Ludwig Boltzmann Institute
Archaeological Prospection and Virtual Archaeology

ANNUAL REPORT

2012

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1. LBI ArchPro - Overview

1.1 Goals

Considering the massive threat of destruction and deterioration of buried cultural heritage and the need for efficient and reliable identification, documentation and interpretation methods, large-scale application of non-invasive archaeological prospection methods comprise a great potential. They are the most appropriate solution in order to provide archaeologists and planning authorities with the necessary spatial information for the protection and possible investigation of such threatened heritage at the appropriate scales: the archaeological site as well as the surrounding archaeological landscape.

Considering the state-of-the-art and the future demands for non-invasive professional archaeological prospection a consortium of European research institutes, heritage boards and public bodies supported by the Ludwig Boltzmann Gesellschaft (http://www.lbg.ac.at) established in 2010 the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro). The LBI ArchPro (http://archpro.lbg.ac.at) is an innovative research centre for the development and application of advanced non-destructive prospection methods. It combines latest remote sensing methods, high-resolution near surface geophysics, sophisticated computer science, geomatics and archaeology. The LBI ArchPro is dedicated to the development of new, highly efficient technologies for non-invasive data capturing, data processing, virtual reality visualization as well as the advancement of theory and methodology of archaeological prospection. An important goal of the institute is the publication and scientific and public dissemination of new developments and results obtained through the application of the research and developments through exemplary, large-scale, international archaeological case studies, addressing the professional community as well as the general public.

Even though the Valetta convention (Malta treaty), stating that non-invasive methods should be applied in archaeology wherever possible, has not been ratified by all member states of the LBI ArchPro consortium, it is regarded as the major basis and guideline for the future development of archaeological research and the LBI ArchPro research programme.

1.2 Partners

In 2012 there were no changes in the composition of the partner consortium:

- **LBG** – Ludwig Boltzmann Gesellschaft (A)
- **NoeL** – Province of Lower Austria (A)
- **NIKU** – Norsk Institut for Kulturminneforskning - The Norwegian Institute for Cultural Heritage - Archaeology Department (N)
- **RAÄ** – Riksantikvarieämbetet - UV Redaktion och Teknik (S)
- **RGZM** – Römisch Germanisches Zentralmuseum in Mainz (D)
- **VISTA** – University of Birmingham - The Visual and Spatial Technology Centre (VISTA) (GB)
- **Uni Vienna** – University of Vienna - Vienna Institute for Archaeological Science (VIAS) and Institute for Prehistory and Early Mediaeval History (UFG) (A)
- **TU Vienna** – University of Technology Vienna - Institute for Computer Graphics and Algorithms (ICG) and the Institute for Photogrammetry and Remote Sensing (IPF) (A)
- **ZAMG** – Central Institute for Meteorology and Geodynamic (A)
- **Airborne Technologies** (A)

Collaboration Partners

Collaborative agreements for scientific research tasks, dissemination and case studies exist with following organizations, institutions and SMEs:

- **Uni Lund** – University of Lund, Department of Archaeology and Ancient History: Case study Uppåkra (S)
- **EAL** – Eastern Atlas GmbH & Co. KG: Magnetic prospection (D)
- **MALÅ** – MALÅ Geoscience AB: Ground Penetrating Radar (S)
- **Vfk** – Vestfold Fylkeskommune: Case study Vestfold (N)
- **Riegl** – Riegl Laser Measurement Systems GmbH: Laser Scanning (A)
- **Pico** – Pico Envirotec Inc.: AirMagnet project (CA)
- **GeoEx** – Geo Experts Research and Planning GmbH: AirMagnet project (A)
- **Uni Bradford** – University of Bradford: Geophysics (GB)
- **ÖAW** – Austrian Academy of Sciences: Carnuntum ArchPro project (A)
- **Uni Gent** – University of Ghent: Carnuntum ArchPro project(B)
- **BOKU** – University of Natural Resources and Life Sciences, Vienna: Remote sensing (A)
- **Wikitude** – Wikitude GmbH: Augmented Reality (A)
- **Interspot** – Interspot Film GmbH: Scientific Documentaries (A)
- **HTL Steyr** – Höhere Technische Lehranstalt Steyr: Hardware development (A)
- **7reasons** – 7reasons Medien GmbH: Virtual Reconstructions (A)
- **ÖAW** – Austrian Academy of Sciences (A)

1.3 LBI ArchPro Board and Scientific Advisory Board

Members of the LBI ArchPro Board:

NoeL:	Franz Humer, Gerhard Pfahler
ZAMG:	Sirri Seren, Michael Staudinger
TU Vienna :	Norbert Pfeifer, Werner Purgathofer
Uni Vienna :	Otto H. Urban, Gerhard Trnka
ABT :	Wolfgang Grumeth, Mario Rathmanner
RGZM :	Falko Daim, Detlef Gronenborn
RAÄ :	Lars Z Larsson, Christina Klotblixt
NIKU:	Carsten Paludan-Müller, Knut Paasche
VISTA :	Vincent Gaffney, Eamonn Baldwin
LBG :	Marisa Radatz, Erich Heiss

Members of the LBI ArchPro Scientific Advisory Board:

Kay Kohlmeyer, Hochschule für Technik und Wirtschaft (HTW) Berlin (D)
Julian Richards, University of York (GB)
Joakim Goldhahn, Linnaeus University (S)
Maurizio Forte, Duke University Durham (USA)
Sarah Parcak, University of Alabama (USA)

On June 1st 2012 four members of the Scientific Board met in Vienna with the LBI ArchPro Team and M. Radatz and E. Heiss from the LBG in order to discuss the research program, progress and deliveries 2011-2012. The next Scientific Advisory Board meeting is planned for autumn 2013.

1.4 The LBI ArchPro Team

In 2012 the staff of the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology comprised the following 21 salaried employees:

- Wolfgang Neubauer (Director)
- Michael Doneus (Deputy Director/Head of Methodological Development)
- Matthias Nöster (Project Management - from June 2012 as external consultant for project management and project development)
- Elisabeth Schadek (Administration Manager)
- Christina Einwögerer (Administration Manager - joined the LBI ArchPro administration team in October 2012)
- Karolin Kastowsky-Priglinger (Head of Public Relations)
- Christian Briese (Head of Data Processing & Visualization)
- Geert Verhoeven (Head of Data Interpretation & Spatial Analysis)
- Michael Pregesbauer (Researcher/Head Data acquisition)
- Agata Klimczyk (Researcher)
- Immo Trinks (Head of Research & Development)
- Alois Hinterleitner (Head of Software Development)
- Klaus Löcker (Researcher)
- Matthias Kucera (Head of Case studies)

- Erich Nau (Researcher)
- Thomas Zitz (Head of Hardware Development)
- Nives Doneus (Head of Dissemination & Communication/Project Development)
- Vlad Sandici (Researcher)
- Georg Zotti (Researcher - joined the team in January 2012; software development for GIS-based archaeological interpretation)
- Sebastian Flöry (Researcher - joined the team in April 2012. He is working in the area of case study data acquisition and data interpretation)
- Philippe De Smedt (Researcher - joined the team in November 2012. He is working on post-processing of electromagnetic prospection data)

Staff in-kind contributions:

- Christian Gugl, contribution from ÖAW
- Camillo Ressl, contribution from Vienna University of Technology, Department of Geodesy and Geoinformation
- Rainer Schreg, contribution from RGZM
- Lars Gustavsen, contribution from NIKU
- Christer Tonning, contribution from Vfk
- Eamonn Baldwin, contribution from VISTA

Temporary staff:

- Viktor Jansa (Field Director)
- Manuel Gabler (Field Director)
- Mario Wallner (Field Director)
- Roland Filzwieser (Field Assistant)
- Jakob Kainz (Field Assistant)
- Ranko Manojlović (Field Assistant)
- Hannes Schiel (Field Assistant)
- Petra Schneidhofer (Field Assistant)
- Christopher Sevara (Field Assistant)
- Tanja Trausmuth (Field Assistant)

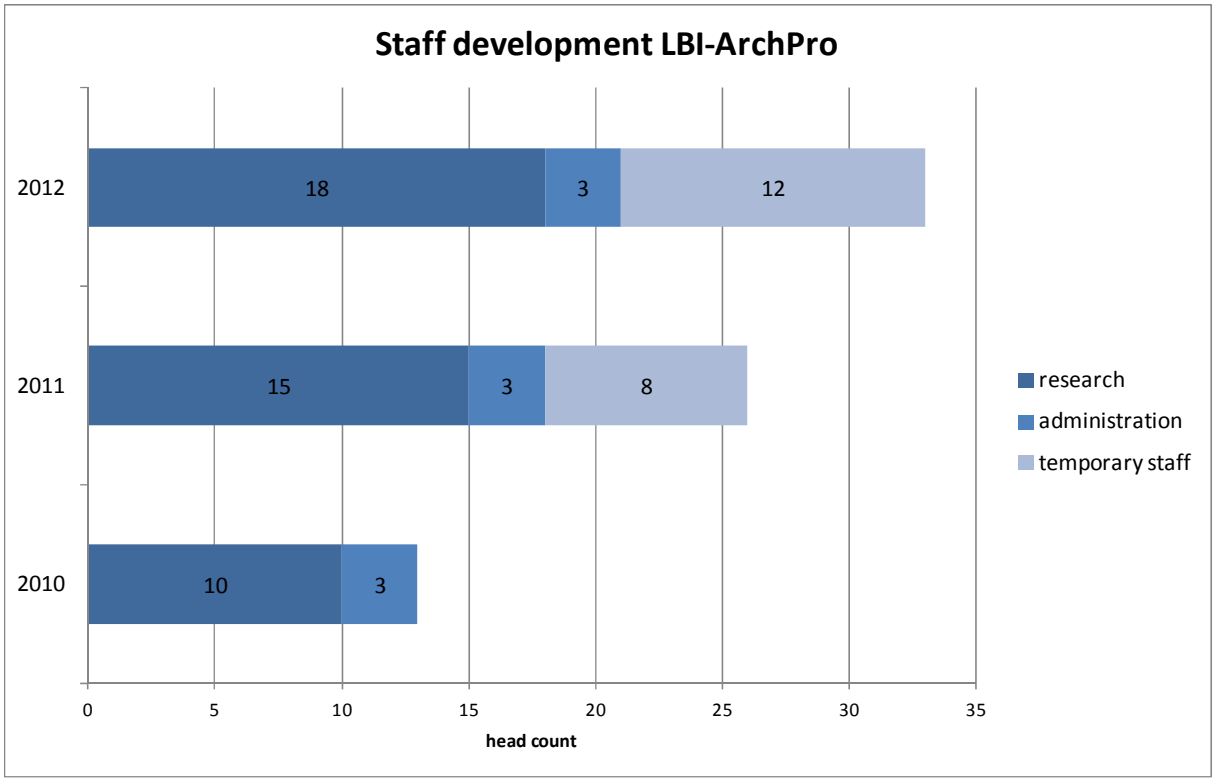
Initiative College for Archaeological Prospection (IC ArchPro)

The University of Vienna installed within the VIAS at the end of 2011 an interdisciplinary Initiative College for archaeological prospection (ic-archpro.univie.ac.at). Research fellows of the IC are working in close collaboration with the LBI ArchPro staff on the archaeological analysis of LBI ArchPro case study data and various methodological data. IC ArchPro PhD students are

- Martin Fera
- Manuel Gabler
- Jakob Kainz
- Karolin Kastowsky-Priglinger
- Michal Ruš
- Petra Schneidhofer
- Christopher Sevara
- Tomáš Tencer
- Katalin Tolnai
- Willem Vletter

IC ArchPro associated PhD research fellows

- Valeria Poscetti
- Joris Coolen
- Eamonn Baldwin
- Christine Markussen
- Agata Klimczyk
- Ulrike Fornwagner



Graph 5: Staff development 2010-2012 of the LBI ArchPro

1.5 Infrastructure

New premises in Langenzersdorf

The greatest change in terms of infrastructure was the move of the LBI ArchPro to new additional premises practically located in the Northern outskirts of Vienna, in easy reach of the main highway providing fast access to Case study sites as well as to Vienna airport. The new premises comprise an office building with about 200 m² office space and a workshop and storage area of some 400 m². The latter provides sufficient space for all LBI ArchPro measurement systems, vehicles and equipment, while the office provides workspace for permanent and temporary staff concerned with the archaeological prospection and survey equipment and data. Testing of the equipment and preparations for the case studies will become much more efficient thanks to this new location. Furthermore, the site provides space for trainings and lectures.

The building is rented and only limited adaptations had to be made in order to meet the institutes' requirements.

The new LBI ArchPro premises in Langenzersdorf with ample storage space and workshop area (left) and office space (right).

The storehouse and workshop area in the new premises offers ideal conditions for vehicle and survey instrumentation maintenance, development, adaptation and tests.

Further important investments into the LBI ArchPro infrastructure made in 2012 include:

Measuring equipment

- A 16 channel 400 MHz MALÅ Imaging Radar Array (MIRA) GPR system
- A Javad RTK-GPS System
- An Eastern Atlas Digitizer

Vehicles

- VW van for field work related transport
- VW van with integrated workshop as case study service vehicle
- Kubota Rough Terrain Vehicle for field surveys
- ATV Dinli 700 for field surveys (replacing a Blade TGB quad bike)
- ATV Dinli 800 for field surveys

IT and multi media

- Renox Mobile presentation system
- Wacom PL-2200 board
- Lynx Workstation 2600 T
- Nikon D7000 digital camera

1.6 Highlights 2012

Lange Nacht der Forschung

On April 27th 2012 the LBI ArchPro participated in the *Lange Nacht der Forschung* (Long night of science), the largest event for public communication of science in Austria. The numerous visitors were informed about the latest developments in remote sensing technology, high-resolution near surface geophysical prospection and data visualization.

The LBI ArchPro team at the Lange Nacht der Forschung (© LBI ArchPro)

Kinderuni - Kids university

At the Kinderuni Vienna 2012 (http://kinderuni.at/) the LBI ArchPro was represented with great success: over 150 children listened to a lecture on modern non-invasive approaches in archaeological research. There was a great immediate response from the audience and the "Kinderuni" assistance, resulting in the LBI ArchPro to be invited to give a lecture again in 2013.

Children listening attentively at a lecture given at the Kinderuni 2012. (© UniWien)

Outstanding paper award for the LBI ArchPro

The Society of Exploration Geophysicists has nominated the paper "*Integrated geophysical archaeological prospection resulting in the discovery of the school of gladiators in the Roman town of Carnuntum in Austria*" given at the 2012 SEG Annual Meeting in Las Vegas, Nevada, USA, amongst the top 30 papers presented at the meeting (out of a total 906 papers), strongly encouraging the presentation of the paper to the SEG's international Sections and Associated Societies.

COST Action 1208

On invitation of the organizer of the successful European COST Action (European Cooperation in Science and Technology) Transport and Urban Development TU1208 *Civil Engineering Applications of Ground Penetrating Radar (GPR),* to which the LBI ArchPro had contributed, the LBI ArchPro participates as national partner in the management committee of this action and chairs the Working Group 4 (*Different applications of GPR and other non-destructive testing technologies in civil engineering*). This participation confirms the LBI ArchPro as an important player in the field of latest large-scale, high-resolution professional GPR applications and opens new possibilities for applied European research and collaboration projects with scientific impact and of benefit for the LBI ArchPro partner organizations.

1.7 Public relations

Summary of press releases and press coverage

LBI ArchPro

- http://novine.novilist.hr/Default.asp?WCI=Rubrike&WCU=285A286028632859285A2863285A28582859285A28632897289C289728632863285E285C285C285D285D285D286328632863 28582863B
- http://spie.org/x90865.xml
- http://www.kleinezeitung.at/kaernten/klagenfurtland/3064559/erster-pfahl-weg-zum-museum.story
- http://derstandard.at/1336698203106/Geophysiker-Der-Herr-Hofrat-schaut-ins-Erdinnere
- http://www.wienerzeitung.at/themen_channel/wissen/forschung/453717_Verwirrspiel-im-Weinviertel.html?em_redirect_url=%2Fthemen_channel%2Fwzwissen%2Fforschung%2F453717_Verwirrspiel-im-Weinviertel.html
- Universum Magazin, März 2012
- http://derstandard.at/1334530900570/Wiener-Stadtteil-Archaeologische-Schaetze-in-Aspern
- http://www.servustv.com/cs/Satellite/Article/Der-Salon-am-Dienstag-011259427513017

Carnuntum, A

- http://search.salzburg.com/news/artikel.html?uri=http%3A%2F%2Fsearch.salzburg.com%2Fnews%2Fresource%2Fsn%2Fnews%2Fsn0723_07.05.2012_41-39544928
- http://www.noen.at/lokales/noe-uebersicht/bruck/aktuell/Carnuntum-1-Million-fuer-Detail-Forschung;art2674,377326
- http://www.noen.at/lokales/noe-uebersicht/bruck/aktuell/US-Archaeologen-zaehlen-Carnuntum-zu-den-Top-10;art2674,364357
- http://www.wienerzeitung.at/themen_channel/wissen/technologie/452244_Roentgenblick-in-die-Erde.html
- http://www.krone.at/Wissen/Carnuntum_wird_mit_neuem_Bodenradar_vermessen-Bis_zu_drei_Meter_tief-Story-318942
- http://noe.orf.at/news/stories/2529950/
- http://kurier.at/archiv/volltext.php?schluessel=EGEEHGWPOWPAPAGACTCTHHRE&suche=kurier&suchevonjahr=2012&suchevonmonat=06&suchevontag=03&suchebisjahr=2012&suchebismonat=06&suchebistag=10&suchseite=&offset=1380&simple=1
- http://www.noen.at/lokales/noe-uebersicht/bruck/aktuell/US-Archaeologen-zaehlen-Carnuntum-zu-den-Top-10;art2674,364357
- http://derstandard.at/1334795746415/Archaeologie-Vollstaendige-Vermessung-Carnuntums-geplant

Falkenstein, A

- http://medienportal.univie.ac.at/uniview/forschung/detailansicht/artikel/archaeologie-vergessene-klause-entdeckt/
- http://derstandard.at/1342139446433/Archaeologische-Entdeckung-in-vergessener-Klause-gemacht
- http://www.dersonntag.at/news/articles/2012/07/25/a6556/detailinfo
- http://www.meinbezirk.at/anthering/magazin/sensationsfunde-am-falkenstein-d223846.html

Vestfold, N

- http://www.niku.no/no/arkeologi/geofysiske_undersokelser/vikingtids_bybebyggelse_oppdaget_ved_gokstadhaugen/Vikingtids+bybebyggelse+oppdaget+ved+Gokstadhaugen.9UFRnWZj.ips
- http://eavis.aftenposten.no/aftenposten/87093/archive/demo/?page=12
- http://www.sb.no/nyheter/stort-vikingfunn-pa-heimdal-1.7120722
- http://www.norwaypost.no/index.php/news/latest-news/26610-new-viking-village-discovered--26610
- http://www.nrk.no/nyheter/distrikt/ostafjells/vestfold/1.8030863
- http://tb.no/kultur/stort-vikingfunn-pa-heimdal-1.7120935
- http://www.tv2.no/nyheter/innenriks/nytt-vikingfunn-i-sandefjord-minst-15-bygninger-3730996.html
- http://www.mre.no/npkdirekte/5018226.o2.html
- http://www.framtidinord.no/ntb/innenriks/article530730.ece
- http://www.vfk.no/Nyheter/2012/03mars2012/vikingby.aspx
- http://theforeigner.no/pages/news/new-norway-viking-settlement-discovered/
- http://nikuarkeologi.wordpress.com/2012/12/04/en-geofysisk-gate/

Breitenbach, D

- http://www.examiner.com/article/mammoth-ivory-workshop-discovered-germany
- http://www.alphagalileo.org/ViewItem.aspx?ItemId=124350&CultureCode=en
- http://www.sciencedaily.com/releases/2012/09/120926092620.htm
- http://www.juraforum.de/wissenschaft/aelteste-elfenbeinwerkstatt-der-welt-in-sachsen-anhalt-entdeckt-413462
- http://www.mz-web.de/servlet/ContentServer?pagename=ksta/page&atype=ksArtikel&aid=1348125976531&calledPageId=987490165154

Uppakra, S

- http://www.uppakra.se/gravdagbok/2012-06-25-tack-for-vardefull-hjalp/
- http://www.sydsvenskan.se/omkretsen/staffanstorp/spar-av-forntida-palissad-funnen/
- http://www.sydsvenskan.se/omkretsen/staffanstorp/pa-jakt-efter-berattande-gravar/

Stonehenge, GB

- http://www.epochtimes.de/neuer-hinweis-auf-sonnenanbetung-vor-stonehenge-845971.html
- http://www.artdaily.com/index.asp?int_new=52033&int_sec=2#.URDdIGfIn4t

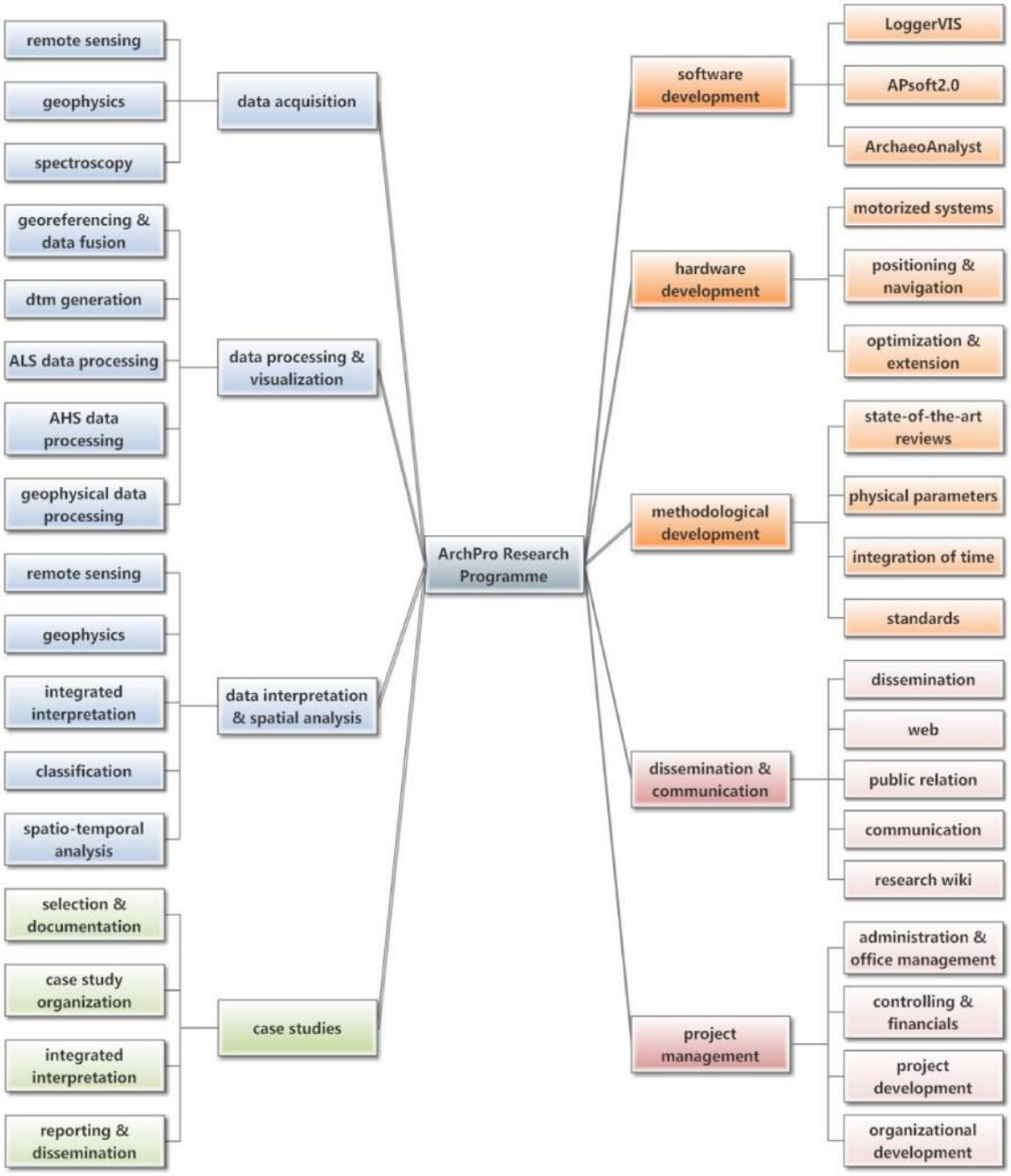
2. Restructuring of the LBI ArchPro research program

After the first 18 months of the LBI ArchPro the initial structuring of the research program into three program lines (PL1 *Archaeological Remote Sensing,* PL2 *Archaeological Geophysical Prospection*, and PL3 *Archaeological Interpretation, Spatial Analysis & Virtual Archaeology)* turned out to be not suitable for the complex research objectives, which claim for a high degree of interaction and collaboration within the research team.

The integration of the workload associated with the case studies into the research program had not been outlined in detail in the original research program. The synergies between basic and applied research within the case studies have also not been made explicit and therefore had developed into a parallel structure within the LBI ArchPro organizational structure. The lack of detailed definition of the individual work packages and the respective responsibilities within the research team led to a complex situation for both the LBI ArchPro staff and the partners.

The LBI ArchPro Board therefore put the director in charge of a restructuring of the research program. The restructuring was intended not to change the main content agreed on by the partners, but to form a more comprehensive and feasible organizational structure, allowing easy evaluation and further extension in the future. The fundamental motivation of the LBI ArchPro – to advance non-invasive archaeological prospection methodology and technology for the detailed documentation and investigation of entire archaeological landscapes – has already been presented in the initial research proposal and will not be repeated in the new research program, which is meant to provide a detailed description of the intended work to be covered and goals to be achieved in the first phase of operation of the institute, up to March 31st 2014.

By restructuring the research program into the logical workflow "***Data acquisition***", "***Data processing & visualization***", "***Data interpretation and spatial analysis***", a greater interdisciplinary linkage between the initially separated program lines is established, with improved potential for positive synergy effects and intensified collaboration. The thematic grouping of research and development work packages into "***Methodological development***", "***Software development***" and "***Hardware development***" corresponds to a sensible pooling of tasks, resources and competences. The integration of the workload associated with the "**Case Studies**" into the research program as well as the assignment of areas of responsibility to individual researchers and the setting of milestones will permit a more structured and streamlined approach. A comprehensive research and development program for the LBI ArchPro comprises scientific activities and work packages as well as the aspects of organizational development, "**Project Management**" and "**Dissemination and Communication**" for a sustainable future development of the research institute.



Overview of the restructured LBI ArchPro research program

The activity of the LBI ArchPro following the revised program is based on nine columns of basic and applied research and development. The individual proposed topics and their sub-tasks have the potential for wide ranging applications, future extensions and development, focusing on spatial archaeology at the scale of landscapes as the main archaeological research objective. The work packages are well defined and manageable and the structure of the new research program will enable comprehensive controlling and evaluation of the respective progress.

3. Results

3.1 Data Acquisition

Remote Sensing data acquisition

Repeated test flights have been undertaken in the case study areas. The Case Study area in Zillingdorf was covered with Airborne Hyperspectral Scanning (AHS) by Airborne Technology on several dates and partly even repeatedly at different day-times: 5th of March, 26th of April, 9th, 10th, 11th, 18th, and 31st of May. The Case Study areas Carnuntum, Kreuttal and St. Anna were covered by AHS and Airborne Laserscanning (ALS) on 18th of June. Oblique flights were made over Carnuntum, Kreuttal and Zillingdorf areas during May and June (29th of May: Carnuntum, Zillingdorf; 14th of June: Kreuttal, Zillingdorf; 22nd of June Carnuntum; 27th of June Carnuntum, Kreuttal, Zillingdorf). In course of the oblique photography test flights new structures were detected for example in Carnuntum: in the west end of the Civil-Town (grave buildings), in the area of the governor's palace and along the grave-road. By June 2012 the AHS und ALS Remote Sensing data acquisition had been completed for the Case Study areas of Großrußbach, Carnuntum and St. Anna. In case of the LBI ArchPro Case Study Uppåkra ALS and AHS data was acquired through a grant provided by the Swedish Torsten Söderberg foundation. After initially processing of the data it has been sent to the Swedish partners. The detailed analysis of the ALS data has considerably progressed and has been shared with the involved LBI ArchPro collaboration partners.

The versatile main airborne platform of LBI ArchPro partner ABT with integrated airborne laser-, hyper-spectral- and thermal-scanners.

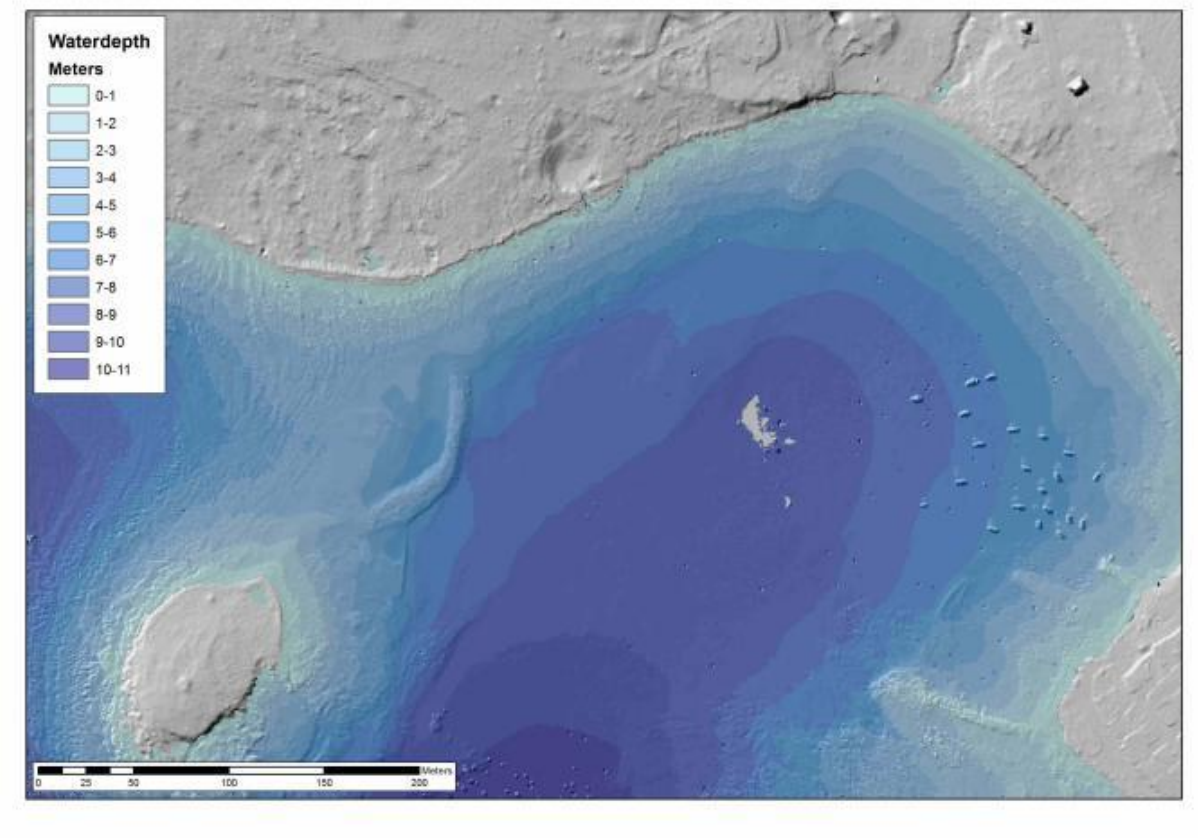
As a part of the subtask "Evaluation of the information content of the data set regarding the time frame" the case study area of St. Anna was evaluated: The area has been documented using ALS in April 2006, April 2007, December 2009, June 2010, May 2011 and November 2011. In all cases a RIEGL ALS System Q680i was used. The idea was to investigate the datasets and analyze the archaeological information content in order to obtain information on the optimum time frame for

data acquisition as well as information on how much archaeological information will be lost when scanning under sub-optimal conditions.

The task "Test flights in project areas with new camera kit" is related to the ARAP project coordinated by the LBI Partner Uni Vienna, since it will use the Arduino-based solution as a camera add-on to automatically obtain position and orientation information from the aerial shots. The connection of a low-cost IMU/GNSS system with a Nikon camera speeded up the process and this task has almost been completed. This development is largely due to the fact that LBI ArchPro partner TU Vienna has involved one of their students with working on a diploma thesis on the topic of how to connect the APM 2.0 to the camera and how to use it in order to generate the most suitable navigation solution.

A one-day workshop on terrestrial laser scanning was organized for the LBI ArchPro team by Riegl Company. The well attended workshop took place in Vienna, UFG building on May 4th 2012.

Next to the tasks that are defined by the research program, a new research focus was directed towards a novel remote sensing technique: Airborne Laser Bathymetry (ALB) in collaboration with Uni Vienna and ABT. This new generation of airborne bathymetric laser scanners utilises narrow green laser pulses for high resolution hydrographic surveying. A small archaeological pilot study conducted at the northern Adriatic coast of Croatia was financed by LBI ArchPro Partner RGZM.



Result of Airborne Laser Bathymetry at the Roman port of Kolone, Croatia

Spectroscopy

For the task "Systematically collect ground-based measurements using a spectrometer" some field work has been done in the spring of 2012. During several weeks LBI ArchPro team in cooperation with Uni Vienna has tried to acquire spectral data. Due to the bad weather the amount of spectral data collected is not as substantial as expected. Nevertheless, we have seen how even the smallest variables can influence the result and were looking for better ways to optimise the data sampling and indication of sample points in the field. The research will continue the next two years, as this year has to be seen as a learning and development process.

Geophysical data acquisition

By the end of 2012 the large-scale archaeological geophysical prospection within the LBI ArchPro case studies has reached a total coverage of 22 square kilometres (18.68 km^2 magnetics, 3.43 km^2 GPR) at unprecedented spatial measurement resolution.

In 2012 during the case study Stonehenge for the first time four motorised 8-channel Foerster Fluxgate magnetometer systems were used in parallel.

Motorised LBI ArchPro fluxgate magnetometer systems in operation at Stonhenge

In early 2012, the within the LBI ArchPro and partner organizations existing AMMS Caesium magnetometer data logging devices manufactured by PicoEnvirotec Inc were converted by their VP of Engineering, Ivo Mejzr, in Vienna to state-of-the-art analogue-digital (A/D) converters for integration with the motorized LBI ArchPro magnetometer solutions and systems.

Array of five A/D converters for a 20 channel Caesium magnetometer system

In July 2012 a novel 6-channel motorized Caesium magnetometer system was assembled and successfully tested on the Neolithic site at Altruppersdorf.

Motorized 6-channel Caesium magnetometer system

In the framework of the large-scale archaeological prospection project Carnuntum a second 16-channel 400 MHz MALÅ Imaging Radar Array was acquired, fitted with inbuilt ruggedized field PC, new small RTK-GPS rover and taken into operation. A newly constructed hydraulic front mount permits the uninterrupted operation of the MIRA system along ultra-long profiles, considerably speeding up the data acquisition process: instead of surveying in traditional manner in zigzag mode along parallel measurement swaths now it is possible to survey in large loops, similar to the highly efficient magnetic prospection routine. For the purpose of dealing with data acquired in such manner the in-house developed processing software APSoft 2.0 has been adapted adequately. First test measurements conducted in Carnuntum resulted in impressive coverage rates of 5 hectares within six hours of survey time using 10×10 cm GPR trace spacing.

The in 2012 newly acquired 16-channel 400 MHz MIRA system dedicated for the large scale Carnuntum prospection project. The novel hydraulic front-mounting permits new data acquisition along very long profiles driven in loops

Under 2012 the yet unsatisfactorily operating two motorized six channel 500 MHz SPIDAR GPR prototype systems were taken into operation in a joint effort between the LBI ArchPro and the Canadian manufacturer Sensors & Software (S&S). With the support of S&S engineer and SPIDAR firmware developer Adam Fazzari deployed to Föllim in Lower Austria in summer 2012 it was finally possible to track down hardware and firmware issues that earlier had prevented the large-scale application of the SPIDAR systems. In connection with the Vestfold case study for the first time reasonable and efficient operation of the SPIDAR systems was possible in autumn 2012.

Operation of the 6-channel 500 MHz SPIDAR system at Gokstad (Gokstad burial mound is visible in the background).

3.2 Data Processing and Visualisation

Geo-referencing and data fusion

Within the task "Geo-referencing of repeated ALS test flights" one of the main focuses was a complete re-processing of the ALS data from partner NIKU. This was necessary in preparation of the collaboration aimed to monitor topographic landscape changes through time in the area of Mølen, Vestfold. The processing started with the raw full-waveform information (sdf-files) and aside from the echo determination the direct georeferencing and strip adjustment of the ALS data was necessary. The georeferencing was completed for both study areas. Furthermore the processing and analysis of the ALS data sets of St. Anna and Carnuntum was completed.

In case of the task "Ortho-rectification of relevant aerial photography from the case study area" different orthophotos from the case studies Halbturn and Carnuntum have been orthorectified. At the end of the year summaries, statistics and reports were created. The main report shows to which extent the current LBI ArchPro case studies are covered with consistent, large-area orthophotomaps, providing also the source of the orthophoto, the spatial resolution and the acquisition year for each data set.

Digital terrain model generation

The task "Advanced DTM generation for archaeological interpretation" focused on the development and testing of the workflow for hierarchic robust interpolation within the new OPALS packages (opalsRobfilter etc). For a group of four tested software packages unified reports and comparisons have been prepared. After completion of the workflow development, the workflow was tested on several study areas, refined and newly tested on several data sets (ALS Vaihingen, ALS Leitha). A further topic addressed was the processing and DTM generation of the ALB data from Croatia.

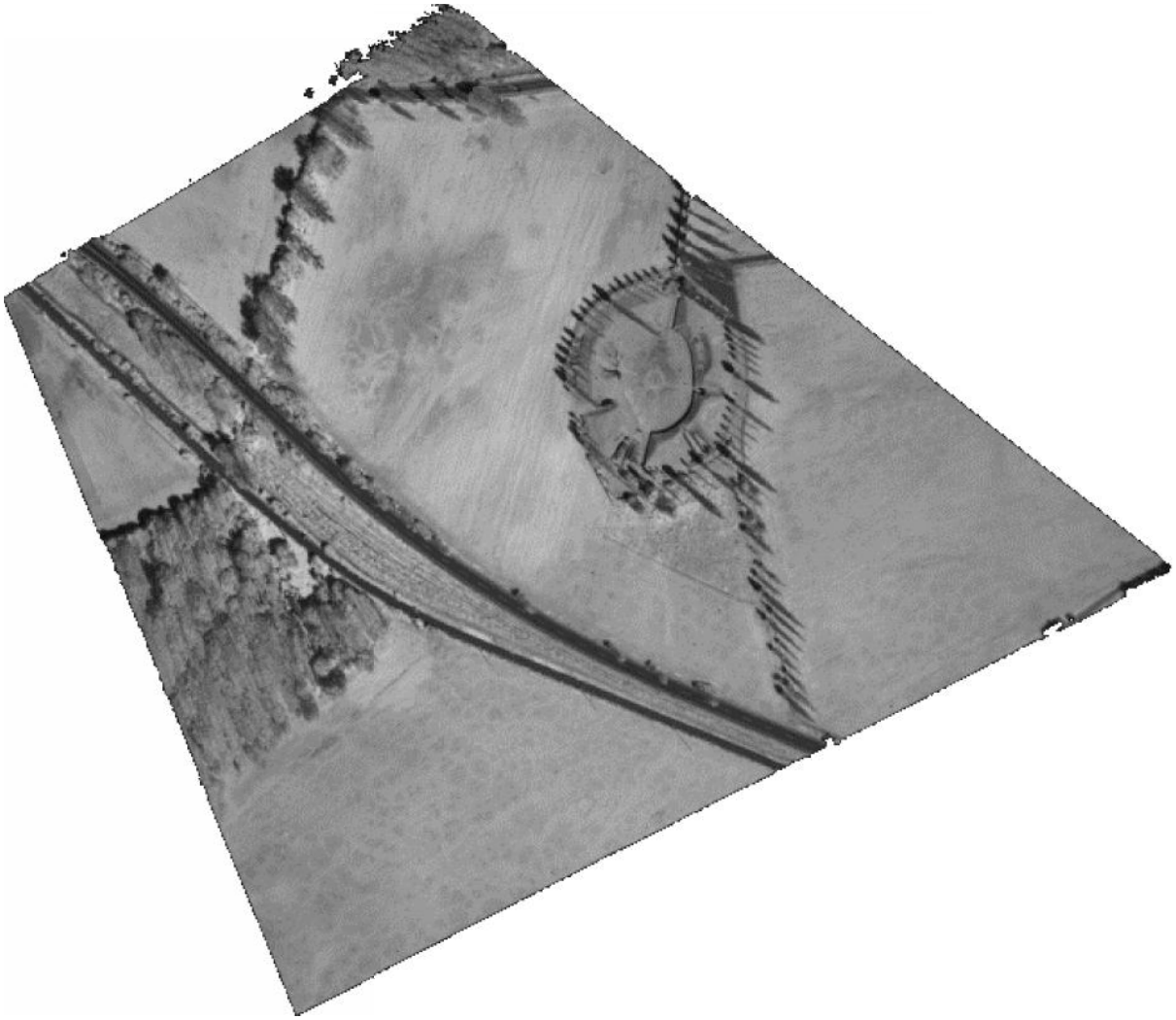
It has also been evaluated to which extent the current LBI ArchPro case studies are covered with surface and terrain models. For those study areas that already have models additional documentation has been generated. For those that did not yet have any, new models have been generated from available data, providing as well appropriate documentation.

Within the task "DTM generation from TLS and ALS" the definition of relevant workflows is the main focus. Workflows that are already known through the DTM generation from ALS will be used, adapted and extended. The magnetic prospection campaign conducted in April in Stonehenge was used to scan the western part of the Stonehenge project area, which will be completed in 2013. Georeferencing and a first rough cleaning of data (automatic elimination of vegetation points, data homogenisation) was performed using RiScanPro. Systematic processing and generation of the DSM/DTM was postponed until the entire project area has been scanned (2013).

ALS data processing

The work on the radiometric calibration of ALS data was continued due to its current potential. Aside from papers on the calibration of single-wavelength data, first results for multi-wavelength data sets were published (Silvilaser paper and Melbourne paper) and presented (ISPRS congress Melbourne,

EARSL workshop Ghent). The oblique aerial photographs that had been taken over Carnuntum at the same time that the ALS data had been acquired (May 26th 2011) were rectified. The camera used was a converted NIKON D90, which due to an exchange of the internal filter now records infrared wavelengths. Therefore, this will be a good basis to compare with the radiometrically calibrated ALS data.



Orthorectified NIR-photograph from amphitheatre and the school of gladiators at Carnuntum taken on May 26th 2011.

As part of the work package "Automated visualizations based on ALS data" the ALS Visualization toolbox has been created and introduced to the LBI ArchPro team as Beta release. The toolbox assembles many important tools that are very useful for ALS data processing and visualization. It consists of specific tools including ArcGis scripts, LasTools, Topography Tools and the in-house developed tools. Additional tools need to be programmed, such as Sky View Factor, Openness, semi-automatic classification approaches, etc. In addition, the toolbox documentation describing the used scripts has been prepared and provided to the LBI ArchPro team.

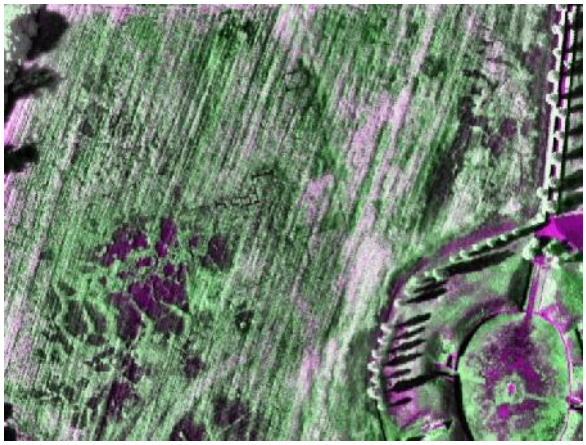
AHS data processing

In regard to the work package "Geo-referencing and radiometric adjustments" a survey campaign took place in April 2012 in order to improve the spatial resolution of the AHS and ALS data for the case study Carnuntum. The goal of the measurements was to obtain control information for the AHS orthorectification and ALS strip adjustment (the KT points for the coordinate system transformation, points for the total station's positions in order to record the roof points, the characteristic ground points, roof points).

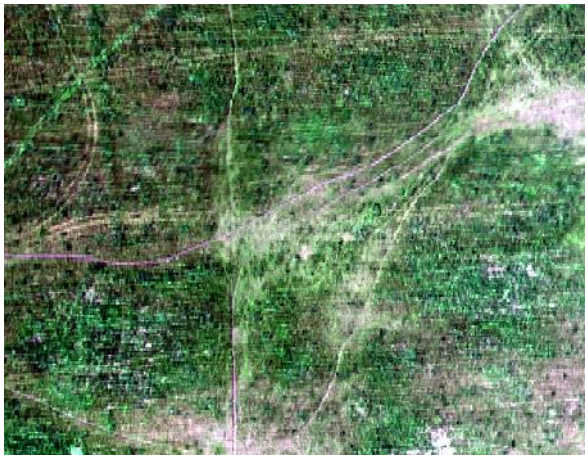
LBI ArchPro partner ABT has provided new software packages for geo-rectification (PARGE) and atmospheric correction (ATCOR). Both products have been tested and are ready for use after training. The first datasets have been processed.

Regarding the "Evaluation of the AHS toolbox" some tests were conducted, the toolbox was updated and enhanced by the LBI ArchPro collaboration partner BOKU Vienna. First thorough tests on two properly georeferenced HySpex VNIR strips were made, all CropMark functions were evaluated (using this specific dataset) and a methodology was developed for comparing all the images that were produced. These results were presented at two conferences (AARG 2012 in Budapest and EARSeL 2012 in Ghent). Especially worthwhile are the use of Red Edge Inflection point (REIP) and Distribution fitting based on a Gamma curve. The evaluation task has therefore been completed.

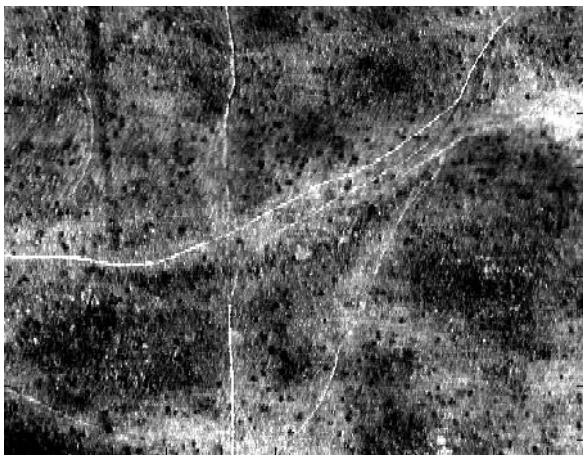
Conventional RGB



Red Edge Inflection point



Visual RGB



Gamma (band 1)

Geophysical data processing

The evaluation of the ZAMG Software APmag and APradar software has been completed. For the task "Migration of GPR data" a simple form of data migration has been implemented in to software APradar and tested in regard to the migration width that is taken into account. Further comprehensive migration tests using a test data set (Forum Carnuntum or school of gladiators, subsequently Birka) are necessary. A review over the use and implementation of the reduction to the pole (RDP) methodology has been compiled. Several authors (Tabbagh et al., C.T. Young) recommend the use of the Analytical Signal (AS) over RDP. Firsts implementation tests of the AS computation have been tested in MATLAB. Test data sets have been Steinabrunn and Roseldorf. Further improvements and its implementation into APSoft 2.0 are required.

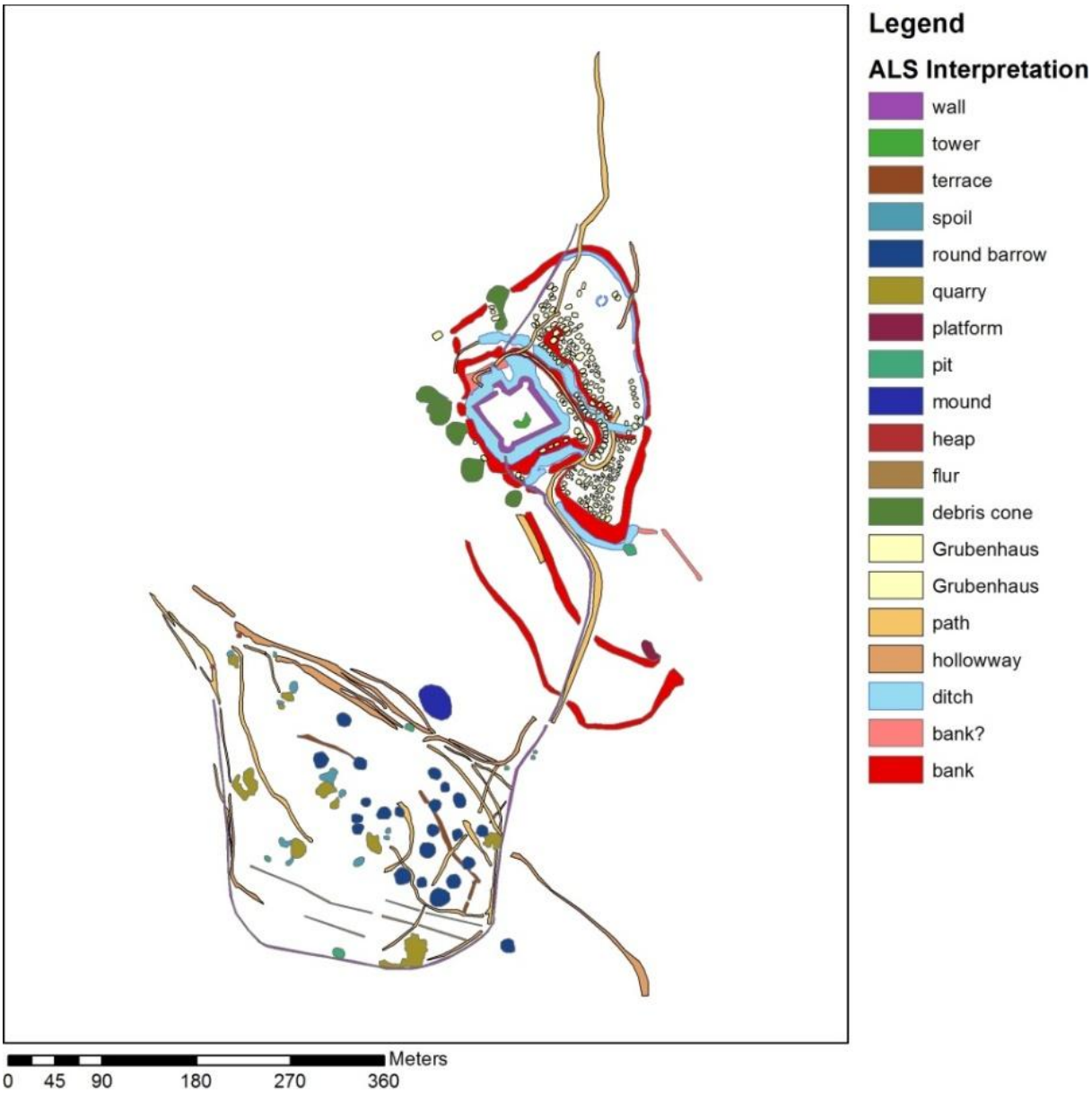
3.3 Data interpretation and spatial analysis

Remote sensing data interpretation

For the task "Archaeological Interpretation of ALS data" the ALS dataset acquired in the framework of the case study Birka-Hovgården was been largely interpreted: over 2,200 round barrows were drawn in ArcGIS.

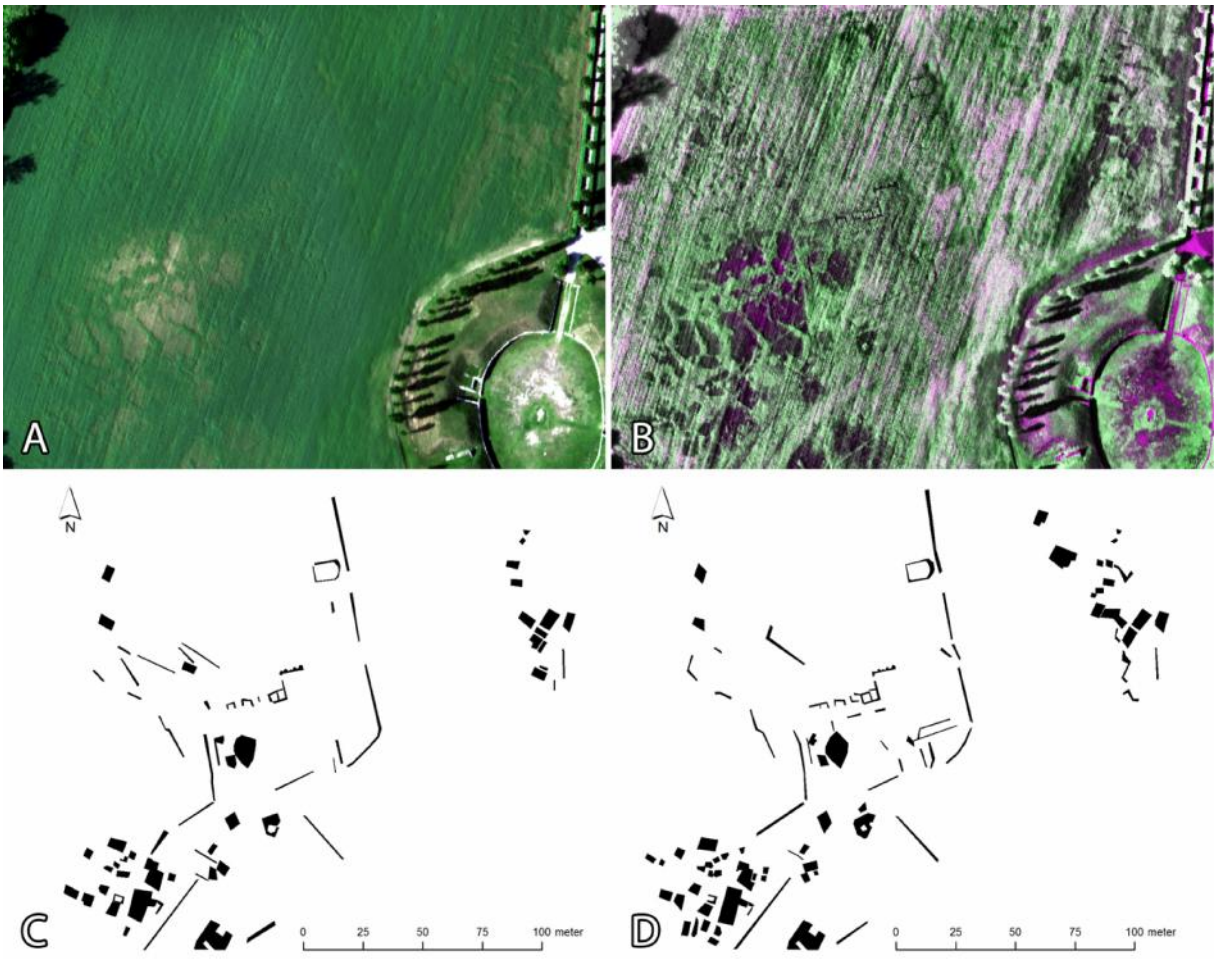
A detailed interpretation of the data from case study areas Halbturn and St. Anna was started and has been completed to 50%. Additionally, it has been attempted to process the high-resolution ALS data from Kreuttal, but this task has not been finished due to a problem in the software OPALS, which will be solved in the near future. Therefore, the interpretation of the Kreuttal data will be commenced in January 2013. The ALS-data from Uppåkra were filtered and processed and will be interpreted in parallel with the Kreuttal data set.

Also the interpretation of the ALS and ALB datasets from Croatia was notably successful. The use of ALS in dense, low, and mostly evergreen vegetation that is covering the case study area has proven the viability of this technique even under these difficult environmental circumstances. To our knowledge, no archaeological investigations using ALS have been conducted so far in this kind of Mediterranean vegetation. During the test-flight, the coastal area was also surveyed using Airborne Laser Bathymetry (ALB), a system for measuring the depth of relatively shallow waters by using a green laser scanning system operated from a fixed wing aircraft. The test was very successful and resulted in surface models with half a planimetric resolution of 50 cm at depths between 6 and 10 m, revealing topography, archaeological structures such as submerged Roman/Byzantine villa rustica walls or harbour structures. The results demonstrate the potential of this novel technique to map submerged archaeological structures over large areas in great detail, for the first time providing the possibility for systematic, large scale archaeological investigation of such environments.



State of interpretation of the St. Anna ALS-data set at the end of 2012

For the work package "Evaluation of Repeated ALS flights" another topic was the specification of a comparison workflow due in December 2012. It had been decided that the best way to compare the interpretation of an area – regardless, whether the interpretation is based on different prospection techniques or on timelapse measurements using the same method – would be through direct comparison of the amount of archaeological information derived. Therefore, a model was created in ArcGIS, which directly compares two Feature Classes (e.g. Shapefiles). This model will convert shape-files (Polygon, Line or Point shapes) to Raster datasets, in which the cell values will be either “0” (no archaeology) or “1” (archaeology), assuming that all drawn features in the shape-files are archaeologically relevant.



(A) a conventional RGB aerial image; (B) a false colour composite created by means of the novel REIP algorithm. Both (A) and (B) are histogram-stretched. (C) and (D) hold the interpretations of the archaeological structures discernible in (A) and (B) respectively

An AHS data set from the case study area Carnuntum, covering the *ludus* area, for the task "Archaeological Interpretation of AHS data" was received in August 2012. This data set was a part of the data acquired during the latest flight in which a new sensor (the HySpex VNIR imager) was employed. Using PARGE, MATLAB CropMark Toolbox and the new release of Exelis Envi (version 5.0) software it was possible to process the dataset properly. CropMark functions were evaluated using this specific dataset, and a methodology was found for the comparison of all the images that were produced. These results were presented at two conferences (AARG 2012 in Budapest and EARSeL 2012 in Ghent).

Geophysical data interpretation

The interpretation workflow developed during the last decades by ZAMG Archeo Prospections® and Wolfgang Neubauer has been evaluated. Test interpretations by all respective team members have been carried out and were widely discussed during an internal LBI ArchPro workshop.

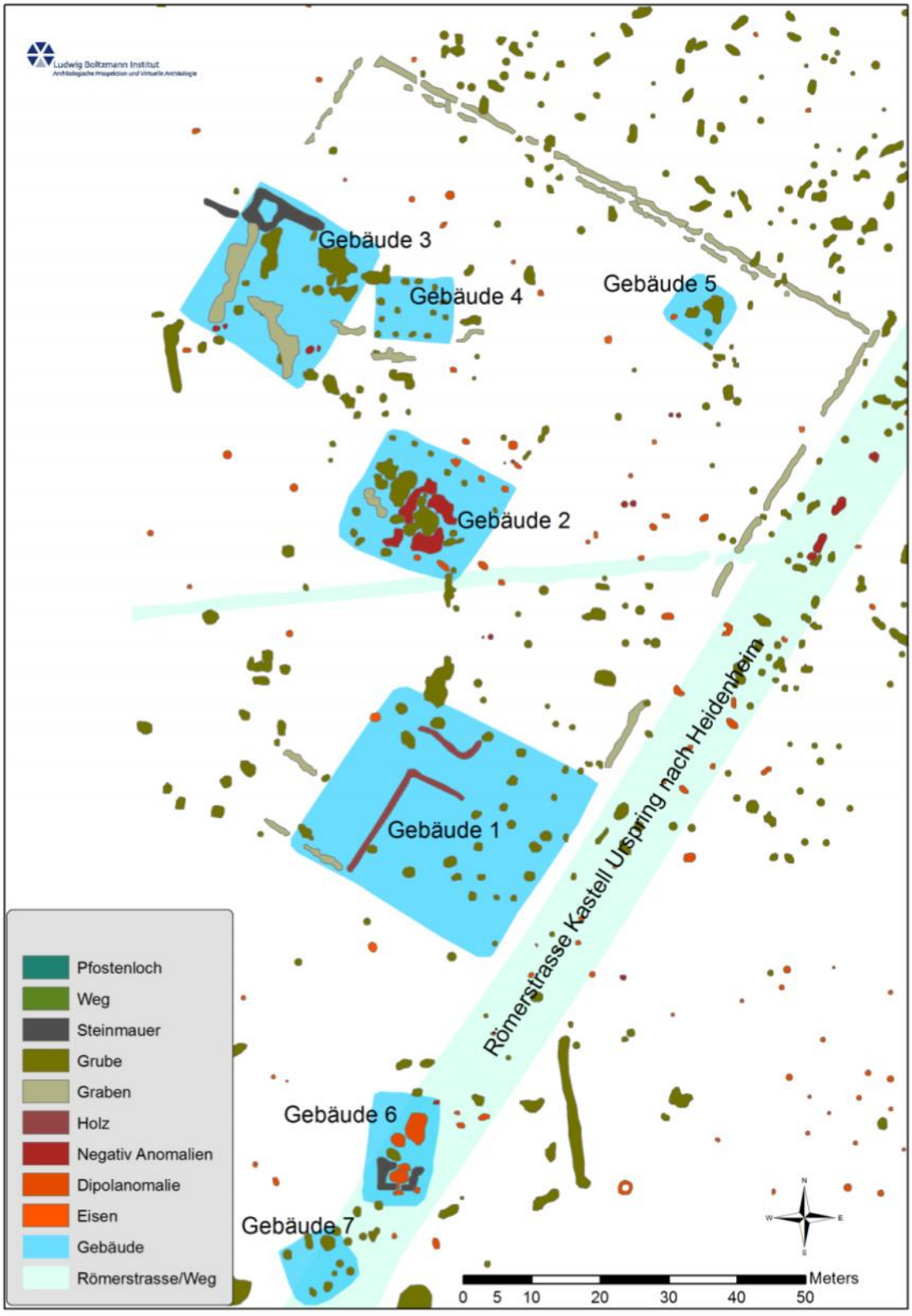
For the future interpretation of all case study data a comprehensive GIS-based interpretation work flow will be developed. This work flow will be based on the ESRI Geodatabase® format (geoDB). Currently, the initial geoDB design is being reviewed and enhanced. The development of the workflow and the respective documentation will be done using software packages SmartDraw and Geodatabase Diagrammer. These two software products provide the perfect environment for the definition of requirements, specifications and implementation of GeoDB templates to be interfaced as XML documents directly to ESRI ArcMap®. All initial interpretation results have been integrated into the final GeoDB based structure until the end of 2012.

In connection with the design of the geodatabase and first archaeological interpretation of the Kreuttal datasets best practice guidelines for interpretation have been considered and tested. General focus has been set on redundancy concerning the workflow and practicability of used templates. The aim is to enforce a logical workflow of the interpretation of geophysical data. In a first step the structure and design of the geodatabase was defined. Once a geodatabase had been defined using ESRI´s Geodatabase Diagrammer it was tested in ArcGis 10.0 concerning usability. Different templates have been tested and evaluated so far. After each test the original geodatabase was again modified with the Diagrammer. The final step will be to introduce the newly designed geodatabase and workflow guidelines to the LBI ArchPro to be tested on all case study data sets.

Integrated archaeological interpretation

For the work package "Data conversion and data integration of existing digital archives" several files with needed Coordinate Reference Systems (CRS) for all LBI ArchPro case studies were created. All old and new CRSs of every individual case study and a list of all their parameters were compiled in an Excel sheet. In addition to this work, correct CRS files for ArcGIS were prepared and a tutorial on how to best transform CRS using the NTv2 solution in ArcGIS was produced. Finally, an internal workshop was organized on that matter.

Regarding the task "GIS based integrated data interpretation" an interpretation workshop has taken place in Oslo together with LBI ArchPro partner NIKU und Vfk (participants: Erich Nau, Wolfgang Neubauer, Lars Gustavsen, Lise-Marie Bye-Johansen, Christer Tonning, Vibeke Lia, Knut Paasche).



Archaeological interpretation of a Roman timber farmstead near Stubersheim (D).

Classification of prospection data

First tests with object oriented classification approaches have been undertaken in the framework of the task "Classification of multi-temporal AHS datasets". The work package started with methodological questions (initially focusing on the pixel-based algorithms). In parallel, guidelines are developed.

Classification of ALS data is in a preliminary state. For the time being the main focus is placed on the preparation of the reference data for further analysis. Currently, the woodlands of Leithagebirge are being investigated in this regard. The point-clouds of three chosen test areas have been manually classified according to the materials/objects scheme. Point-clouds of all three test areas were divided into three classes: ground, non-ground, object-points of archaeological relevance. For the entire process of manual classification a report with guidelines and a virtual presentation were prepared. A field control was necessary in order to evaluate the effect of manual work. Therefore the field control for Area 02 was performed and successfully completed. Performing a field control for Area 03 was not possible due to dense vegetation, and therefore was postponed to 2013.

3.4 Methodological development

State-of-the-art reviews and standards

The tasks "ALS state-of-the-art", "AHS review on theory, technology, methodology and archaeological applications" and "Review of spatial and spatio-temporal methods in archaeology" have been finished and have resulted in internal reports and/or bibliographical databases. Furthermore, background research for “Archaeological Geochemistry - review on theory, technological and methodological state-of-the-art” is work in progress. The results will include the development of a database of archaeological features, geochemical signatures and soil parameter, and new standardization of data acquisition and processing methods for archaeo-geochemical prospection.

For the task "Review multichannel/multi-frequency GPR" the following multichannel systems have been tested on a test site in Carnuntum: MIRA, 3d-radar step-frequency system, IDS STREAM system, SPIDAR system. Several test surveys conducted by others with 3d-radar and STREAM systems have been recently published and numerous measurements have been conducted by the LBI ArchPro with the MIRA and SPIDAR systems. Currently the MIRA system is by far the most advanced and reliable multichannel GPR system. Intensive efforts in collaboration with Sensors & Software for the enhancement of the S&S SPIDAR system were fruitful in 2012. Further test surveys with the 3d-radar step-frequency system and new models of the IDS Stream system are desirable.

Physical parameters

As a part of the task "Integration of EM measurement devices" a test survey was conducted over the school of gladiators in Carnuntum. A research team of the University of Ghent in collaboration with the LBI ArchPro has impressively demonstrated how a new generation of EM devices from the Canadian manufacturer DualEM results in meaningful and for archaeological prospection useful, efficiently collected EM data, providing large-scale information on soil conductivity and magnetic susceptibility. Currently the LBI ArchPro does not have access to a DualEM instrument. First enquiries regarding a possible development of a multichannel EM device have been made with DualEM.

The use of GPR systems that permit the simultaneous registration of GPR data by multiple receivers for signals emitted by individual transmitters could result in data that via normal-moveout (NMO) analysis may provide more insight into the velocity distribution in the subsurface, possibly resulting in improved depth-imaging as well as increased signal-to-noise ratios due to trace stacking after application of NMO corrections. The MIRA system permits in principle two shooting sequences. Test measurements are required to evaluate the existing potential. Requirements for extended shooting tables for the coverage of the entire 16 channel array spread have to be formulated. Future milestones: Discussion of possible transmitter-receiver geometries; definition of shooting tables; test survey in Carnuntum; data analysis; recommendation; adaption of the system and processing software.

Standards

Basic result of the task "Standardizing the data acquisition and post processing methods" is a list of all necessary guidelines (best practice) for all procedures and workflows, maintenance rules for systems but also guidelines for general logistics and organisation. The latter ones are necessary in order to provide each system used in the field with well defined manuals, including its functionality, maintenance and operation. As a tribute to the fact that most systems still are being improved, which is an integral part of the research program, for each system a log-book has to be introduced. Due to these manuals and the log-books the personnel should be able to operate the specific systems, for which they are trained in appropriate manner.

Guidelines defined within this task will include: Manuals and log-books for all systems and vehicles. Manuals and check lists for the correct maintenance of all systems and vehicles, Operating rules for vehicles and systems, Safety rules for surveys, Logistic and Organisation of surveys (case studies), Reporting system for case studies and fieldwork, Reporting system for system and vehicle maintenance, Performance of systems and vehicles, “Ethic” rules for surveys and Post-processing rules and recommendations (APSoft 2.0). So far guidelines for the Förster magnetometer system, the ATVs/Quad bikes, the setup of the RTK-GPS JAVAD, the post-processing of geophysical data with APsoft 2.0 and the handbook for Case Studies have been realized.

3.5 Software development

LoggerVIS 2.0

The development of LoggerVIS 2.0 has been completed. The software has been finalized for use with Foerster magnetometer systems. First successful tests for use with Caesium magnetometer systems were conducted in June and July 2012 (software in beta stage). Further tests and developments were necessary in order to reliably capture the Caesium magnetometer signal, which due to synchronization issues between digitizers at times can be unstable. Data are correctly being read from the digitizers now. Both manual as well as motorized Caesium magnetometer tests were successfully conducted with LoggerVIS 2.0. The possibility for manual measurements with the Caesium systems has been implemented. Three LoggerVIS modes currently exist: motorized magnetics, motorized non-magnetics (e.g. GPR), and manually operated magnetics. A novelty for the Fluxgate magnetometers using the Eastern Atlas Digitizers is the display of the pulse-per-second

(PPS) signal. A manual describing the new developments in LoggerVIS 2.0 has been written. In autumn and winter the improvements and bug fixes were accompanied by various field tests. The new Caesium magnetometer system was several times tested and the new ruggedized PC system also. The online visualization function was also further developed in order to comply with the new Caesium magnetometer system and in this process it was improved in terms of performance and view quality for both types of magnetometers. Also, an improved Magnetic Values chart visualization was developed in order to help observe sensor malfunctions during data acquisition.

APsoft 2.0

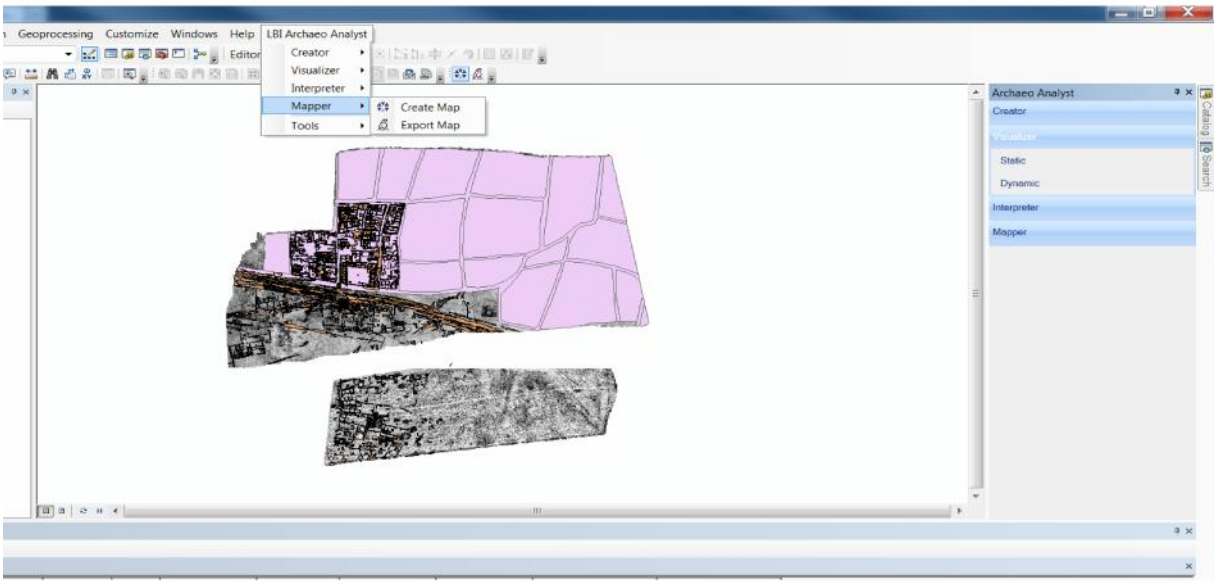
The work package "Processing software for motorized geophysical prospection" was further developed in order to meet the needs of the new hardware developments and to solve occurring problems. The magnetic processing software ***apmag*** was upgraded to use GPS-quality 5 data, to include entire directories of prospection data, to support the xml-data versions 1.1 and later 2.0 and to apply new spatial filters. Several algorithms were time-optimized and new algorithms were developed to analyse the incoming data in order to restore missing entries. A new synchronisation method for systems without PPS-signal was developed by locating single well synchronised entries, leading to much better results than the old statistical method. In order to support caesium systems several test measurements were carried out. The magnetic processing software was updated to support caesium data and to synchronise several Picodas-systems. An algorithm was developed to reduce the influence of the relative tilt of the motor vehicle due to the terrain using the altitude information of the DGPS measurements. All processing algorithms were optimized for processing caesium data by adapting internal processing parameters. For the manually operated caesium system the software was upgraded to support the positioning by Leica totalstation tracking. The GPR processing software ***apradar*** was upgraded by implementing a (5-point) depth depending velocity model for depth-slice calculation, and by supporting this velocity model by the 2D and 3D migration algorithms. The migration algorithms also were upgraded to support a depth-depending width of the migration window. A new algorithm was developed for resampling the time-triggered GPR-data to data with (optimal) constant trace distances. A Wallis-filter algorithm was implemented for GPR-depth-slice data to enhance areas with strong energy absorption. An algorithm was implemented to reduce the influence of signal variations due to variations of antenna coupling in case of rough ground conditions. Several algorithms were time optimized and extended to handle 3D GPR-fields larger than 2 GBytes in size. Missing entries in MALÅ Imaging Radar Array (MIRA) -"*.pdt" files are now detected and restored. The synchronisation of MIRA data was significantly improved. A first trial was implemented in order to detect geological layers in GPR-data. A method for reducing long-wavelength antenna variations in GPR depths-slices was implemented. The software was upgraded so that the MIRA system can be operated in long rounds without stopping, instead of measuring lines in zig-zag mode.

For the task "APsoft 2.0" a functional and graphical user interface (GUI) specification was developed. The goal is to integrate existing processing software into an easy-to-use program for the processing of magnetic and GPR prospection data. The software will support three different predefined processing modes (raw, standard, enhanced) and an expert mode in which it will be possible to define all parameters individually and to run several processing steps in parallel. The three

predefined steps serve different purposes: "raw" to control the quality of the data, "standard" to deliver a fast, first standardized processing and "enhanced" to produce the best results even if they are time consuming. To speed-up the development the entire task was divided into two main tasks: Programming of the GUI interface and transferring the existing software into dynamically linked libraries (dll) that communicate with the GUI via a special interface. The GUI and the fast functions to read grid data has been implemented, the transformations of the existing software into a dll has been started. However, both tasks are still under development.

Archaeo Analyst

For the "ArchaeoAnalyst" software development the requirements have been specified. ArchaeoAnalyst is the name of a GUI- and Wizard-based extension for ArcGIS 10.1 and later, to be developed by LBI ArchPro for internal use only, which collects and combines tools for data import and processing in a way optimally suited for LBI ArchPro projects. A project started with ArchaeoAnalyst and its contained data shall be properly geolocated from the beginning onwards, metadata shall be correctly filled, and a homogeneous project structure shall simplify and help avoiding errors and confusion when working inside the various case study areas. LBI ArchPro collects data from different sources: Geomagnetics (different systems), Earth resistance, Ground Penetrating Radar (GPR; different systems), Airborne Laser Scanning (ALS), Terrestrial Laser Scanning (TLS; Time-Of-Flight and Structured-Light systems), conventional, multichannel and hyper-spectral aerial photography. All source images are evaluated and interpreted individually, but results should be combined and displayed together. Also combinations of different raster images of different sources, created on-the-fly, shall allow the integrated interpretation of data. For support in the preparation of publications, standardized map layouts shall be supported (with homogeneous presentation of equal features, meaningful legends, scale, grids, LBI ArchPro logo, etc).



Screenshot of the ArcGIS based GUI of the Archaeo Analyst software

3.6 Hardware development

Motorized systems

New magnetometer carrier systems were designed, built and tested for both fluxgate and caesium probes. The EAL instrument carriers were after training extensively tested during the case study in Vestfold, Norway. The motorized Caesium magnetometer system was setup and tested for the first time under real fieldwork conditions in Altruppersdorf, Austria. The JAVAD RTK-GPS has been reconfigured for use with the Caesium magnetometer.

Ruggedized hardware components for the data logging device of the new MIRA 2 system were acquired and assembled. The necessary software components were installed in the new Kubota carrier vehicle and tested. The new JAVAD Sigma RTK-GPS system was configured and tested. The complete new system was put successfully into operation in Carnuntum, were first test surveys were conducted, demonstrating a great efficiency of the new system.

The SPIDAR ground penetrating system was adapted and is operating at reasonable speed with a resulting GPR trace resolution of 25 x 5 cm.

Motorized SPIDAR GPR in operation

Positioning and navigation

Available and new positioning devices in form of smaller RTK-GPS devices (JAVAD Sigma) have been tested, configured and adapted for use with the geophysical prospection systems. Initial problems

regarding RTK update rate and port configurations were solved and the two new systems are now fully functional. During the case study Norway an ALTUS RTK-GPS of the Norwegian partner NIKU was configured for use with the motorized Fluxgate magnetometer systems. The MALÅ Geoscience MIRA radios and robotic Leica TCRP 1200 totalstation were successfully tested in Carnuntum for the positioning of the Caesium magnetometer in situations where GPS reception is problematic. Manual GPS stake-out of survey areas was successfully tested using the JAVAD Tracy COGO software.

Optimization and extension of survey systems

First motorized Caesium magnetometer tests employing six sensors were conducted in July 2012. In 2011 comprehensive test measurements at Stonehenge were conducted for testing the optimum sensor placement and gradiometer distance using a manually operated Caesium system. Construction of a suitable frame for the mounting of the sensors will facilitate different sensor and gradiometer configurations (e.g. pyramidal mounted sensors in rows of 5-4-3 or 4-3-1 from bottom to the top at 20, 80 and 110 cm height.

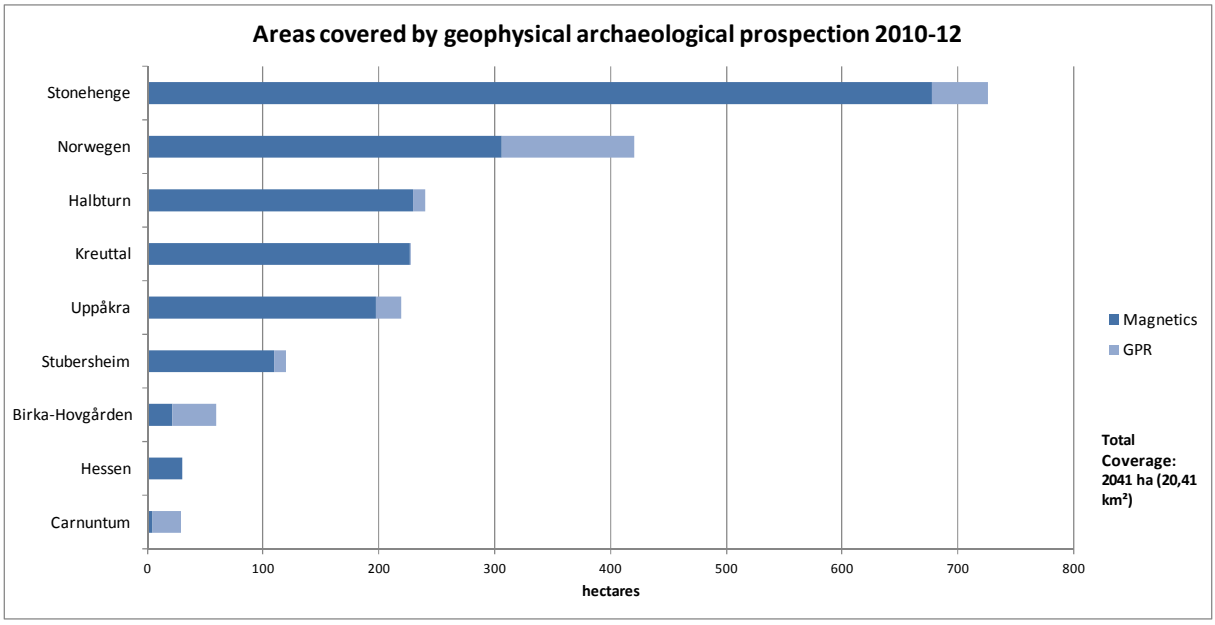
3.7 Case studies

Case study selection and documentation

In the task "Case study standards, documentation guidelines and geoDB maintenance" a focus was set on the design and maintenance of a geodatabase. Preceding work dealt with the setup of the necessary infrastructure, including the data structure, file structure, server design etc. Therefore a first step has been to define the different steps in which data is occurring. First of all, raw data (first step) has to be stored after each campaign according to the handbook of case studies. Post-processed data (second step) has to be provided for archaeological interpretation afterwards. The geodatabase will contain this interpretation data (third step) and basic raster datasets. The geodatabase has to be designed in a way that all attributes linked to an object (point, line, polygon, ...) are well defined. It has been checked whether existing datasets are compatible with the new design of the geodatabase (which has been and will be tested and evaluated throughout 2012 and winter 2013). Secondly, it was confirmed whether it is possible to change from a file based geodatabase type to a server based one in a second development step. In both cases data compatibility is gained. Each case study will be represented by an individual geodatabase. Therefore, its maintenance is within the responsibility of each case study leader.

Case study organization

The case study documentation is partly defined by the Handbook for case studies and the LBI ArchPro reporting system. The work described was conducted in February 2012. Within the Handbook all the responsibilities and the time schedule are defined. For example, the field director has to write a report for each campaign within two weeks of the end of the campaign, and has to provide it to the case study leader and the head of case studies. This report forms then the basis for further reporting done by the case study leader. The design of the reports is defined through the LBI ArchPro reporting system, which has been defined earlier. Photo and Video documentation have also been evaluated and defined already.



Total GPR and magnetic coverage since 2010 listed according to case study area

Case study Halbturn (A)

The geophysical prospection was continued in November 2012. A total of about 90 hectares was covered by geomagnetic prospection. The prospected areas contain a small number of archaeological structures and are showing mainly modern structures, such as old field boundaries and paths from the 19th century. The measurements will be continued in 2013. Within the interpretation of the case study area relevant aerial photographs were re-interpreted, since the area of interest is today larger than in the 90's, when the last interpretation of aerial photographs had been done. The results from this interpretation were also useful for the planning of the geophysical winter season 2012. A small survey has taken place in the spring of 2012 in order to give evidence for dating of the new discovered archeological features. The interpretation of the ALS dataset added very few new archaeological structures (due to long-term erosion in the course of extensive agriculture); anyway, it provided a proper visualization basis of the "man-made" flat landscape. This visualization is the first key for the understanding of the Roman settlement and the economic development on a landscape scale, since it allows us to identify geomorphological characteristics, which were significantly important for the location and design of settlements and agriculture and/or animal husbandry.

Case study St. Anna (A)

Airborne data acquisition has already been completed (for more details see "Remote sensing data acquisition"); geophysical prospection of the relatively small areas has to be scheduled. The areas to be measured are mainly meadows, which are easily accessible. Single structures (potential kilns) in the forest would be interesting to investigate using magnetics.

Case study Carnuntum (A)

Flights have been executed over the case study area (for more details see "Remote sensing data acquisition"). Geophysical work has been carried out in the framework of the ArchPro Carnuntum research project (see below).

Case study Kreuttal (A)

The field work in the case study area of Kreuttal consisted in 2012 of three campaigns and some smaller ones. Due to excellent weather conditions (5 cm snow cover, sunlight, no wind) a survey to verify ALS detected objects was carried out on the 10th of February. A first geophysical prospection campaign was undertaken from March 19th until April 4th. Throughout this survey the Förster 10 sensor fluxgate system and the Eastern Atlas 10 sensor fluxgate system were used to cover 80 ha in the area of Hornsburg. At the end of the campaign a test concerning vibrations of the sensors at the extreme end of the carts was made. On the 20th and 21st of March a workshop for geophysical prospection was held at the Ochsenberg/Kreuzstetten. During the workshop, TLS tests with the new Riegl VZ400 laser scanner were performed. In May 2012 partner Uni Wien excavated a part of the prospected area at Ochsenberg/ Kreuzstetten. This excavation was accompanied and monitored by the LBI ArchPro concerning geoarchaeological investigations. A second geophysical survey campaign was carried out between September 17th and 28th using the Förster 8 sensor fluxgate system, covering 60 ha in the area of Kreuzstetten. Finally, a presentation of the LBI ArchPro and first results was organized for the 12th of October in Kreuzstetten. Additionally, we obtained the latest high-resolution ALS dataset for the entire Kreuttal area from LBI ArchPro partner NoeL. The data is currently being processed and filtered. It will be interpreted during the first half of 2013.

Case study Flavia Solva (A)

Between the 6th and 10th of February 2012 high-resolution geophysical GPR measurements were conducted in the Roman Town of Flavia Solva. The measurements were carried out with the motorized 16-channel MIRA system with 8 × 8 cm trace resolution. Already in the period between 2000 and 2003 manually GPR and magnetometer surveys had been carried out. The aim of the new survey therefore was to prospect already explored areas with higher resolution, as well as new areas for gaining a better understanding of Roman urban structures and for comparison of data quality.

Case study Zillingdorf (A)

The case study Area Zillingdorf has been systematically recorded over one vegetation period (11 flights). A parallel data acquisition with two different hyperspectral sensors was done, using Specim Eagle II (400 – 970 nm), Hyspex VNIR- 1600 (400 – 1000 nm) as well as Hyspex SWIR 320e (970 – 2500nm). In this way a large hyper-spectral data-set was created. The use of geophysical prospection methods is planned for the future in order to compare the detected archaeological features with those obtained from airborne data acquisition.

Case study Stonehenge (UK)

In 2012 the magnetic measurements were extended to the west, south and east of the Stonehenge main monument applying up to four motorized fluxgate systems equipped with 8 sensors each. The

magnetic survey was accompanied by a terrestrial laser scanner survey for the production of a high-resolution digital terrain model. The outline of the case study "The Stonehenge Hidden Landscape Project" and an overview of the results from the campaigns in 2010 and 2011 have been published in the peer reviewed journal Archaeological Prospection. So far more than 7 km^2 have been prospected applying magnetics and ground penetrating radar.

Case study Vestfold (N)

In 2012 two fieldwork campaigns have been conducted in the framework of the case study Larvik / Vestfold. The campaigns took place in the period from April 21st to May 16th and from September 8th to September 30th 2012. The campaign in spring 2012 had the main aim to support the geophysical fieldwork of partners ZAMG and NIKU in connection with the "Gokstad Revitalised Project" of the University of Oslo (http://www.khm.uio.no/prosjekter/gokstad/). As there was some time left during this campaign further work on the actual LBI ArchPro case study could be carried out as well. The main objective of the September campaign was to finalize the magnetic prospection in the area of Tjøllingvollen, to start with the magnetics in the area of Slagen valley and to finalize the fieldwork around Gokstad. An interpretation workshop was conducted in Oslo together with partners from NIKU and Vfk.

Case study Uppåkra (S)

In 2012 some 40 square kilometres of high-resolution full-waveform airborne laser scanning data were acquired around Uppåkra and an airborne hyper-spectral survey was conducted with the financial support of Torsten Söderberg Foundation. Soil samples taken at the Iron Age settlement for the investigation of magnetic anomalies of presumably archaeological origin have been analysed in the laboratory in collaboration with members of the IC ArchPro. The magnetic susceptibility measurements show that it was not yet possible to determine a conclusive cause for the observed anomalies, suggesting that the origin for the first in 1997 by the University of Kiel and in 2010 again by the LBI ArchPro mapped increased magnetisation possibly originates from deeper layers than those sampled so far. An archaeological test excavation conducted in 2000 by Lund University had as well failed to determine the cause for these anomalies. Further invasive soil sampling will be required in order to solve this archaeologically and geologically important question. In collaboration with the partners from RAÄ-UV and Lund University a scientific article on the state-of-the-art archaeological prospection, excavation and 3D digital documentation of a Neolithic grave discovered by the LBI ArchPro in 2010 and mapped with high-definition GPR has been prepared.

Case study Birka (S)

The high-resolution airborne laser scanning data from the Swedish UNESCO World cultural Heritage site Birka-Hovgården, showing in unprecedented detail a digital terrain model of the island of Björkö and the southern part of the neighbouring island of Adelsö, has been processed and prepared for the generation of a physical model. First interpretations of outstanding anomalies have been conducted for both GPR and magnetic data. With help of the Swedish Geological Survey it was possible to identify a mayor magnetic anomaly as being caused by an exceptional geological anomaly (Kärsö

diabase). The GPR data is highly complex. An IC ArchPro PhD student deals with aspects of GPR interpretation using data from Birka.

Case study Kilianstädten (D)

From October 1st to 5th 2012 the first geophysical survey campaign of the new case study Kilianstädten/Hessen was carried out together with the LBI ArchPro partner RGZM (Detlev Gronenborn). Within two-and-a-half working days an area of nearly 30 ha was covered using the Förster 8 sensor fluxgate system. Thereby it was possible to detect the fortification ditch auf an Early Neolithic Linearbandkeramik settlement together with several typical dwellings and pits.

Case study Breitenbach (D)

The excavations of partner RGZM at the Aurignacian open-air site of Breitenbach (approx. 1 ha) represent a unique chance to study the spatial organization of Early Upper Paleolithic sites. Apart from providing new insights into the complexity of Aurignacian site use, the case study is expected to yield answers to the question as to how far the emergence of 'base-camp'-like spatial behavior relates to the "cultural modernity" of early modern humans. The 2012 campaign was accompanied by detailed ground penetrating radar surveys on top of the palaeolithic layers after uncovering the topsoil.

3.8 Dissemination and communication

In regard to this work package a detailed dissemination strategy as well as an internal "Communication guidelines document" were developed for 2012. A media contact database was set up to render the LBI ArchPro press releases more effective in the future. Additionally, monthly updates on events and press-releases are placed to the LBI ArchPro website. The LBI ArchPro folder was translated into English and a Booklet for the Carnuntum LBI ArchPro project was prepared and printed. Regarding the work package "Public relations" please see the section 1.8 at the beginning of the report.

A number of internationally renowned researchers and scientists visited the LBI to transfer knowledge, exchange ideas and discuss forms of scientific collaboration.

Visiting researchers:

- Alexandros Stampolidis, the Aristotle University of Thessaloniki, Dept. of Geophysics, Exploration Geophysics Laboratory, Greece
- Paul Garwood, University of Birmingham, United Kingdom
- Dominic Powlesland, University of York, United Kingdom
- Geoff Avern, consultant Nikon, United Kingdom
- Chris Gaffney, University of Bradford, United Kingdom
- Pete Horn, English Heritage, United Kingdom
- Bob Pavlik, Pico Envirotec Inc., Canada
- Ivo Mejzr, Pico Envirotec Inc, Canada
- Adam Fazzari, Sensors and Software, Canada

- Christoph Hartmann und Michael Schulz, Allsat, Germany

4. Other activities

4.1 Scientific cooperations & third party founded projects

Carnuntum ArchPro project

The prospection work conducted 2012 in Carnuntum extended over several weeks in March, July, August, September and December. Starting with the area of civil town west of the Forum ("Tiergarten") geophysical prospections were conducted further west along the Roman road; the western project area, including the amphitheatre and areas to the west of the of the "Heidentor", were completely covered. Collaboration partner Uni Ghent conducted an extended electromagnetic prospection survey in the area of the civil town.

As part of the collaboration between the Institute for Studies of Ancient Culture of the Austrian Academy of Sciences (ÖAW) and the LBI ArchPro the further interpretation of geophysical and aerial prospection data from Carnuntum has commenced in 2012. Currently, the analysis concentrates on the geophysical measurements from the area of the gladiatorial school. New publications related to the discovery of the gladiatorial school have been submitted, including extensive literature reviews, in particular the review of the earlier research into the area of the municipal amphitheatre. The Carnuntum monograph about the canabae legionis has passed in the end of 2012 last corrections and is in print. In October 2012 partner ÖAW has conducted a systematic field survey in the area of the gladiatorial school, which was funded by the Province of Lower Austria. The goal of this survey was to obtain evidence for a chronology of the settlement activities in this city region and to enable a better temporal interpretation of the geophysical and aerial archaeological results. A grid of 10 × 10 m was laid out and systematically searched by a four-person team resulting in a total coverage of 2.45 ha. The documentation and interpretation of the found material is work progress.

AirMagnet project

In relation to the FFG AirMagnet Project the PDAC International Convention was visited. At this opportunity the project partner PicoEnvirotec, supplier of the LBI ArchPro Caesium sensors and magnetometer systems was visited for fruitful discussions, as well as GPR system manufacturer Sensors & Software (the LBI uses several S&S GPR systems, amongst others two 6 channel SPIDAR systems). A first meeting with the managers of DualEM, manufacturer of novel outstanding electromagnetic imaging systems, regarding the possibility for multichannel EM systems for archaeological prospection, was held in Toronto on kind invitation by Rick Raylor and Scott Holladay.

FWF – ARAP-"Automated Rectification of Aerial Photographs"

For the corresponding results see "Remote sensing data acquisition".

St. Gilgen / Falkenstein (A)

In summer 2012 a small-scale investigation of an old pilgrimage site at Falkenstein was successfully conducted. Near the church at Falkenstein in St. Gilgen, situated on the pathway to St. Wolfgang, two previously unknown basement rooms and a wooden water pipe related to a mythological spring were found, laying in the foundations of a long-forgotten hermitage.

4.2 LBI ArchPro workshops and scientific events

Joint IC ArchPro-Workshop 2 "Geophysical Prospection“

27. - 29. February 2012, ZAMG – Central Institute for Meteorology and Geodynamics, Vienna, Austria

Workshop "Latest Developments in Remote Sensing and Geophysical Prospection"

24. - 26. October 2012, Schloss Hernstein, Austria

Joint IC ArchPro-Workshop 3 "Interpretation“

26. - 29. November 2012, Hotel Veltlin, Poysdorf, Austria

LBI ArchPro - Team-Workshop Halbturn

LBI ArchPro team workshop took place on 15th and 16th March 2012 in Halbturn, Austria. The workshop was moderated by VIP Consulting, Vienna.

Meet Science 2012

"Meet Science" is organized periodically by the Ludwig Boltzmann Gesellschaft, focusing on the presentation of research funded by the LBG to the interested public. On October 23rd 2012 the LBI ArchPro has participated in the event together with other Ludwig Boltzmann Institutes and Clusters. The video production presented at the Meet Science event is available from http://archpro.lbg.ac.at

4.3 Teaching activities

Summer 2012

Wolfgang Neubauer, University of Vienna

- 060089 UE Practice in archaeological stratigraphy, together with Martin Fera
- 060090 PV Privatissimum
- 060091 LG Excavation practice II
- 060102 SE Geophysical prospection
- 060104 SV Stonehenge - the biography of an archaeological landscape, together with Paul Garwood, Unviversity of Birmingham, GB
- 060105 SV Prospecting Archaeological Landscapes - From Landscape to Lostscape. A third of a century searching for the archaeology of the Vale of Pickering, together with Dominic Powlesland, York University, GB

Michael Doneus, University of Vienna

- 060038 UE+EX Excursion abroad (12-day) Southern Norway / Southern Sweden, together with Erich Draganits and Wolfgang Neubauer
- 060041 SE SE Geoarchäologie
- 060095 UE Surveying for archaeologists, together with Wolfgang Neubauer
- 060097 PV Privatissimum

Immo Trinks, University of Vienna

- 060100 PR Geophysical prospection, practical training
- 060101 SV Magnetic and electromagnetic prospecting - Theory and Practice

Matthias Kucera, University of Vienna

- 060116 UE Experimental Archaeology, together with Mathias Mehofer , Stefan Eichert , Hannes Herdits , Wolfgang Lobisser , Franz Pieler and Johann Reschreiter

Christian Briese, TU Vienna

- 122428 UE Topographic models, together with Norbert Pfeifer and Gottfried Mandlburger

Winter 2012/2013

Wolfgang Neubauer, University of Vienna

- 060042 SE Interpretation of prospection data
- 060046 PV Privatissimum
- 060051 VO Selected Aspects of Viking Age, together with Knut Paasche, NIKU, N
- 060055 SV Stonehenge and timber circles, together with Alex Gibson, University of Bradford

Michael Doneus, University of Vienna

- 060035 VO STEOP: BA VO aus: Grundlagen — Luftbildarchäologie
- 060036 UE GIS-Anwendungen in der Archäologie
- 060084 UE Extensive und intensive Feldbegehungen
- 060102 PV Privatissimum
- 060119 VU Luftbildarchäologische Interpretation

Immo Trinks, University of Vienna

- 060056 VO STEOP: BA VO aus: Grundlagen - Geophysikalische Prospektionsmethoden
- 060058 VU Bodenradar - Theorie und Praxis

- 060114 VU Geophysikalische Prospektion

Matthias Kucera, University of Vienna

- 060038 VO STEOP: BA VO Basics of Experimental Archaeology, together with Stefan Eichert, Karina Groemer, Hannes Herdits, Wolfgang Lobisser, Mathias Mehofer, Erich Nau, Franz Pieler, Johann Reschreiter and Ingrid Schierer
- 060072 VO STEOP: BA VO aus: Scientific Methods in Archaeology - Geo- and Bioarchaeology, together with Günther Karl Kunst , Otto Cichocki , Erich Draganits , Matthias Kucera , Gabriele Scharrer-Liška , Ursula Thanheiser , Karin Wiltschke-Schrotta , Reinhard Zetter

5. Publications and conferences

5.1 Articles in journals

Articles published in journals listed in the ISI Web of Science

1. Gaffney, Chris; Gaffney, Vince; Neubauer, Wolfgang; Baldwin, Eamonn; Chapman, Henry; Garwood, Paul et al. (2012): The Stonehenge Hidden Landscapes Project. In: *Archaeol. Prospect.* 19 (2), S. 147–155.
2. Lewisch, E.; Kucera, Matthias; Tappert, R.; Tessadri, R.; Tappert, M.; Kanz, F. (2012): Occurrence of nephrolithiasis in a population of longsnout seahorse, Hippocampus reidi Ginsburg, and analysis of a nephrolith. In: *Journal of Fish Disease 2012.*
3. Saey, Timothy; van Meirvenne, Marc; Trinks, Immo; de Smedt, Philippe; Verhoeven, Geert Julien Joanna; Neubauer, Wolfgang (in Press): Integrating multi-receiver EMI measurements to interpret the soil-landscape around the school of gladiators, Carnuntum. In: *European Journal of Soil Science*.
4. Verhoeven, Geert (2012): Near-Infrared Aerial Crop Mark Archaeology: From its Historical Use to Current Digital Implementations. In: *J Archaeol Method Theory* 19 (1), S. 132–160.
5. Verhoeven, Geert; Doneus, Michael; Briese, Christian; Vermeulen, Frank (2012): Mapping by matching: a computer vision-based approach to fast and accurate georeferencing of archaeological aerial photographs. In: *Journal of Archaeological Science* 39 (7), S. 2060–2070.
6. Zlinszky, András; Mücke, Werner; Lehner, Hubert; Briese, Christian; Pfeifer, Norbert (2012): Categorizing Wetland Vegetation by Airborne Laser Scanning on Lake Balaton and Kis-Balaton, Hungary. In: *Remote Sensing - Open Access Journal* 4 (6), S. 1617–1650.

Articles with peer-review published in national journals

1. Neubauer, Wolfgang (2012): Kreisgrabenanlagen – Middle Neolithic Ritual Enclosures in Austria 4800-4500 BC. In: Alex Gibson (Hg.): Enclosing the neolithic. Recent studies in Britain and Europe British. Oxford: Archaeopress (BAR International Series, 2440).
2. Schreg, Reiner; Kastowsky-Priglinger, Karolin; Trinks, Immo (2012): Großflächige archäologische Landschaftsprospektion auf der Stubersheimer Alb. In: *Archäologische Ausgrabungen in Baden-Württemberg* 2011, S. 39–44.
3. Doneus, Michael; Kühtreiber, Thomas (in Press): Landscape, the Individual and Society: Subjective Expected Utilities in a Monastic Landscape near Mannersdorf am Leithagebirge, Lower Austria. In:

Natascha Mehler (Hg.): Historical Archaeology in Central Europe (Society of Historical Archaeology Special Publications).

Articles published in journals without peer-review

1. Gabler, Manuel; Trinks, Immo (2012): Large-scale archaeological prospection of the Iron Age central place Uppåkra. In: *ISAP News* (30), S. 6–8.
2. Neubauer, Wolfgang; Seren, Sirri (2012): Die Entdeckung der Gladiatorenschule in Carnuntum. In: *Acta Carnuntina*, S. 4–13.
3. Verhoeven, Geert (2012): Straightforward archeological orthophotos from oblique aerial images. In: *SPIE Newsroom*. http://spie.org/x90865.xml.
4. Verhoeven, Geert; Doneus, Michael; Briese, Christian (2012): Computer vision techniques: towards automated orthophoto production. In: *AARGnews* 44, S. 8–11.
5. Zotti, Georg; Skarits, H. (2012): Zwischen Solstitium und Äquinox. Astronomie+ Raumfahrt. In: *Astronomie+ Raumfahrt49* 49 (6), S. 23–45.

5.2 Books and book chapters

1. Doneus, Michael (in Press). Die hinterlassene Landschaft. Erkennen, Erklären und Verstehen in der Landschaftsarchäologie. Mitteilungen der Prähistorischen Kommission: Verlag ÖAW.
2. Doneus, Michael; Gugl, Christian; Doneus, Nives (2013). Die Canabae von Carnuntum – ein Modell für römische Lagervorstädte? Von der Luftbildprospektion zur siedlungsarchäologischen Synthese. Römischer Limes in Österreich 47: Verlag ÖAW.
3. Doneus, Michael; Griebl, Monika (Eds.) (in Press): Die Leitha - Facetten einer archäologischen Landschaft. Wien: Verlag Österreichische Gesellschaft für Ur- und Frühgeschichte (Archäologie Österreichs Spezial).
4. Doneus, Nives (Ed.) (in Press). Halbturn I. Das kaiserzeitliche Gräberfeld von Halbturn, Burgenland: Archäologie und Geschichte (Band 1), Intention, Abfall oder Zufall - naturwissenschaftliche Untersuchungen (Band 2). Monographien RGZM: Verlag RGZM.
5. Neubauer, Wolfgang; Doneus, Michael; Trinks, Immo; Verhoeven, Geert; Hinterleitner, Alois; Seren, Sirri; Löcker, Klaus (2012): Long-term Integrated Archaeological Prospection at the Roman Town of Carnuntum/Austria. In: Paul Johnson und Martin Millett (Hg.): Archaeological Survey and the City. University of Cambridge Museum of Classical Archaeology. Oxford: Oxbow (Monograph Series, No. 3), S. 202–221.
6. Verhoeven, Geert (2012): Methods of visualisation. In: Howell G. M. Edwards und Peter Vandenabeele (Eds.): Analytical Archaeometry. Selected Topics. Cambridge: Royal Society of Chemistry, S. 3–48.
7. Verhoeven, Geert (2012): Rethinking the Spectrum – The Digital (R)Evolution in Archaeological Aerial Reconnaissance. In: Paul Johnson und Martin Millett (Hg.): Archaeological Survey and the City. University of Cambridge Museum of Classical Archaeology. Oxford: Oxbow (Monograph Series, No. 3), 45-67.

5.3 Conference proceedings

Full articles in proceedings of scientific conferences

1. Briese, Christian; Pfennigbauer, M.; Lehner, Hubert; Ullrich, Andreas; Wagner, W.; Pfeifer, N. (2012): Radiometric Calibration Of Multi-Wavelength Airborne Laser Scanning Data. In: Mark R. Shortis, W. Wagner und J. Hyyppä (Hg.): XXII ISPRS Congress, Technical Commission VII, 1-7. Imaging a Sustainable Future. Melbourne, Australia, 25 August - 01 September, 2012. ISPRS: ISPRS (ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., 1-7), S. 335–340.
2. Briese, Christian; Zach, Gerald; Verhoeven, Geert Julien Joanna; Ressl, Camillo; Ullrich, Andreas; Studnicka, Nikolaus; Doneus, Michael (2012): Analysis of mobile laser scanning data and multi-view image reconstruction. In: Mark R. Shortis und J. Mills (Hg.): Proceedings of the XXII ISPRS Congress, Vol. XXXIX- B5. Imaging a Sustainable Future. Melbourne, Australia, 25 August - 01 September, 2012. ISPRS: ISPRS (ISPRS Archives, Volume XXXIX), S. 163–168.
3. Neubauer, Wolfgang; Doneus, Michael; Trinks, Immo (2012): Advancing the Documentation of Buried Archaeological Landscapes. In: Mark R. Shortis und J. Mills (Hg.): Proceedings of the XXII ISPRS Congress, Vol. XXXIX- B5. Imaging a Sustainable Future. Melbourne, Australia, 25 August - 01 September, 2012. ISPRS: ISPRS (ISPRS Archives, Volume XXXIX), S. 547–552.
4. Pfeifer, N.; Glira, P.; Briese, Christian (2012): Direct Georeferencing With On Board Navigation Components Of Light Weight Uav Platforms. In: Mark R. Shortis und J. Mills (Hg.): Proceedings of the XXII ISPRS Congress, Vol. XXXIX-B7. Imaging a Sustainable Future. Melbourne, Australia, 25 August - 01 September, 2012. ISPRS: ISPRS (ISPRS Archives, Volume XXXIX), S. 487–492. http://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XXXIX-B7/487/2012/.
5. Pregesbauer, Michael; Briese, Christian; Verhoeven, Geert; Doneus, Michael (2012): Towards fuzzy hyperspectral edges. Radiometric strip adjustment of AIS data. In: Proceedings of the EAGE Near Surface Geoscience 2012. Paris, France, 3 - 5 September 2012.
6. Trinks, Immo; Neubauer, Wolfgang; Doneus, Michael (2012): Prospecting Archaeological Landscapes. In: Marinos Ioannides, Dieter Fritsch, Johanna Leissner, Rob Davies, Fabio Remondino und Rossella Caffo (Hg.): Progress in cultural heritage preservation. 4th International Conference, EuroMed 2012 : Limassol, Cyprus, October 29-November 3, 2012 : proceedings. Lemessos, Cyprus, 29.10.-03.11.2012. Berlin, Heidelberg: Springer. http://link.springer.com/chapter/10.1007/978-3-642-34234-9_3.
7. Zotti, Georg; Neubauer, Wolfgang (2012): A Virtual Reconstruction Approach for Archaeoastronomical Research. In: Gabriele Guidi und Alonzo C. Addison (Hg.): 18th International Conference on Virtual Systems and Multimedia. Milan, Italy, 02.-05.09.2012. IEEE, S. 33–40.
8. Zotti, Georg; Neubauer, Wolfgang (2012): Virtual Reconstructions in a Desktop Planetarium for Demonstrations in Cultural Astronomy. In: Marinos Ioannides, Dieter Fritsch, Johanna Leissner, Rob Davies, Fabio Remondino und Rossella Caffo (Hg.): Progress in cultural heritage preservation. 4th International Conference, EuroMed 2012 : Limassol, Cyprus, October 29-November 3, 2012 : proceedings. Lemessos, Cyprus, 29.10.-03.11.2012. Berlin, Heidelberg: Springer, S. 170–180. http://link.springer.com/chapter/10.1007/978-3-642-34234-9_17.

Abstracts of conference papers, posters

1. Atzberger, Clement; Wess, Michael; Verhoeven, Geert; Doneus, Michael (2012): A Matlab GUI for Imaging Spectroscopy in Archaeology. In: EARSeL Workshop 2012 Ghent. Advances in Remote

Sensing for Archaeology and Cultural Heritage Management. Programme and Book of Abstracts. EARSeL. Ghent, S. 9–10.

2. Briese, Christian; Doneus, Michael; Verhoeven, Geert (2012): The spectral dimension of a point cloud – finding crop marks in radiometrically calibrated ALS data. In: EARSeL Workshop 2012 Ghent. Advances in Remote Sensing for Archaeology and Cultural Heritage Management. Programme and Book of Abstracts. EARSeL. Ghent, S. 20–21.
3. Briese, Christian; Pfennigbauer, M.; Ullrich, Andreas; Pfeifer, Norbert (2012): Radiometric Analysis of Mulit-Wavelength Airborne Laser Scanning Data of Different Case Study. In: Silvilaser 2012. 12th International Conference on LiDAR Applications for Assessing Forest Ecosystems. Vancuver, Canada, 16.-19.09.2012, S. 128. Online verfügbar unter http://silvilaser2012.com/wp-content/uploads/2011/11/Silvilaser2012_Program_Abstracts.pdf.
4. Doneus, Michael; Verhoeven, Geert; Pregesbauer, Michael; Briese, Christian; Trinks, Immo; Rathmanner, Mario (2012): Advanced archaeological airborne remote sensing. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 35.
5. Doneus, Nives; Pregesbauer, Michael; Doneus, Michael (2012): Land and Water – connecting topography in maritime archaeology. Abstract. In: EAA 18th annual meeting. European Association of Archaeologists. Abstracts. Helsinki, Finland, 29.08.-01.09.2012, S. 299.
6. Fera, Martin; Neubauer, Wolfgang; Doneus, Michael (2012): 3D documentation and visualization of stratigraphic excavations. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 28.
7. Kucera, Matthias; Nau, Erich; Kastowsky, Karolin; Schneidhofer, Petra; Fera, Martin (2012): Terrestrial 3D laser scanning in archaeology. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 36.
8. Neubauer, Wolfgang; Doneus, Michael; Trinks, Immo; Verhoeven, Geert; Hinterleitner, Alois; Humer, Franz et al. (2012): The Roman town of Carnuntum – an outstanding example of long-term integrated archaeological prospection. In: The Roman Archaeology Conference 22. Frankfurt am Main, Germany, 29.03 - 01.04.2012. Abstracts. Institutum Archeologicum Germanicum. Frankfurt am Main, S. 25.
9. Neubauer, Wolfgang; Nau, Erich; Trinks, Immo; Seren, Sirri; Löcker, Klaus; Klein, Michael (2012): The school of gladiators at Carnuntum - virtual reconstruction based on archaeological prospection data. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 44.
10. Neubauer, Wolfgang; Seren, Sirri; Hinterleitner, Alois; Doneus, Michael; Löcker, Klaus; Trinks, Immo et al. (2012): Integrated geophysical archaeological prospection resulting in the discovery of the school of gladiators in the Roman town of Carnuntum in Austria. In: Proceedings of the 82nd Annual Meeting of the Society of Exploration Geophysicists. SEG Technical Program Expanded Abstracts. 82nd Annual Meeting of the Society of Exploration Geophysicists. Las Vegas, Nevada, USA, 4-9 November, 2012. Las Vegas: Society of Exploration Geophysicists.
11. Poscetti, Valeria; Trinks, Immo; Neubauer, Wolfgang (2012): 3D archaeological interpretation of ground penetrating radar data. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 34.

12. Pregesbauer, Michael; Trinks, Immo; Kucera, Matthias; Nau, Erich; Löcker, Klaus; Hinterleitner, Alois et al. (2012): Large-scale high-resolution near-surface geophysical prospection for the investigation of archaeological landscapes. In: Proceedings of the 82nd Annual Meeting of the Society of Exploration Geophysicists. SEG Technical Program Expanded Abstracts. 82nd Annual Meeting of the Society of Exploration Geophysicists. Las Vegas, Nevada, USA, 4-9 November, 2012. Las Vegas: Society of Exploration Geophysicists.

13. Trinks, Immo; Löcker, Klaus; Neubauer, Wolfgang; Seren, Sirri; Hinterleitner, Alois (2012): Large scale high-resolution geophysical prospection in archaeology. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 19.

14. Trinks, Immo; Nau, Erich; Löcker, Klaus; Gabler, Manuel; Pregesbauer, Michael; Biwall, Anders et al. (2012): Large-scale archaeological prospection of Iron Age Central Places in Sweden. Poster. In: EAA 18th annual meeting. European Association of Archaeologists. Abstracts. Helsinki, Finland, 29.08.-01.09.2012, S. 119.

15. Verhoeven, Geert; Doneus, Michael; Briese, Christian; Atzberger, Clement (2012): Turning hyperspectral pixels into archaeological information. In: EARSeL Workshop 2012 Ghent. Advances in Remote Sensing for Archaeology and Cultural Heritage Management. Programme and Book of Abstracts. EARSeL. Ghent, S. 81–82.

16. Verhoeven, Geert; Doneus, Michael; Briese, Christian; Atzberger, Clement (2012): Turning Hyperspectral Pixels into Archaeological Information. In: Aerial Archaeology, Remote Sensing and the Archaeological Process (AARG 2012). Budapest, Hungary. Programme and Abstract volume. Budapest, S. 11.

17. Verhoeven, Geert; Doneus, Michael; Briese, Christian; Neubauer, Wolfgang; Doneus, Nives; Trinks, Immo et al. (2012): Latest developments in remote sensing of Roman urban and rural sites in Austria. In: The Roman Archaeology Conference 22. Frankfurt am Main, Germany, 29.03 - 01.04.2012. Abstracts. Institutum Archeologicum Germanicum. Frankfurt am Main, S. 25–26.

18. Zlinszky, A.; Mücke, W.; Lehner, Hubert; Briese, Christian; Pfeifer, N. (2012): Vegetation mapping from medium-density discrete echo Airborne Laser Scanning data: a case study of the Lake Balaton wetlands. In: European Geosciences Union General Assembly 2012. Geophysical Research Abstracts. Vienna, Austria, 22.-27.04.2012 (EGU2012-11539,, Vol. 14).

19. Zotti, Georg; Neubauer, Wolfgang (2012): Virtual relity in archaeo-astronomical research. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 25.

20. Zotti, Georg; Neubauer, Wolfgang (2012): Virtual reality reconstruction and astronomical simulation of Neolithic monuments in Austria. In: The First International Conference «Virtual Archaeology-2012«. Program and abstracts. Saint-Petersburg (Russian Federation), 4-6 June, 2012, S. 40.

5.4 Invited scientific lectures

1. Briese, Christian (2012): New techniques and future possibilities of ALS. Workshop: One Decade of Airborne Laser Scanning at Hintereisferner. Obergurgl, Austria, 03.10.2012.

2. Briese, Christian (2012): Airborne Laserscanning Burgenland - Qualitätskontrolle. Fachtagung der Energie Burgenland Geoservice GmbH "Aktuelle Erfahrungsberichte und Entwicklungen im ALS zur Erfassung von Infrastruktureinrichtungen. Frauenkirchen, Austria, 22.11.2012.
3. Doneus, Michael (2012): Remote Sensing in Archaeology. DITECUR – Digital technologies in cultural landscape research. ERASMUS Lifelong Learning Programme, Intensive Programme. University of Zagreb. Zagreb, Croatia, 30.01.2012-12.02.2012.
4. Doneus, Michael (2012): Integrierte archäologische Prospektion – neueste Entwicklungen und Anwendungen. Ringvorlesung "DENKEN und MESSEN – Naturwissenschaftliche Methoden in der Archäologie. University of Graz. Graz, Austria, 20.03.2012.
5. Doneus, Michael (2012): Die hinterlassene Landschaft - Prospektion und Landschaftsarchäologie. Archäologisches Kolloquium. Institut für Archäologie, Denkmalkunde und Kunstgeschichte. Otto-Friedrich-Universität Bamberg. Bamberg, Germany, 24.04.2012.
6. Doneus, Michael (2012): Integrierte archäologische Prospektion - neueste Entwicklungen und Anwendungen. Vortragsreihe des Zentrums Archäologie und Altertumswissenschaften. ÖAW. Vienna, Austria, 12.06.2012.
7. Doneus, Michael (2012): 3D visualisation of survey and excavation data. Third Specialization Forum "3D visualisation for the study and management of complex archaeological sites". RADIO Past, NOEL. Carnuntum, Austria, 02.07.2012.
8. Doneus, Michael (2012): Airborne, ground based and underwater - advancing integrated archaeological prospection. EARSeL Workshop: Advances in Remote Sensing for Archaeology and Cultural Heritage Management. Uni Ghent, EARSeL. Ghent, Belgien, 19.09.2012.
9. Doneus, Michael (2012): Advancing the documentation of buried and submerged archaeological landscapes. Seminar at School of Archaeology. University College Dublin. Dublin, Irland, 29.11.2012.
10. Doneus, Michael (2012): Advancing the documentation of buried and submerged archaeological landscapes. Keynote. lrish Quaternary Association Annual Symposium 2012: Remote Sensing: Applications in Quaternary Science, archaeology and landscape management. Geological Survey of Ireland. Dublin, Irland, 30.11.2012.
11. Trinks, Immo (2012): Archäologische Prospektion - Mit Bodenradar und Magnetometer auf den Spuren vergangener Kulturen. Archäologischer Verein in Freising. Freising, Germany, 28.02.2012.
12. Trinks, Immo; Nau, Erich (2012): Geophysical surveys at Gokstad 2011-2012 - Results and future plans. Gokstad revitalised seminar. Sandefjord, Norway, 26.03.2012.
13. Verhoeven, Geert Julien (2012): The Archaeological application of LAAP. Archaeolandscapes Aerial Archaeology Summer School 2012. Mérida, Spain, 19.06.2012.
14. Verhoeven, Geert Julien (2012): Near-infrared and near-ultraviolet aerial imaging. Archaeolandscapes Aerial Archaeology Summer School 2012. Mérida, Spain, 20.06.2012.
15. Verhoeven, Geert Julien (2012): New techniques in 3D mapping - Using Structure from Motion (SfM) in aerial archaeology. Archaeolandscapes Aerial Archaeology Summer School 2012. Mérida, Spain, 20.06.2012.
16. Verhoeven, Geert Julien (2012): (Airborne) Digital Photography at Portus and Isola Sacra. Portus Workshop: Research during 2009/2010. British School of Rome. Rome, Italy, 12.07.2012.

17. Verhoeven, Geert Julien (2012): Mapping history from the air - Combining low-altitude camera platforms and computer vision techniques to inventory papaeontological and archaeological sites in four dimensions. Digital Fossil 2012. Museum für Naturkunde. Berlin, Germany, 26.09.2012.

5.5 Other lectures (not included in conference proceedings)

1. Briese, Christian; Pfennigbauer, M.; Ulrich, A.; Pfeifer, Norbert (2012): Radiometric Analysis of Mulit-Wavelength Airborne Laser Scanning Data. ELMF (Europen Lidar Mapping Forum). Salzburg, Austria, 04.12.2012.
2. Doneus, Michael; Doneus, Nives; Briese, Christian (2012): Airborne laser scanning and Mediterranean environments - Croatian case studies. Hrvatsko Arheološko Društvo. Mali Lošinj, Croatia, 01.10.2012.
3. Doneus, Michael; Doneus, Nives; Pregesbauer, Michael; Briese, Christian (2012): ALB - Airborne laser bathymetry: underwater prospection in Croatia. Hrvatsko Arheološko Društvo. Mali Lošinj, Croatia, 01.10.2012.
4. Doneus, Michael (2012): Luftbildarchäologie - GIS-gestütztes Archivierungssystem APIS. ESRI-Anwenderkonferenz: SynerGiS 2012. Alpbach, Austria, 23.10.2012.
5. Neubauer, Wolfgang (2012): LBI ArchPro Case study Uppåkra. Uppåkra Museum. Uppåkra, Sweden, 07.09.2012.
6. Roncat, A.; Wieser, M.; Briese, C.; Pfeifer, N. (2012): Experiences with Full-Waveform Data Processing and Radiometric Calibration of ALS Campaigns with C4Austria. Workshop "One Decade of Airborne Laser Scanning at Hintereisferner". Obergurgl, Austria, 03.10.2012.
7. Trinks, Immo (2012): Großflächig hochauflösende geophysikalische archäologische Prospektion mit Bodenradar und Geomagnetik. Meteorologisch-Geophysikalisches Kolloquium. Institut für Meteorologie und Geophysik in Kooperation mit ZAMG. Vienna, Austria, 07.11.2012.
8. Verhoeven, Geert Julien Joanna; Doneus, Nives; Doneus, Michael (2012): From 2D pixel to 3D vertex – accurate and straightforward three-dimensional documentation of cultural heritage from the Cres/Lošinj archipelago. Hrvatsko Arheološko Društvo. Mali Lošinj, Croatia, 01.10.2012.

5.6 Miscellaneous

Doneus, Michael (2012): Blick in die Vergangenheit. Sehen und Erkennen verborgener archäologischer Landschaften. Antrittsvorlesung an der Universität Wien. 29. Juni 2012.

Verhoeven, Geert (2012): Orthophotoproduction from archaeological aerial photographs using computer vision. In: *Profil*.