in São Paulo. The data were acquired in April/May and July 2013. Numerical modelling was performed to make simpler the interpretation of the processed data. The field data allow imaging the main characteristic of the study area in terms of seismic and electromagnetic waves (interfaces and velocity profiles). The geotechnical data (saturation and particles size distribution) also support the model to generate the synthetic radargrams for different water content conditions. Coda Wave Interferometry (CWI) is the method of cross-correlating short time-windows of the data and plotting the time lag versus the window central time. From these results, we found that applying the CWI method can be used to monitor small velocity changes, which can be related to slight moisture content variations. The outcomes of this activity are reported in:

Prado, R.L., E. Slob and R.M. Mendes, "Geophysical support for the assessment/monitoring of partially saturated soils on land susceptible to shallow landslides", accepted for the presentation at the 1st SEG/SBGf Workshop on Near Surface Geophysics, Salvador, Brazil, 3-4 December 2014.

As a spin-off from these activities, USP submitted a research project proposal for financial support by the Federal Brazilian Science without Borders program in which TUDELFT and USP collaborate. The proposal entitled *Seismic and electromagnetic data inversion to enhance near surface characterization* was granted in 2014 and will run for three years. The project involves four scientists and three PhD students from USP and two scientists and two PhD students from TUDELFT, and several mutual visits are planned.

Second case

The second case regarded the validation of the microwave tomographic approaches jointly developed by CNR and USP for forensics purposes. The experiment was concerned with the monitoring of the decomposition of a buried organic target (a pig taken as a human being simulant). The target was buried on December 18th, 2012 at the USP campus in Pirassununga (SP). GPR data have been collected at different times, with the aim to evaluate the application of the qualitative inversion through microwave tomography for monitoring of a decomposing target. This campus was

chosen for the experiment because there was already an area available to bury an animal, avoiding the bureaucracy for environmental care necessary to develop this kind of experiment in the USP campus in São Paulo (SP). For this experiment a pig (*Sus scrofa*) with mass comparable to that of an average human (about 70 to 80 kg) was buried. The animal was chosen due to similarities in its decomposition process and the decomposition process of a human being, according to biochemical analyses.
Several GPR measurement surveys were performed at different times and the microwave data processing had the aim of achieving a qualitative analysis in order to detect and estimate the shape/extent of the grave and the buried pig. The microwave tomography also allowed locating the grave itself, due to an improvement on the visualization of the clutter caused by soil disturbances
The scientific outcomes of these investigations have been published in

E. R. Almeida, E.R., I. Catapano, J.L. Porsani, F. Sodovieri, "Ground Penetrating Radar and microwave tomography for forensic imaging", International Workshop on Forensic Science and Archaeology 2013. November 22-23, 2013, Rome, Italy.

E. R. Almeida, J. Porsani, I. Catapano, G. Gennarelli, and F. Soldovieri, "GPR data analysis enhanced by microwave tomography for forensic archaeology," Proc. of 15th International Conference on Ground Penetrating Radar GPR 2014, June 30-July 4, 2014.

A scientific paper is going to be submitted on the first days of December 2014 in order to present a comprehensive performance analysis of the microwave tomography applied to the data acquired over a decomposing organic target.

Third case

A novel strategy based on the linear inversion (imaging) approach has been implemented in order to perform the data processing of GPR data collected in controlled conditions at USP laboratories for studies concerning the possibility to detect and monitor oil spilling in subsurface. The scientific outcomes have been published in the journal papers

Bertolla, L., Porsani, J.L., Soldovieri, F., Catapano, I., "GPR-4D monitoring a controlled LNAPL spill in a masonry tank at USP, Brazil", Journal of Applied Geophysics, vol.103, pp .237 – 244, 2014.

Catapano, I., Affinito, A., Bertolla, L., Porsani, J.L.,Soldovieri, F., "Oil spill monitoring via microwave tomography enhanced GPR surveys", Journal of Applied Geophysics, vol.108, pp. 95-103, 2014.
Catapano I., Bertolla L., Porsani J.L., Soldovieri F, "Pipelines Monitoring Via Microwave Tomography Enhanced GPR Surveys", solicited for the oral presentation at Seventeenth International Water Technology Conference (IWTC- XVII), 5-7 November 2013, Istanbul, Turkey.

WP3 Radar technologies for remote detection and registration of vital signs

During this last part of the project, WP3 has achieved the objectives and technical goals expected according to the AMISS work-plan.

Task 3.1: Analysis of bio-radar technology, achievements, and possible application areas; Design of transmitters, receivers and antennae of the

BioRascan radars that operate in the maximum range of 4-15 GHz; Elaboration and adjustment of the radar design in laboratory conditions.

After an extensive review of the relevant literature, the involved institutions have tackled the issues of BioRadar systems design and implementation in the frequency band of interest. This activity has been the subject of the secondment of Prof. Turk from YTU at BMSTU. The technical details of this activity and its outcomes are collected in deliverable D3.1 "Report on prototypes of designed bio-radars that operate in different part of the overall frequency band 4-15 GHz". Different prototypes of bioradar systems have been designed and realized at BMSTU and CNR and they are described in the papers below, which represent the main scientific outcomes of this Task:

F. Soldovieri, I. Catapano, L. Crocco, L. N. Anishchenko, S.I. Ivashov, "A feasibility study for Life Signs monitoring via a continuous wave radar", International Journal of Antennas and Propagation, Volume 2012, Article ID 420178, 5 pages, doi:10.1155/2012/420178

L. Anishchenko, S. Ivashov , I. Catapano. L. Crocco, G. Gennarelli, F. Soldovieri, "Radar for vital signs characterization: a comparison between two different frequency band systems", Proc. Of 7th International Workshop on Advanced Ground Penetrating Radar Conference, Nantes, France, July 2013.

Task 3.2: Development of approaches for bio-radar data processing and their integration in the system.

Data processing methodologies, independently developed by CNR and BMSTU during the first reporting period, have been further applied to process laboratory controlled data independently collected at both BMSTU and CNR-IREA. The observed results have demonstrated that the two independent processing tools which have been developed are suitable for integration, as they provide comparable information, which are however achieved through different elaborations, thus enabling a cross-validation processing framework.
Scientific outcomes of the activity have been the subject of the conference paper

L. Anishchenko, S. Ivashov , I. Catapano. L. Crocco, G. Gennarelli, F. Soldovieri, "Radar for vital signs characterization: a comparison between two different frequency band systems", Proc. Of 7th International Workshop on Advanced Ground Penetrating Radar Conference, Nantes, France, July 2013.

Task 3.3: Experiments with the designed radar in controlled conditions for detection of human's vital signs and his reaction to different stress factors.
This task was concerned with the assessment of the designed radar systems in controlled and real conditions and benefited of the outcome of Task 3.1 and Task 3.2. In this framework, one important step has been the work carried out during the secondment of two researchers from BMSTU at CNR-IREA. During this secondment, an extensive measurement analysis was performed thanks to the bioradar prototype developed at CNR-IREA (in cooperation with BMSTU and YTU) regarding the characterization of vital signs for biomedical applications and the study of bioradar as tool for sleep syndromes analysis. During this study, the results of the two processing methodologies developed at BMSTU and CNR were compared, by processing data collected under different observation modalities.
As another activity of the task, the effect of possible differences in the measurement protocols adopted at BMSTU and CNR-IREA have been considered. This study has

been preliminary to the adoption of the bioradar systems designed in AMISS for real applications. Scientific outcomes of this task are reported in the following papers.

L. Anishchenko, M. Alekhin, A. Tataraidze, S. Ivashov, A. Bugaev, F. Soldovieri, "Application of step-frequency radars in medicine," Proc. of SPIE 9077, Radar Sensor Technology XVIII, 90771N (May 29, 2014); doi:10.1117/12.2049523..

M.D. Alekhin, L.N. Anishchenko, A.V. Zhuravlev, S.I. Ivashov, L.S. Korostovtseva, Y.V Sviryaev, "Evaluation of sleep disordered breathing using non-contact remote bio-radiolocation method", Sleep Medicine. 2013. Vol. 14, Suppl. 1. pp. e58. http://www.sleep-journal.com/article/S1389-9457(13)01320-8/pdf

M.D. Alekhin, L.N. Anishchenko, A. Tataraidze, S. Ivashov, V. Parashin, L. Korostovtseva, Y. Sviryaev, A. Bogomolov, "A Novel Method for Recognition of Bioradiolocation Signal Breathing Patterns for Noncontact Screening of Sleep Apnea Syndrome," International Journal of Antennas and Propagation, vol. 2013, Article ID 969603, 8 pages, 2013. doi:10.1155/2013/969603, http://www.hindawi.com/journals/ijap/2013/969603/

Tataraidze A., L. Anishchenko, M. Alekhin, L. Korostovtseva, Y. Sviryaev, "Estimation of respiratory rhythm during night sleep using a bio-radar," Proc. of SPIE 9077, Radar Sensor Technology XVIII, 90770Z (May 29, 2014); doi:10.1117/12.2049519.

M.D. Alekhin, L.N. Anishchenko, A. Tataraidze, S. Ivashov, V. Parashin, A. Dyachenko, "Comparison of Bioradiolocation and Respiratory Plethysmography Signals in Time and Frequency Domains on the Base of Cross-Correlation and Spectral Analysis," International Journal of Antennas and Propagation, vol. 2013, Article ID 410692, 6 pages, 2013, doi:10.1155/2013/410692, http://www.hindawi.com/journals/ijap/2013/410692/

M. Alekhin, L. Anishchenko, A.Tataraidze, S. Ivashov, L. Korostovtseva, Y. Sviryaev, and A. Bogomolov. "Selection of Wavelet Transform and Neural Network Parameters for Classification of Breathing Patterns of Bio-radiolocation Signals" Biomedical Informatics and Technology (T.D. Pham et al. (Eds.): ACBIT 2013, CCIS 404, pp. 175-178. Springer, Heidelberg (2013). http://link.springer.com/chapter/10.1007/978-3-642-54121-6_15

A. PROJECT ACHIEVEMENTS

Scientific highlights and research achievements

According to the activities reported in Section1, the main scientific highlights and research achievements are described for each technical WP in the following.

WP1 Microwave and Millimetre wave imaging systems for security

- Development and performance analysis of a novel 2.5D ARM algorithm for fast and reliable analysis of parabolic reflector antennas at millimetre frequencies (YTU).
- Design, realization and validation of a novel ultra-wide band Vivaldi shaped TEM fed dielectric loaded ridged horn and integration as antenna head of the Ground Penetrating Impulse Radar designed by IRE (YTU-IRE).

- Design of a novel compact UWB antenna called “partial dielectric loaded ridged horn” for ultra-wide band (UWB) microwave through-wall imaging system available at BMSTU (YTU-BMSTU).
- Development and performance analysis of an adaptive UWB SAR algorithm and TWI SAR laboratory test measurements for human-like targets at the distance of 2-3 meters from the radar platform (YTU-BMSTU).
- Design and realization of a fully holographic system (hardware + software) for concealed targets detection. The system has been extended also to the case of buried target detection (YTU-BMSTU).
- Development of a 3-Dimensional Analytical Regularization Method (ARM) to perform fast and accurate design and analysis of waveguide array feeder of a parabolic reflector for radiometric passive millimetre wave imaging systems at SRC (YTU-SRC).
- System design knowledge of 35 GHz passive radiometric imaging system and its sub-modules (i.e. antennas, receiver and image processing) were transferred from SRC to YTU.
- Performance analysis of the two radiometric passive imaging systems available at SRC (33 GHz and 94 GHz) thanks to the data processing developed at CNR.

WP2 Development of GPR technologies for subsurface sensing and critical infrastructure monitoring

- Integration of the dielectric loaded compact ridged horn antenna, reflector antenna in the GPR prototype available at IRE and successful validation of the integrated GPR system under a Forward Looking GPR configuration. (YTU-IRE).
- Design, manufacturing and testing of a new digital delay line with low jitter and extended range. Moreover, the stability performance of the system sampling has been improved (IRE-YTU).
- 3 GHz impulse generator based on RF switch-transistor (2N2222 model switch-transistor) has been designed and realized by YTU group in cooperation with IRE. Tests and measurements have been done successfully at YTU Microwave Laboratory (YTU-IRE).
- Design realization and preliminary testing of two low-cost high voltage impulse generators for GPR (YTU-IRE).
- Improvement of the differential transmitting and receiving antenna system for GPR. The Transmitting/Receiving antenna decoupling exceeds up to – 65 dB over the operating frequency band of 0.8÷1.6 GHz (IRE-YTU).
- Development, performance analysis and validation of microwave tomographic approach for GPR data processing under the differential configuration in 2D and 3D geometry (CNR-IRE).
- Validation of a novel data processing for holographic GPR in controlled and real conditions (CNR-BMSTU).
- Improvement of 2D modelling with possibility to include frequency dependent loss models (TUDELFT, USP).
- Development of modelling VRP data from surface reflection data (TUDELFT).
- Improvement of 2D linear inverse scattering approaches in view of their application in real situations (CNR).
- Development, performance analysis and validation of microwave tomographic approach for GPR data processing under the reflection configuration (CNR-IRE) in 3D geometry
- Development of a novel approach based on the use of a periodic lattice to

improve the performances of a microwave tomographic approach in terms of resolution limits (CNR).

- Development, performance analysis and validation of full inverse scattering approach in 1D geometry for quantitative estimation from GPR traces (USP-CNR).
- Development and performance analysis of data-driven 2D and 3D full waveform inversion schemes based on three linear steps (TUDELFT).
- Development and performance analysis of a full waveform inversion scheme based on three linear steps (TUDELFT).
- Validation of linear and non-linear inversion approaches thanks to experimental data collected in controlled and real situations (USP-CNR-TUDELFT).

WP3 Radar technologies for remote detection and registration of vital signs

- Design and realization of three bioradar prototypes. In particular, two systems have been realised at BMSTU working in two different frequency bands, centred at 4 and 15 GHz, respectively. The third system has been realized at CNR and operates in a lower band as compared to the ones of BMSTU, i.e., at about 2 GHz (CNR- BMSTU-YTU).
- Development of specific data processing developed by BMSTU and CNR. The different data processing codes have been compared by means of the validation via experimental data collected at the two institutions. Moreover, the path for their integration has been traced, as they provide different, and complementary ways, to process the radar traces (BMSTU-CNR).
- Extensive analysis of the performance of the bioradar systems. In particular, potential of the device for medical applications has been investigated, with a focus on the monitoring of patients for sleep syndromes analysis (BMSTU-CNR).
- Definition of measurement protocols and processing strategies for medical applications (BMSTU-CNR).

Teaching and Training activities (workshops…)

This action was in charge of all WP-Leaders with the help of the partners.

The transfer of knowledge is below detailed for the technical WPs.

WP1 Microwave and Millimetre wave imaging systems for security

A fruitful cooperation was carried out between **CNR and SRC** for the development of the passive radiometric systems. In particular, the information exchange regarded the design of the radiometric systems and the integration of the data processing developed by CNR. Training was given by Prof. Alex Denisov at CNR on the design and performance analysis of radiometric systems. In particular, Prof. Denisov gave the seminar “Radiometric systems for security and surveillance”, attended by more than 20 students and researchers.

A transfer of knowledge activity occurred between **YTU and BMSTU** about the development and improved design of holographic GPR at BMSTU for its adaptation and UWB development of a TWI SAR system at YTU.

The other transfer of knowledge activity carried out between **YTU and SRC** concerned the antenna and sub-modules designs for radiometric passive millimeter wave imaging system, to be exploited for a possible EU-Horizon 2020-Security coastal surveillance project. During his secondment at SRC, Prof. Turk was trained on 35 GHz and 94 GHz passive millimetre wave imaging systems designed by SRC. Training was given by Prof. Turk on the design of UWB antennas and a reflector antenna design was proposed by Prof. Turk. During the secondments at SRC, ESR Senturk, Keskin, Caliskan were trained on millimeter wave imaging systems design and implementation. They also discussed with Prof Denisov a novel switchable reflector antenna design and fast 2.5D numerical EM analysis approach developed at YTU.

IRE has shared with YTU the knowledge and expertise concerned with the design and realization of high voltage short impulse generators with an avalanche transistor. IRE gained a significant knowledge from YTU about the design and performances of the dielectric loaded compact ridged horn antenna and reflector antenna.

WP2 Development of GPR technologies for subsurface sensing and critical infrastructure monitoring

CNR had a positive information exchange with IRE regarding the design, the realization and the validation of differential GPR systems. CNR and IRE have complementarity expertise. In fact, IRE has a significant background in the design and manufacturing of GPR systems, whereas CNR has an assessed know-how in the development, performance analysis and validation of advanced data processing based on microwave tomography. In particular, IRE and CNR have carried out a numerical validation activity, while IRE has provided CNR with experimental GPR data collected using differential antenna system, for future data processing using tomography approach.
Training was given by Prof. Gennadiy Pochanin at CNR about the design and manufacturing of GPR systems with a focus on differential antenna systems. A seminar “Recent advances on radar systems at Institute for Radiophysics and Electronics of the National Academy of Science of Ukraine’” was given by G. Pochanin and the seminar was attended by more than 20 students and PhD students. During her two secondments at CNR, Dr. Varianytsia-Roshchupkina of IRE was trained on the topic of inverse scattering approaches for GPR data processing. In particular, under the guide of Dr. Soldovieri, Dr. Varianytsia-Roshchupkina was able to implement 2D and 3D inverse scattering codes for differential GPR data processing.

CNR has established a significant cooperation with the USP concerned with the validation of inverse scattering approaches in controlled and real conditions. In fact, USP has a significant expertise in the GPR measurements and surveys in controlled and real conditions also thanks to a large availability of facilities and instrumentations. As said above, CNR has a significant expertise in GPR data processing; therefore, the cooperation has mainly regarded the assessment of the approaches designed by CNR with real data collected at USP.
During his secondment, Dr. Emerson Almeida was trained under the guide of Dr. Soldovieri in the topics regarding the development of microwave tomographic approach and non-linear inverse scattering approaches for soil electromagnetic characterization starting by GPR data. During AMISS project, Dr. Soldovieri was appointed co-advisor of the PhD thesis of Dr. Almeida.
During his secondment at CNR, Prof. Porsani has presented an analysis of the

results of the forward GPR models and the measurements collected at the test site of IAP/USP.

By following the cooperation of the first reporting period (with the secondments of Dr. Anishchenko and Prof. Ivashov at CNR), **CNR and BMSTU** continued the cooperation on the topics of data processing for the holographic radar system of BMSTU. In particular, during her secondment at BMSTU, Dr. Ilaria Catapano has been trained on the advanced data processing for radar systems with a focus on security and safety. At the same time, Dr. Ilaria Catapano trained on inverse scattering methods by giving a seminar entitled “Microwave tomography for radar imaging”.

TUD and USP have exchanged knowledge on data collection, modelling, processing, and imaging/inversion of modelled and measured data. During his secondment at TUD Renato Prado has presented his method of coda-wave interferometry to detect small changes in subsurface conditions over time and to characterize these changes in terms of moisture content variation. TUD has presented a 2D modelling code that was adapted to include frequency-dependent loss models. This has led to a joint publication. Knowledge transfer has taken place by a one-week full-time course on modern modelling, imaging, and inversion methods given by Slob at USP to graduate students and faculty members. Slob gave a seminar on “Imaging and inversion of GPR data”. He was panel member in a round-table discussion on trends and future needs of applied geophysics research on the occasion of the 40th anniversary of the graduate school of the Institute of Applied Geophysics of USP. Slob also shared his imaging algorithm where measurement surface topography is taken into account.

A fruitful cooperation was established between YTU and IRE. During his visit at YTU, G. Pochanin presented achievements of IRE in radiophysics and electronics and shared their experience how to enlarge power budget of GPR and provide more accurate radar measurements. During discussions between G. Pochanin, V. Ruban and A.Turk at the IRE about how to improve GPR performances, they have found out the new way to design the digital delay line with extended range of delays. This idea was implemented in GPR developed at the IRE and tested during the secondment of G.Pochanin, V.Ruban and L. Varianytsia-Roshchupkina at YTU on September, 2014.

WP3 Radar technologies for remote detection and registration of vital signs

The interaction between **BMSTU and YTU** on prototypes design and the one between **CNR and BMSTU** on processing methods have been the framework for a fruitful mutual transfer of knowledge and training on respective expertise.

During the visits of BMSTU researchers at CNR, several seminars and talks have been held in order to illustrate the available expertise and facilities not only with respect to AMISS activities (which have been the focus in any case), but also on a broader perspective. This has indeed suggested further topics and future cooperation. Finally, also in the framework of the above mentioned visits, new possible applications of bioradar have been devised, such as for instance adoption of radar systems for hematoma detection and imaging.
These topics have been further explored during the secondment of Italian researchers (Dr. Catapano and Dr. Scapaticci) at BMSTU. During this visit, the two Italian researchers were further trained on the bioradar systems developed at BMSTU, and took part to some laboratory activities concerned with this system.

Moreover, to explore further possibilities of cooperation in the framework of medical applications of microwaves, Dr. Scapaticci has given a seminar entitled “New methodologies and applications for microwave imaging in biomedical field”, which has outlined the current research activities carried out at CNR relevant to this topic, and their perspectives.

Dissemination of results (conferences, publications…)

The dissemination of the results is concerned with participation to the conferences and publication of the paper related to the project’s scientific outcomes.

In the following, we report only the journal papers and conference proceedings/presentation that include the explicit acknowledgments to AMISS project. Of course, these documents are not fully exhaustive of the dissemination of AMISS activities, which were the subject of many other papers and presentations.

Journal Papers and Book Chapters

1. F. Soldovieri, E. Utsi, R. Persico, and A.M: Alani, "Imaging of Scarce Archaeological Remains using Microwave Tomographic Depictions of Ground Penetrating Radar Data”, International Journal of Antennas and Propagation, Volume 2012, Article ID 580454, 8 pages, doi:10.1155/2012/580454.

2. F. Soldovieri, I. Catapano, L. Crocco, L. N. Anishchenko, S.I. Ivashov, “A feasibility study for Life Signs monitoring via a continuous wave radar”, International Journal of Antennas and Propagation, Volume 2012, Article ID 420178, 5 pages, doi:10.1155/2012/420178.

3. O. M. Yucedag, A.S. Turk, “Parametric Design of Open Ended Waveguide Array Feeder with Reflector Antenna for Switchable Cosecant-Squared Pattern”, ACES JOURNAL, VOL. 27, NO. 8, pp. 668-675, AUGUST 2012.

4. M.D. Alekhin, L.N. Anishchenko, A.V. Zhuravlev, S.I. Ivashov, L.S. Korostovtseva, Y.V Sviryaev. Evaluation of sleep disordered breathing using non-contact remote bio-radiolocation method. Sleep Medicine. 2013. Vol. 14., Suppl. 1. P. e58. http://www.sleep-journal.com/article/S1389-9457(13)01320-8/pdf

5. M.D. Alekhin, L.N. Anishchenko, A. Tataraidze, S. Ivashov, V. Parashin, L. Korostovtseva, Y. Sviryaev, A. Bogomolov., "A Novel Method for Recognition of Bioradiolocation Signal Breathing Patterns for Noncontact Screening of Sleep Apnea Syndrome," International Journal of Antennas and Propagation, vol. 2013, Article ID 969603, 8 pages, 2013. doi:10.1155/2013/969603, http://www.hindawi.com/journals/ijap/2013/969603/

6. M.D. Alekhin, L.N. Anishchenko, A. Tataraidze, S. Ivashov, V. Parashin, A. Dyachenko, "Comparison of Bioradiolocation and Respiratory Plethysmography Signals in Time and Frequency Domains on the Base of Cross-Correlation and Spectral Analysis," International Journal of Antennas and Propagation, vol. 2013, Article ID 410692, 6 pages, 2013, doi:10.1155/2013/410692, http://www.hindawi.com/journals/ijap/2013/410692/

7. F. Soldovieri, A. Natale, V. Gorishnyak, A. Pavluchenko, A. Denisov, L. Chen, “Radiometric Imaging for Monitoring and Surveillance Issues,” International Journal of Antennas and Propagation, vol. 2013, Article ID 272561, 8 pages, 2013.

doi:10.1155/2013/272561

8. M.D. Alekhin, L.N. Anishchenko, A.V. Zhuravlev, S.I. Ivashov, L.S. Korostovtseva, Y.V. Sviryaev, A.O. Konradi, V.B. Parashin, A.V. Bogomolov, “Estimation of Information Value of Diagnostic Data Obtained by Bioradiolocation Pneumography in Non-contact Screening of Sleep Apnea Syndrome”, Biomedical Engineering, Vol. 47, No. 2, July, 2013, pp. 96-99. Translated from Meditsinskaya Tekhnika, Vol. 47, No. 2, Mar.-Apr., 2013, pp. 36-38.

9. Catapano I, Affinito A., Gennarelli G., di Maio F., Loperte A., Soldovieri F., “Full three-dimensional imaging via ground penetrating radar: assessment in controlled conditions and on field for archaeological prospecting”, Applied Physics A, vol. 115, pp. 1415-1422, 2014

10. G. Gennarelli, R. Persico, F. Soldovieri. “Effective imaging systems based on periodic lattices.” Applied Physics Letters, vol. 104.19 (2014): 194103.

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Persico R., Pochanin G., Ruban V., Orlenko A., Catapano I., and Soldovieri F. High decoupled antenna and microwave tomography in GPR. (Under resubmission)

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Conference Proceedings and Abstracts

1. I. Catapano, M. Bavusi, A. Loperte, L. Crocco, and F. Soldovieri, “On the combined use of radar systems for multi-scale imaging of transport infrastructures”,

European Geophysical Union General Assembly 2012, April 2012, (ORAL PRESENTATION)

2. F. Soldovieri, “AMISS - Active and passive MIcrowaves for Security and Subsurface imaging”, in Abstract Booklet of People 2012 Conference, Nicosia, Cyprus, Nov. 2012, ISBN 978-9963-700-55-4, (POSTER PRESENTATION)

3. L.N. Anishchenko, S.I. Ivashov, F. Soldovieri, I. Catapano, L. Crocco, “COMPARISON STUDY OF TWO APPROACHES FOR BIORADAR DATA PROCESSING”, IET Radar Conference 2013, Xi'an, China, April 2013 (POSTER PRESENTATION).

4. L. Crocco, E. Slob, A.S. Turk, I. Catapano, F.Soldovieri, “Active and Passive Microwaves for Security and Subsurface Imaging (AMISS)” in CONFERENCE PROCEEDINGS PEOPLE 2012 Marie Sk#odowska-Curie Actions In Horizon 2020, pp. 56-65, CYPRUS, 5-6 November 2012, ISBN 78-9963-700-62-2.

5. I. Catapano, L. Crocco, F. Di Matteo, A.S. Turk, E. Slob, F. Soldovieri and the AMISS Team, “AMISS - Active and passive Microwaves for Security and Subsurface imaging”, abstract in Proceedings of European Geophysical Union General Assembly 2013, Wien, Austria, April 2013 (POSTER PRESENTATION).

6. I.Catapano, L. Crocco, A. Affinito, G. Gennarelli, and F. Soldovieri “Monitoring by holographic radar systems”, abstract in Proceedings of European Geophysical Union General Assembly 2013, Wien, Austria, April 2013 (EGU2013-12450) (POSTER PRESENTATION).

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8. E. Slob, “Non-destructive monitoring of layered infrastructure using GPR data”, abstract in Proceedings of European Geophysical Union General Assembly 2013, Wien, Austria, April 2013 (ORAL PRESENTATION).

9. I. Catapano, L. Crocco, A. Affinito, G. Gennarelli, V. Razevig, I. A. Vasiliev, S. I. Ivashov, F. Soldovieri, “On the Holographic Radar as A Tool for structural monitoring”, Proceedings of 4th Workshop on Cultural and Natural Heritage, 6-7 June 2013 - Matera, Italy, (POSTER PRESENTATION).

10. Slob E. and K. Wapenaar, “GPR wave field decomposition, synthesis, and imaging for lossless layered vertically transverse isotropic media”, Proceedings of the International Workshop on Advanced Ground-Penetrating Radar (IWAGPR2013), pp. 21-26. Nantes, France, July 2-5, 2013.

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15. M.D. Alekhin, L.N. Anishchenko, A.V. Zhuravlev, A.B. Tataraidze, V.V. Razevig, I.A. Vasilyev, V.B. Parashin, S.I. Ivashov, A.S. Bugaev, "Verification of Bio-radiolocation Method with Respiratory Plethysmography for Non-contact Remote Breathing Monitoring", (Paper #1012 –ORAL PRESENTATION at Session EuMC38), European Microwave Conference, October 2013.

16. Alekhin M.D., Anishchenko L.N., Zhuravlev A.V., Ivashov S.I., Korostovtseva L.A., Sviryaev Y.V Evaluation of sleep disordered breathing using non-contact remote bio-radiolocation method(Paper #1458 – ORAL PRESENTATION at Session Technical) - World Congress on Sleep Medicine 2013.

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18. I. Catapano, L. Bertolla, J. L. Porsani and F. Soldovieri,, "PIPELINES MONITORING VIA MICROWAVE TOMOGRAPHY ENHANCED GPR SURVEYS", solicited for the oral presentation at Seventeenth International Water Technology Conference (IWTC- XVII), 5-7 November 2013, Istanbul, Turkey.

19. G.P. Pochanin, V.P. Ruban, P.V. Kholod, A.A. Shuba, A.G. Pochanin, A.A Orlenko "Enlarging of power budget of ultrawideband radar", Proc. of the 6th International Conference on "Recent Advances in Space Technologies-RAST2013" June 12 14, 2013. Istanbul (Turkey). pp. 213-216.

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21. Slob, E., "High-resolution imaging and inversion of 3D GPR data for layered media", poster presentation at the EGU General Assembly, Vienna, April 7-12, 2013.

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28. Ruban V.P., Shuba O.O., Pochanin O.G., Pochanin G.P., Turk A.S., Keskin, A.K., Dagcan S.M., Caliskan A.T. “Analog Signal Processing for UWB Sounding”, Proc. of 7th International Conference on Ultra Wideband and Ultra Short Impulse Signals (UWBUSIS), pp. 55-58, September 15-19, 2014, Kharkiv, Ukraine.

29. Varianytsia-Roshchupkina L.A., Gennarelli G., Soldovieri F., “Comparison of Two Differential GPR Systems for Imaging Objects under a Reflection Configuration” Proc. of 15th International Radar Symposium, Gdansk, Poland, June 16-18, 2014.

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31. R. Persico, F. Soldovieri, I. Catapano, G. Pochanin, V. Ruban, O. Orlenko, “Experimental results of a microwave tomography approach applied to a differential measurement configuration”, Proc. of 7th International Workshop on Advanced Ground Penetrating Radar (IWAGPR 2013) , pp. 65-69, Nantes, France, July 2013.

32. E Almeida, J. Porsani, I. Catapano, G. Gennarelli, and F. Soldovieri, “GPR data analysis enhanced by microwave tomography for forensic archaeology,” Proc. of 15th International Conference on Ground Penetrating Radar GPR 2014, June 30-July 4, 2014.

33. F. Soldovieri, “Microwave tomography for radar imaging: status and perspectives,” Plenary talk at 15th International Conference on Ground Penetrating Radar GPR 2014, June 30-July 4, 2014.

34. Slob, E., J. Hünziker, J. Torbecke, and K. Wapneaar, “Creating virtual vertical radar profiles from surface reflection Ground Penetrating Radar data”, Proceedings of the 15th International Conference on GPR2014, Bruxelles, Belgium, June 30-July 4, 2014.

35. R. Prado, E Slob, R.M. Mendes, “Geophysical support for the assessment/monitoring of partially saturated soils on land susceptible to shallow landslides”, Near surface geophysics applied to exploration, engineering and

environmental studies SEG/SGBf Workshop - Salvador -Brasil - 3-4 Dec 2014

EGU GA is the largest Conference in the fields of the geophysical science and it is a good platform for the dissemination of scientific activities.

IWAGPR is one of the most impotent conferences dealing with GPR scientific technological advances, which is held whit a biennial timeline. IWTC represents a good dissemination opportunity of the AMISS outcomes in the field of water monitoring and protection at Mediterranean Countries (Egypt, Turkey, Algeria,..)

15th International Conference on Ground Penetrating Radar GPR 2014 is the worldwide conference on the Ground Penetrating radar. F. Soldovieri, coordinator of AMISS, was invited to give a plenary talk about the data processing for radar imaging. This presentation was quoted as an AMISS dissemination activity.

SESSIONS
In the frame of AMISS activities, Francesco Soldovieri (CNR) has organized and convened two sessions at the European Geophysical Union General Assembly 2013.

From Artefact to Historical Site: Geoscience and Non-Invasive Methods for the Study and Conservation of Cultural Heritage, Conveners: Nicola Masini, Monica Alvarez de Buergo , Lev Eppelbaum, and Francesco Soldovieri.

Electromagnetic sensing techniques and geophysical methods for critical and transport infrastructures monitoring and diagnostics. Conveners: Jean Dumoulin, Francesco Soldovieri, Lorenzo Bigagli, Sven Nordebo.

In these two sessions, the presentations of four works related to AMISS activities were given.

AWARD
The paper L.N. Anishchenko, S.I. Ivashov, F. Soldovieri, I. Catapano, L. Crocco, “COMPARISON STUDY OF TWO APPROACHES FOR BIORADAR DATA PROCESSING”, has been awarded as the Best Poster at IET International Radar Conference 2013, Xi'an, China, April 2013 .

Invited presentation

F. Soldovieri, “Microwave tomography for radar imaging: status and perspectives,” Plenary talk at 15th International Conference on Ground Penetrating Radar GPR 2014, June 30-July 4, 2014

Catapano I., Bertolla L., Porsani J.L., Soldovieri F, “Pipelines Monitoring Via Microwave Tomography Enhanced GPR Surveys”, invited for the oral presentation at Seventeenth International Water Technology Conference (IWTC- XVII), 5-7 November 2013, Istanbul, Turkey.

Pochanin G.P., Ruban V.P., Kholod P.V., Shuba O.A., Pochanina I.Ye., Batrakova A.G., Urdzik S.N., Batrakov D.O., Golovin D.V. “Advances in Ground Penetrating Radars for Road Surveying” 7th International Conference on “Ultra Wideband and Ultra Short Impulse Signals” September 15-19, 2014, Kharkiv, Ukraine .

Special issues
F. Soldovieri has been Editor of two Special Issues on International Journal of

Antennas and Propagation (http://www.hindawi.com/journals/ijap/), an open-access journal, regarding the topics of AMISS and where several AMISS papers have been published.

- R. Pierri, J.C: Bolomey, Q:H: Liu, and F. Soldovieri, “Inverse Scattering and Microwave Tomography in Safety, Security, and Health,” International Journal of Antennas and Propagation, vol. 2013, Article ID 589598, 2 pages, 2013. doi:10.1155/2013/589598

- D. Erricolo, F. Soldovieri, and W.C. Chew, “Propagation Models and Inversion Approaches for Subsurface and Through-Wall Imaging,” International Journal of Antennas and Propagation, vol. 2012, Article ID 821263, 2 pages, 2012. doi:10.1155/2012/821263

The project AMISS has been quoted in the article “Special report Microwaves in Europe: Winning ways” on Microwave Journal, vol. 55, no.9, pp. 86-102,September 2012.

The text is below reported.
“As its title suggests, the results of the Active and Passive Microwaves for Security and Subsurface imaging (AMISS) project will be two-fold – ground penetrating radar for subsurface sensing and critical infrastructure diagnostics and passive and active microwave imaging systems for security applications. The proposal is for two lines of research. The first is concerned with the development, characterization and performance evaluation of new systems, sensors and configurations able to mitigate the clutter, and increase information content and redundancy, for both passive and active microwave imaging, while the second considers the development, implementation and performance evaluation of processing tools.”

Other seminars
A cycle of two seminars of Prof. Moeness Amin was held at IREA-CNR on May 2014, under the AMISS framework. Moeness Amin is a IEEE Fellow and has a very significant expertise in radar imaging. The two seminars were entitled “Compressive Sensing for Urban Radar” and “MULTI-FREQUENCY CO-PRIME ARRAYS FOR DOA ESTIMATION”.

B. PROJECT MANAGEMENT

Management activities were carried out without any significant problem, with the collaboration of all partners. Management activities were aimed at ensuring the execution of all the planned activities and the timely achievement of the expected products.
About the first reporting period, the financial reporting was submitted on time by the Coordinator to the REA on EC Participant Portal in complying with the FP7 reporting rules. The paper C forms were collected and promptly provided to the REA. The first periodic report was submitted on time by the Coordinator on EC Participant Portal in complying with the FP7 reporting rules.
The financial reporting was submitted on time by the Coordinator to the REA on EC Participant Portal in complying with the FP7 reporting rules

A new secondment plan has been agreed among the partners and submitted to the REA. This updating was carried out in order to enhance the scientific/technical content of the project, by profiting of the new opportunities arisen during the

activities, and to recover the secondment situation of the first reporting period. All partners produced a letter stating their agreement about the AMISS secondment updating. The letters stating the transferring of the secondments between the partners have been submitted to the REA. REA agreed with this updated secondment plan. The secondments have been carried out according to this plan.

All the partners provided the administrative support in order to facilitate the feasibility of the secondments, with reference to the VISAs, the invitation procedure, the staying of the seconded persons.

Frequent communications between the Coordinator and the partners were exchanged aimed at a constant monitoring of the project activities.

A continuous flow of information has been activated between the AMISS management and the Project Officer with the main aim to have clear information about mobility modalities in response to the issues raised by the partners.

Project results have been disseminated through the project website and in several international conferences and workshops. Also some results have been published in international peer reviewed journals.

The list of publications referred to the AMISS project have been uploaded on the EC participant portal. The continuous updating of the website in ensured according to the information provided by all the partners.

As last activity of the management, the second periodic and the final reports have been delivered by the Coordinator on EC Participant Portal in complying with the FP7 reporting rules REA. The financial reporting has been submitted by the Coordinator to the REA on EC Participant Portal in complying with the FP7 reporting rules and an adjustment has been provided for the first reporting period, as requested by REA.
The paper C forms have been collected and promptly provided to REA.

C. ADDITIONAL INFORMATION

The effectiveness of the cooperation under AMISS framework is testified by the Memorandum of Understanding and Cooperation setup between the Institute for Electromagnetic Sensing of the Environment of CNR separately with USIKOV INSTITUTE FOR RADIOPHYSICS AND ELECTRONICS (IRE) and Instituto de Astronomia, Geofísica e Ciências Atmosféricas of University of Sao Paulo.

The cooperation between CNR and SRC has activated, thanks to the cooperation of SRC with Chinese entities, a cooperation of CNR with Department of Microwave Engineering in Harbin Institute of Technology and the company SWIEE – South West Institute of Electronic Equipment (a leader company for aerospace and security in China).

We want to stress the fact that several of the partners involved in AMISS are also partners of the COST Action TU1208 “Civil Engineering Applications of Ground Penetrating Radar”. This represents a good opportunity to continue the cooperation beyond AMISS’s life. In addition, the assessed cooperation among AMISS partners can be important in view of the project opportunities offered in Horizon 2020.

CNR researchers are also actively involved in COST action TD1301 “MiMed”. Such a trans-domain action is specifically aimed to accelerate the development of diagnostics devices exploiting microwave frequencies. As mentioned above, this is a topic relevant to the activities in WP3, namely the bioradar systems for vital signs detection and monitoring. Accordingly, in the framework of the second meeting of TD3101 cost action, held in Prague (CZ) on 11-13 September 2014, Lorenzo Crocco has organized a special workshop devoted to bio-radiolocation in which Prof. Ivashov and Dr. Anishchenko have been invited as guest speakers, to present their activities and results, also achieved in the framework of AMISS WP3. Following this meeting, Russian colleagues have started the formal procedures to enrol Russia as an IPC country for the Action.

Finally, the promising results obtained and the huge relevance covered by the vital signs monitoring in the field of health care and medical applications, motivated CNR and BMSTU researchers to pursue their cooperation on this topic beyond the AMISS project. Accordingly, during the visit of Dr. Catapano and Dr. Scapaticci at RSLab an application for a new project in the frame of the bilateral agreement between CNR and Russian researcher centers has been prepared and, later, submitted. The proposal takes its move from the work done in the AMISS project and it is entitled ‘Bioradar Systems for life signs monitoring in medicine: prototypes development and feasibility assessment in controlled and real conditions’. This proposal is devoted to address scientific challenges towards the real applicability of BioRadars in the clinical practice.

The promising results obtained between TUD and USP has resulted in a new three-year research project entitled “Seismic and electromagnetic data inversion to enhance near surface characterization” and is financed by the Brazilian Science without Borders program. In this project Slob is a special visiting researcher and a PhD student from USP will visit TUD to perform laboratory experiments and analyse the data.

At the end of the AMISS project the IRE and YTU have expressed intention to continue cooperation for development in Turkey a GPR system based on GPR made in the IRE.