

JULY 23, 2010



BAALBEK RISK PREPAREDNESS STRATEGY PROJECT REPORT



Phase II, project on Capacity building of human resources for digital documentation of World Heritage Sites affected by 2006 war in Lebanon project is a donation of the United Nations to Lebanon

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ACKNOWLEDGEMENTS



Figure 1: recording in Temple of Bacchus, using the laser scanner in Baalbek, author.

The authors wish to acknowledge and thank the support of UNESCO Beirut The Directorate General of Antiquities (DGA) for inviting to contribute in the project entitled “Capacity building of human resources for digital documentation of World Heritage Sites affected by 2006 war in Lebanon” during Phase I and Phase II.

It has been a unique opportunity to contribute to the capacity building of Lebanese experts in the field risk preparedness, condition survey and preventive maintenance, as well as to contribute to the protection of Baalbek.

In addition, we wish to thank the support of Joseph Kreidi, Frederic Hussein , Assaad Seif, Ghassan Ghattas, Selim Germanos and the rest of the UNESCO Beirut and DGA staff for their support of this project.

We must also acknowledge the hard work and crucial contribution of our senior expert members: Pierre Smars, Teresa Patricio, Bjorn Van Genechten; as well as, our junior experts: Liesbeth Lacroix and Tom Coenegrachts, their work is the core of this project. Special thanks to Kristine Loonbeek and the staff of the Leuven Research and Development for their help in logistics.

Finally, we want to thank all those individuals and institutions that in one way or the other helped with the completion of this report.

Mario Santana Quintero – Koen Van Balen

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Figure 2: 3D point cloud of the Semi-Circular forecourt and propylaea, by A. Seif, G. Ghattas, Bureau Stéphan and B. Van Genechten.

P R E F A C E



Figure 3: T. Coenegrachts working on the surface degradation assessment, T. Patricio.

Baalbek has been inscribed on the UNESCO World Heritage list according to the following criterias:

- to represent a masterpiece of human creative genius
- (V) to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change

When reviewing the nomination file and especially looking at these two criterias, which was submitted to UNESCO in 1998 at the early stages of the World Heritage List, is evident a lack of understanding of the “significance” of the property and why it is important

to all of us, undoubtedly it is an outstanding place and worth been protected by humanity. Prior to this part of the project, a Phase I was developed, collaborating with the Directorate General of Antiquities of Lebanon, consultants from the R. Lemaire International centre for Conservation (KU Leuven) guided the 3D recording of the property using a time-of-flight laser scanning device, which produced a reliable and accurate set of 3D points clouds.

At this phase II, the current project is aimed at providing the methodological framework for “Risk Preparedness” to evaluate the rate of decay affecting the integrity of the traces in the fabric of the significance of the property. The state of conservation of a designated pilot area was studied in detail. The methodology was tested on that area. In future, it can serve as an example for future works on the entire assessment of the property.

This work represented the effort of a multidisciplinary and international team of experts from Lebanon, Belgium, Portugal and Venezuela with the support of UNESCO Beirut.

Additionally, the team has produced a number of guidelines for the preparation of measured drawings of the entire property using 3D Laser Scanning data and panoramic photography acquired during Phase I.

This report describes activities carried out by consultants from the Raymond Lemaire International Centre for Conservation (RLICC) at the University of Leuven and the University College St. Lieven according to objectives and terms of reference of the project Phase II under the framework of the '*Capacity building of human resources for digital documentation of World Heritage Sites affected by 2006 war in Lebanon*', which is a donation of the United Nations to Lebanon and administered by the UNESCO-Beirut for Lebanon's Directorate General of Antiquities (DGA).

According to the terms of reference of this project, the main objective is to build capacities of Human Resources in charge, or potentially linked with, the conservation, the development and the enhancement of tangible cultural heritage in Lebanon.

The target group will be the DGA staff and local experts while the main subject of the action is to prepare a 'Risk Preparedness Strategy' (RPS) of Baalbek World Heritage Site, based on accurate high definition 3D digital data recorded using a laser scanner.



Figure 4: participants during field training in Baalbek, author.

The International Consultant was in charge of implementing the following tasks:

- Follow up the preparation by DGA staff of a 'Site Atlas' of Baalbek from the 3D laser scanning (3DLS) data for Risk Preparedness;
- Assess previous investigation carried out in Baalbek, eventually identify gaps and additional



Figure 5: T. Patricio during field training in Baalbek, O. Kallab

issues that will provide appropriate information to prepare a RPS for this property;

- Identify methods for transferring previous 'condition assessment' investigations into the data collected using the 3D laser scanner;
- Provide training on RPS to DGA staff and local experts;
- The preparation and submission of the report on the activities carried out and Risk Preparedness Strategy proposed for Baalbek.

R E S U L T S

This project aimed at producing the following deliverables:

- A Metric Survey Site Atlas and damage atlas with information relevant for Risk Preparedness;
- The definition of the appropriate procedures in order to perform a regular update of the risk preparedness strategy to detect changes and alterations in Baalbek that might affect the integrity of the property;
- Develop capacity of DGA and local experts in Lebanon to carry out Risk Preparedness Strategies.
- Improvements in heritage site conservation by providing a workflow for preparation of Site Atlas for Risk Preparedness using 3D Laser Scanning technology.

It is important to point out that during a first mission undertaken by Dr. T. Patricio and Dr. P. Smars, the senior experts carried out an extensive assessment of documents and available information in possession of the DGA, which were the proposed base for the elaboration of the Risk Preparedness Strategy according to the Terms of Reference of Phase 2 with our institution. The assessment revealed that the available information on surface degradations was insufficient and incomplete.

AREA OF INTEREST

North-Western semi-circular room of the Great Court

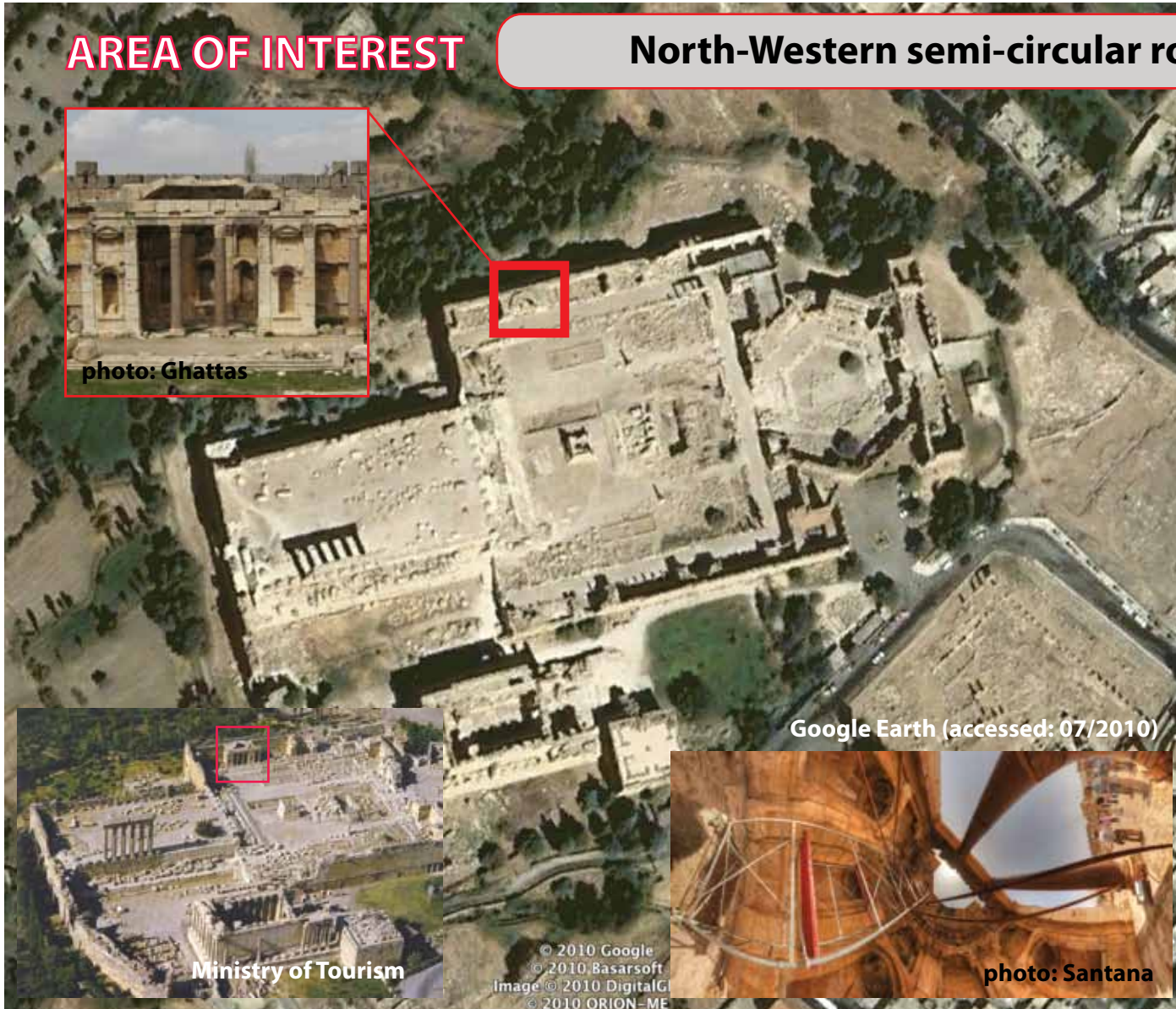


Figure 6: area of interest



of its size - its reduced dimensions allows to develop in detail the methodology in the time span of the project



It offers the possibility to study the "time dimension" – the semi-circular chamber was restored by anastylosis in the 20th century



It presents an interest from the view point of surfaces and structural pathology



the existing pathologies at the North-Western semi-circular chamber of the Great Court are very must characteristics of the Baalbek degradations.

This required developing a “rapid-assessment” in situ to acquire a reliable surface degradation mapping approach.

For this reason, a revision of the original program schedule was proposed. The missing information was fundamental to give a sound base to the risk map. In this new plan, Dr T. Patricio, expert in condition assessment undertook 2 more field missions and Dr. Bjorn Van Genechten undertook one additional mission. As well as, the inclusion of a second junior expert in conservation to assist the DGA in mapping the surface degradations.

Subsequently, it was decided to limit the area of interest to the ‘North-Western semi-circular chamber’ of the Great Court. According to Mission Report 1: this area was chosen because (see appendix 5.1):

- Of its limited size; its reduced dimensions allows to develop in detail the methodology in the time span of the project;
- It offers the possibility to study the “time dimension” – the semi-circular chamber was restored by anastylosis in the 20th century;
- It presents an interest from the viewpoint of surfaces and structural pathology – the existing pathologies at the North-Western semi-circular chamber of the Great Court are very

representative for the degradations at the Baalbek site.

This pilot area provided the opportunity to develop a “sound methodology” in the long-term for the DGA to carry an extensive risk preparedness assessment of the entire property in the future. For an extensive explanation of the approach, please consult Appendix 5.1.

Furthermore, the ash cloud covering the flying space of Europe affected several missions and delayed the implementation of Activity 3, which had to be rescheduled..

Other obstacles were identified in the digitizing of condition survey maps, as the DGA encountered unexpected administrative shortages and the workflow was more complicated than it seemed. However, the project experts decided to prepare the risk preparedness strategy in spite of these issues, as this workflow can be improved in the future with future collaboration.

In addition, to the work carried out, a dissertation at master level for conservation of monuments and sites at the R. Lemaire International Centre for Conservation (University of Leuven) has been produced by Liesbeth Lacroix with the information and experience acquired during this phase of the project. The thesis will be sent to the DGA and UNESCO after presentation in September 2010.

DELIVERABLES

The project deliverables consist in the following products:

- **Risk Preparedness strategy (consult Appendix 1):** this document describes surface research on the risk/hazards affecting the carried out on the North-Western semi-circular chamber of the Great Court selected in the World Heritage Property of Baalbek, based on the damage atlas, condition survey and structural pathology interpretation;
- **Surface condition and Degradation atlas (consult Appendix 2.1 and 2.2):** carried out on the North-Western semi-circular chamber of the Great Court consisted firstly Degradation Atlas, which is followed by the condition of the surface recording by graphical registration of the degradations. This was based on the Mapping the standards and specifications defined by the ICOMOS International Scientific Committee for Stone (ISCS), illustrated glossary on stone deterioration patterns, were followed;
- **Structural Pathology Interpretation (consult Appendix 3):** carried out on the North-Western semi-circular chamber of the Great Court to assess the structural integrity based on the 3D

laser scanner dataset and careful observation consisted on assessment of cross sections (on critical areas), analysis of horizontal deformations, analysis of rotations of blocks, mapping of crack pattern, and Analysis of the horizontality of the joints;

- **Procedures for the creation of orthophotographs based on the point-cloud using Cyclone (consult Appendix 4.1):** this document provides a guidelines and tutorial to generate colour ortho-projections of heritage places recorded with laser scanning and 360 panoramic photography.
- **Procedures on generating a mesh and creating slices using the Geomagic software (consult Appendix 4.2):** this document provides a step-by-step manual on how to produce these type of representations for condition survey;
- **Mission reports:** providing detailed information on the schedules, progress and results of each activity have been included in Appendix 5.

These deliverables have been prepared to provide an accurate picture of the results of the Risk Preparedness Strategy, based on the careful assessments and guidelines developed in close collaboration with the DGA throughout the entire phase II.

A C T I V I T I E S

This part describes briefly the activities implemented, progress and results at each stage of work. Consult chart 1 for information on the dates and length of each activity.

ACTIVITY 1: ASSESSMENT OF EXISTING INFORMATION RELEVANT FOR RISK PREPAREDNESS

This activity took place in Beirut and Baalbek, it involved the assessment of existing information relevant for the preparation of the risk preparedness strategy, as well as, to establish how the 3D point cloud captured with the laser scanner will be used to produce a reliable dataset for condition survey.

In collaboration with Dr. Assaad Seif and Ghassan Ghattas from the DGA, Dr. Pierre Smars, Dr. Teresa Patricio, and Dr. Bjorn Van Genechten were involved in two missions. An outline of the result is provided in Appendix 5.1 and 5.2 containing the mission reports..

This first mission was crucial to identify the lack

of sufficient information available to prepare a Risk Preparedness Strategy that permitted reformatting the schedule of activities and provide more time for field assessments to overcome this obstacle.

The second mission, which overlap between Activity 1 and 2 allowed defining the procedures and production of the following products for the condition survey:

- Orthophotographs at a scale 1/20 for each 'element' of the room;
- Horizontal and Vertical sections at critical places through the walls;
- Depth maps & Normal maps to indicate rotations;
- Crack and joint maps.

ACTIVITY 2: PREPARATION OF SITE ATLAS

This activity consisted in the preparation of measured maps needed by the condition survey and structural integrity experts to assess the risk of the site; it involved debriefing meetings in Belgium with Dr. Bjorn Van Genechten and Dr. Teresa Patricio, as well as, a field mission of three weeks to Lebanon.

The field mission was carried out by Liesbeth Lacroix

PROJECT IMPLEMENTATION: SCHEDULE

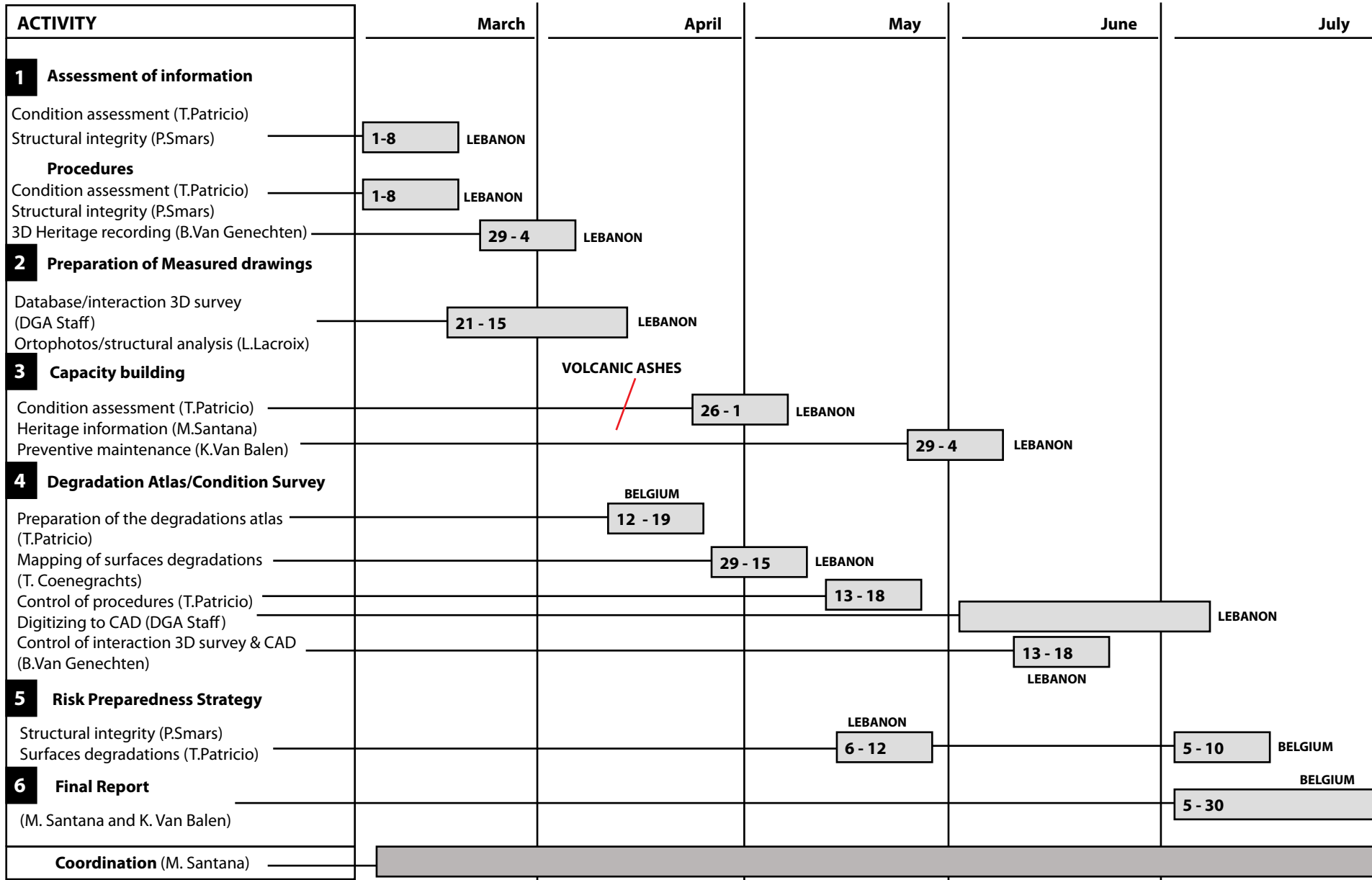


Chart 1:

(junior expert), who under the coordination of Dr. Assaad Seif assisted Ghassan Ghattas (DGA documentation expert) in the preparation of measured drawings of the area of interest to the Northwestern semi-circular room of the Great Court as mentioned previously on Activity 1. The delivered products consisted of the following items:

- The Orthophotographs and Depth maps in TIFF format
- AutoCAD files with the imported Orthophotographs and Depth maps
- PDF files of all Orthophotographs and Depth maps (A3-format)

In addition the “Procedures for the Creation of Orthophotographs Based on the Point Cloud Using *Cyclone*” and the “Procedures on generating a mesh and creating slices using the Geomagic software” were prepared for future work using these applications with laser scanning point clouds (Please consult Appendix 4.1 and 4.2). More information about this activity can be found on Appendix 5.3 containing the mission report.

ACTIVITY 3 RISK PREPAREDNESS TRAINING: PREVENTIVE MAINTENANCE

This activity consisted in the preparation and



Figure 7: coloured point cloud of pilot area, G. Ghattas.

implementation of a training programme tailored for DGA staff about condition survey, risk preparedness and preventive maintenance. It involves two missions to Lebanon, each mission (Beirut, Lebanon). The training contents were developed in close collaboration with Dr. Assaad Seif. UNESCO Beirut assisted in providing logistics and meals.

The training course included two modules:



Figure 8: DGA experts during field training in Baalbek, author.

1. Surface degradation identification and mapping: this module was taught by Dr. Teresa Patricio during a three-days sessions.
2. Heritage information for Monitoring and Preventive Maintenance: this part was taught by Dr. Mario Santana Quintero and Prof, Dr. Koen Van Balen and involved a three-days sessions with a field excursion to Baalbek.

The training consisted on the following activities:

- Lectures, including fundamentals and illustrated by case studies;
- Fieldwork, hands-on training on archaeological

sites, including Baalbek;

- Discussion sessions, involving the understanding of skills acquired during the training, as well, as consensus building around the issues affecting Baalbek and relevant to the preparation of a Risk Preparedness Strategy;
- Wrap up sessions and a demo on condition survey applications.

To support the lectures and fieldwork, a 4GB memory stick was provided to each participant containing the lectures, an extensive bibliography of reference documents and results of the wrap up sessions. An evaluation on the quality of the training was performed. More details can be found on Appendix 5.4 and 5.5.

ACTIVITY 4: RAPID-ASSESSMENT OF DEGRADATIONS OF AND ITS DIGITIZING

This activity 4 consisted on the “Surfaces Condition Mapping of the North-Western semi-circular chamber of the Great Court at Baalbek”. It involved three phases of work:

- Phase 1:
 - Classification by the Identification of the existing surface degradations.



Figure 9. P. Smars and A. Seif during reconnaissance of Baalbek, T. Patricio

- Phenomenological registration by the description of the observed and identified damages.
- Photographical registration of every representative type of the identified patterns.
- Preparation of the illustrated Atlas (please see annex 2).

- Phase 2:
 - Graphic registration of the surface degradations of the North-Western semicircular chamber of the Great Court using the basemaps the prepared with ortho projections by Liesbeth Lacroix and the DGA.
- Phase 3:
 - Digitalization of surface degradations mapped using automatic and semi-automatic approaches.

Phase 1 and 2 in collaboration with Dr. Assaad Seif and Ghassan Ghattas from the DGA, involved the participation of Dr. Teresa Patricio in the preparation of the illustrated atlas and Tom Coenegrachts (Junior expert), who travelled to Lebanon and stayed for three weeks to carry out the graphic registration of surface degradations. He carried out extensive fieldwork on Baalbek, he was assisted by Ms Laure Salloum, archaeologist of the Baalbeck region and responsible for the site of Baalbek, who installed a movable scaffolding on the area selected for the condition survey work. More information can be found on Appendix 2 (Damage Atlas), 5.4, and 5.5.

Phase 3, involved a mission of Dr. Bjorn Van Genechten to Lebanon for 5 days, which in collaboration with Dr. Assaad Seif and Ghassan Ghattas from the DGA, carried out tests on automatic and semi-automatic approaches to

digitize surface degradation maps. These tests proved inadequate, because intensive manual checking procedure was necessary to ensure the quality of the digitalization. The main problems were caused by the fact that the line drawings were made with pencils, which does not provide clear, undoubtfull lines, and also by the fact that the hatching patterns were not consistent enough to ensure proper hatch recognition.

Finally a decision was made to perform the digitalization manually. To ensure that the condition mapping expert and the structural expert will have a proper dataset to work with for the risk analysis of the site, it was decided to have the digitalization finished by the 31st of may, however, the digitalization time lasted until beginning of July 2010 due to unforeseen problems caused by the Ash Cloud in Europe and unforeseen load of work at the DGA.

ACTIVITY 5: RISK PREPAREDNESS STRATEGY

This activity involved a mission to Lebanon, in which Dr. Teresa Patricio and Dr. Pierre Smars carried out addition assessment work for the preparation of the strategy, as well as, meetings with Dr. Assaad Seif and Ghassan Ghattas from the DGA, to review progress



Figure 10: field session during training of the DGA staff, author.

of digitalization of surface degradations maps and the strategy. As mentioned in Activity 4, the progress of the damage atlas was affected by the delay in finalizing the digitization of the surface condition maps, in Appendix 5.9 a short report is given about this procedure.

Furthermore, the mission report in Appendix 5.8 underlines the meetings with the DGA and international experts about the preparation of the “Risk Preparedness Strategy”, in which focus was given to identify all those hazards/risk identified during the condition survey, as well as other hazards/risk that the project might not have considered.

Additionally, a debriefing meeting was organized in Belgium with Dr, Mario Santana Quintero to review the strategy structure and reporting. This activity also had foreseen office work in Belgium in order to compile the RPS.

The final delivery of this activity is provided in Appendix 1, compiling the different assessment carried out throughout this phase of work in order to deliver a sound “Risk Preparedness Strategy” of the pilot area that can be replicated to assess the entire property of Baalbek.

ACTIVITY 6: FINAL REPORT

This activity involves a consensus building among experts involved in the project and the coordination team to prepare a wrap-up summary of the project achievements in the preparation of the different deliverables. It involved office work in Belgium with extensive exchange of electronic correspondence.

RECOMMENDATIONS

HERITAGE INFORMATION STRATEGY AT BAALBEK

As described by Letellier (2007, p. xiii): *“As a prerequisite for informed conservation, recording is a prime responsibility of everybody involved in conservation processes. All those involved with the understanding, care, and management of a heritage place must have access to existing information and will generate records, which must be preserved and made available to others. It is the task of heritage managers and decision makers to establish policies and programs for the correct recording and effective management of conservation-related information”*.

The group of experts involved in this project carried out an exhaustive research on existing documentation of the property, this included previous mitigations, archaeological research reports, development projects, brochures, etc.

This part represented a considerable investment of time; it is recommended that the DGA should review their current “heritage information strategy”, as not only essential documentation is on heritage places

difficult to fully identified, but also by adopting the use of laser scanning and other digital tools that triplicate the amount of information that can be captured of a property in specific periods of time will become unmanageable.

The experience with the incomplete data set made available at the start of the project demonstrates that the DGA should request data in a format and level of accuracy and of reliability to be able to use them for the monitoring and the management of the site. DGA’s heritage information system should reflect those requirements towards information providers.

Critical questions about the future of the information collected in this project deal with are:

- By whom and how would will the 3D point cloud data be maintained, stored, managed, and made accessible or shared in the future among stakeholders?
- How would the surface conditions and structural integrity be linked to the 3D point cloud data?
- When and how will the current surface condition mapping be implemented on the entire property?

These are issues that should be addressed by an

appropriate heritage information strategy.

The current administration of the DGA has hired specialized staff on GIS, it is recommended that with the assistance of UNESCO and other organization this institutions receives support to design, develop and adopt a information system cataloguing and storing all information about heritage places in Lebanon. This system should provide the opportunity of sharing information among cultural heritage stakeholders.

COORDINATION OF MITIGATIONS AND ASSESSMENTS AT BAALBEK

During the four months of missions to Lebanon, the expert members encountered several groups of international organization carrying out similar projects in Baalbek; this was frustrating, as it seems actions are duplicated and it revealed to be very difficult to exchange valuable information between the groups. It is important that UNESCO and other international aid agencies in consultation with the DGA evaluate the adoption of a system to coordinate actions, providing coordinated actions that will ensure adequate use of funds allocated to the protection of cultural heritage.

PREPARATION OF A LONG-TERM RISK PREPAREDNESS STRATEGY FOR BAALBEK

The current RPS prepared by this project focussing on the defined pilot area has produced a reliable methodology to carry out an extensive research on the entire property of Baalbek. The report based on the reliable data from 3D Laser Scanner provided an appropriate dataset for producing a measured drawing atlas of the site for identification of surface degradation, this information can be enriched with more nondestructive methods to identify issues beyond the surface that would yield more relevant information as e.g cracks.

This project has also evidenced the shortcomings of previous assessments of the condition of Baalbek that should be addressed from now on in the future.

It is recommended that the DGA prepare a strategy to systematically map the entire site documenting the state of preservation and the different risks to start with a systematic monitoring. It should include the mapping of the surface degradation and an assessment of the preliminary structural integrity, following the approach

developed. This baseline information will be the start of an appropriate monitoring system.

Additionally, the system developed in this project has evidenced the clear need of not only allowing foreign missions to carry out research on Baalbek, but also to tackle the conservation of the property. It is recommended that UNESCO along with the DGA encourage foreign universities and research institutions in the field of conservation of cultural heritage to have opportunities to carry out research on the preservation of this important World Heritage Property.

Specific recommendations on surface degradation mapping

- A complete study (in-situ and in laboratory) of materials (decayed and not decayed) and the various environmental parameters affecting these materials surfaces; as well as, on the various weathering forms is required.
- A in depth study of the sun's rotation in relation with the interior wall of the semi-circular chamber; as well as, to accurately identify the most exposed areas to rain and wind.
- Porosimetric analysis should be done on local stones to check its susceptibility to frost and thawing.
- Definition regular monitoring procedures for Risk

Preparedness Strategy on surfaces condition by implementing a constant and periodic monitoring of the surfaces degradations is required;

- Review and compile a summary of the already existing projects and research (ARS Progetti, PlanArch, IFAPO, etc), to evaluate the potential gaps and missing knowledge; as well as, to prepare a framework suitable for the necessary conservation of the surfaces (and of the property);
- Use GIS with the accurate 3D data collected for referencing in space and in time with the existing information (reports, plans, iconography, etc). The available information should be at the disposal of all stakeholders involved in the conservation and management of archaeological sites (authorities, experts, and researchers);
- Facilitate access to the information. The following points should be considered:
 - Creation of a unique database that is accessible to all the stakeholders;
 - Provide broad access to the "risk map" and related information, which can help in development and increase its efficiency.

Specific recommendation on structural integrity:

- Complete the first-level assessment for all the site (mostly qualitative, using the techniques

illustrated in this project: pathology interpretation, historical intervention documentation).

- Necessary to give relevant priorities for interventions and future studies.
- Improve general knowledge on aspects relevant to all structural analysis:
- Commission a study to better define the seismic hazard in Baalbek:
 - Complete the inventory of documents or studies on the seismicity of
 - Lebanon (possibly affecting the archaeological site of Baalbek)
 - Make a synthesis. Extract from the existing information what is relevant for the site.
 - Study the local situation of the site (influenced by local geological factors) (soil, distance to faults, expected source mechanism...) [there is very little on that]
 - Prepare necessary data for structural analysis: a set of relevant accelerograms that can be used for non-linear structural analysis, peak ground acceleration (pga) expected for various return periods, response spectra.
 - Possibly Install monitoring devices in Baalbek, such as an accelerometer, which I aimed at recording of smaller earthquakes that would help defining response spectra and would complement

a climatic factor monitoring (mainly useful for understanding of surface pathology)

- Possibly prepare a separate document on the geological and geotechnical condition of the site.
- Commission a study to define the structural behavior of the materials;
- Devise a strategy to complete the 3D survey (parts not measured by the laser scanner, upper parts, construction technique). Test it on the most critical areas of the site;
- Organize the information and make it easily available (above studies + historical photographs + photographic inventory + ...);
- Design more suitable areas to install the superstructures of “Baalbek international festival”;
- Start the iterative dynamic (gather data, synthesize, define priorities, improve knowledge, prepare interventions) described in the “Risk Preparedness Strategy”.

PREVENTIVE MAINTENANCE

The training course on Activity 3 evidenced the need the need to establish an appropriate maintenance strategy for the property as currently very little maintenance work is done. Many projects focus on mitigation towards the entire preservation of the remains in Baalbek, without taking

into consideration that is more cost effective to start doing punctual repairs of the site. The current RPS developed is the starting point to develop a preventive maintenance plan.

The difference between management policies based on preventive conservation versus curative conservation have been clarified;

Preventive conservation stresses the continuity in a cyclic way of the steps required to identify, assess and remediate conservation problems, including maintenance actions. The steps are identified as Analysis, Diagnosis, Therapy and Control.

A proper risk assessment is essential to join the monitoring of damage to come to the right preventive conservation management.

E X P E R T S

DIRECTORATE GENERAL OF ANTIQUITIES EXPERTS

Assaad Seif

He studied archaeology at the Lebanese University and received in February 2010 his PhD from Paris1 Pantheon-Sorbonne on “The Spatial Dynamics and the Pottery of the Syro-Palestinian Corridor from the Neolithic to the Middle Bronze Age : The Case of the □Akkār”. He taught GIS applications in archaeology for the Landscape Archaeology MA students at Paris1 in 1999. He is a Honorary Senior Research Associate at the Institute of Archaeology, UCL and member of the Editorial Advisory Board of CMAS (A publication dealing with the Conservation and Management of Archaeological Sites; Maney Publishing, UK). He worked on numerous excavations and is scientific director of more than 20 urban excavations mainly in the Beirut region. He is currently the Coordinator of Archaeological Research and Excavations at the Lebanese Directorate General of Antiquities.

He coordinated many scientific research projects with the CNRSL namely covering the domains of geo-archaeology and Archaeo-seismology in North Lebanon. He initiated the current project in collaboration with the UNESCO office in Beirut, and was responsible for the overall coordination on behalf of the DGA.

Ghassan Ghattas

He completed technical studies in surveying and civil engineering. He worked for 10 years as a support specialist for the Leica Geosystems’ local representative in Lebanon, a period during which he received



Figure 9: DGA experts: A. Seif and G. Ghattas.

extensive training on the use of total stations, GPS and surveying and photogrammetry software. He worked on several projects, one of which is the preparation of a complete IKONOS satellite imagery for Lebanon and the establishment of a geodetic network for the city of Khartoum using GPS. He is currently working at the DGA as a GIS and surveying specialist. His involvement in this project included, amongst other things, the contribution in the development of the surveying methodology and the design of a GIS database for the surface degradations. He is currently following post-graduate studies in GIS at the Vrije Universiteit in Amsterdam.



Figure 10: intl. senior experts: T. Patricio, M. Santana Quintero, P. SMars, K. Van Balen, and B. Van Genechten

INTERNATIONAL SENIOR EXPERTS

Teresa Patricio

She completed studies on architecture in Portugal, obtained a Master of Science in Architecture, Specialization Conservation of Historic Towns and Buildings, by the R. Lemaire International Centre for Conservation (University of Leuven) in 1993, and she obtained a PhD on “*Conservation of Archaeological remains. Drawing of an applied methodology* », at the Lemaire Centre (University of Leuven) in 2004. She is currently Invited Professor at the Lemaire Centre and at the University of Évora (Portugal).

She has a private office in Brussels, she has been providing public and private clients with Cultural Heritage Expertise. Her office covers a wide range of projects and activities including conservation of monuments and heritage sites in various countries. She collaborates with major foreign and domestic

institutions including UNESCO, ICOMOS (International Council on Monuments & Sites) and European Institutions.

Mario Santana Quintero

He completed undergraduate studies in architecture and obtained a PhD on ‘The use of three-dimensional documentation and dissemination techniques in studying built heritage’ at the R. Lemaire International Centre for Conservation (University of Leuven) in 2003. He is currently Assistant Professor at the Lemaire Centre and post-doctoral researcher for the MACE EU Project, University of Leuven. A Professor at the University College St Lieven and lecturer at the University of Pennsylvania, he serves as Vice President of the ICOMOS Scientific Committee on Heritage Documentation (CIPA) and Executive Officer of the Virtual Systems and Multimedia Society (VSMM Society).

Pierre Smars

He is assistant professor at the department and graduate school of cultural heritage conservation at the national Yunlin University of Science & Technology. He has a degree in architectural engineering from the Catholic University of Louvain, UCL (1989) and completed a master degree in conservation of monuments (1992) and a Ph.D. in engineering (2000), both at the Catholic University of Louvain KUL.

He had been working at the R. Lemaire Centre for Conservation at the KUL from 1993 to 2001. From 2001 to 2003, he was research associate at the University of Bath. From 2003 to 2005, he worked on projects in Afghanistan and in Pakistan (in collaboration with the University of Aachen) and at the World Heritage Centre in Paris. Since 2005, he is working at the National Yunlin University of Science & Technology.

Koen Van Balen

Prof. Dr. Ir.Arch. Koen Van Balen: he has a degree in engineer-architecture (1979), in architectural conservation (1984) and a Ph.D. in engineering (1991). He focuses his activities on the preservation of historical structures and on the understanding of the behavior of ancient materials and building technologies. He is professor in building materials and their preservation. His research concerns technical

aspects in conservation embedded in conservation methodologies for the architectural heritage. He is strongly connected to heritage organizations in Flanders (a.o. Monumentenwacht Vlaanderen) and with international NGO's in the field.

He is the holder of the UNESCO chair on Preventive Conservation, Monitoring and Maintenance of Monuments and Sites at the RLICC set-up in collaboration with Monumentenwacht Vlaanderen and with the University of Cuenca in Ecuador.

Bjorn Van Genechten

He is an architectural engineer, active in research on photogrammetry and laser scanning. He has been active in different international laser scanner projects as the scanning of the Ramses II statue in Cairo and a UNESCO project called "Capacity building of human resources for digital documentation of World Heritage Sites affected by 2006 war in Lebanon" among others. From 2007 till 2008, he was involved in a Leonardo project called "3DRISK MAPPING", of which the outcome is at this time considered a state-of-the-art book on laser scanning and its applications.

In June 2009, he successfully presented his Ph.D. "Creating Built Heritage Orthophotographs from Laser Scans" at the K.U. Leuven and since October 2009 he is a full time professor at the University College KaHo St.-Lieven in Ghent.

INTERNATIONAL JUNIOR EXPERTS

Liesbeth Lacroix

She is an architectural engineer, graduated at the University of Leuven. Currently, on the second of the Advanced Master in Conservation of Monuments and Sites at the Raymond Lemaire International Centre for Conservation (RLICC), in which she is preparing a thesis on “The use of Terrestrial laser scanning for condition mapping of historical sites”. She also conducted an Internship at the Metric Survey Team of English Heritage in 2009.

Tom Coenegrachts

He is an archaeologist graduated at the University of Leuven. Currently, on the second of the Advanced Master in Conservation of Monuments and Sites at the Raymond Lemaire International Centre for Conservation (RLICC). He has worked at many ruined castles, not only doing excavation work, but also equally obtaining information from the standing structures by carefully documenting it using mostly hand drawings, total station and photographs. During his first year of the Master of Conservation of Monuments and



Figure 11: intl junior experts: Liesbeth Lacroix and Tom Coenegrachts.

Sites his knowledge was further developed on condition assessment and preventive conservation.

CLOSING

REMARKS

This Phase II has achieved the development of guidelines and a solid methodology for the preparation of a “Risk Preparedness Strategy” of Baalbek, based on the results of Phase I, when a group of experts captured complete physical 3D surface configuration of the property using laser scanner

It is important that the acquisition of a 3D Mapping device and the “Risk Preparedness Strategy” methodology, compiling results from the definition of a “damage atlas”, surface condition maps and structural surface integrity study is not put aside for the future conservation of this important heritage place.

A set of recommendations have been provided in this report to build up upon the success approaches developed, the information acquired, assessed and presented here should be aimed at ensuring timely, sufficient and relevant information that provides

- An integral approach for setting-up a baseline for monitoring “changes”, rate of change, risk factors and hazards to visitors/staff on the property have been identified in this Phase II;
- Further monitoring is proposed: re-evaluate significance and its relation with integrity, based



Figure 12: western wall, foundations and Bacchus temple, author

on those changes; (it contributes to the periodic reporting of World Heritage Sites)

- Development of a preventive maintenance plan that ensures that issues identified in the RPS are tackled;

Finally and as mentioned in the recommendations, Baalbek can benefit of the creation of a research area within the conservation field, where conservation

institutes, universities and other organizations carry out research aimed at preserving the integrity of the property, this in coordination by the DGA and with support of UNESCO.

R E F E R E N C E S

The following documents were reviewed and used for the compilation of this final report. A more detailed bibliography is provided in the deliverables presented at the appendix of this report for each of the sections.

Letellier, R. Schmid, W. LeBlanc, F. Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places, Getty Conservation Institute, 2007 J. Paul Getty Trust

Lohman, D. Drafting and Designing. Roman Architectural Drawings and their Meaning for the Construction of Heliopolis/Baalbek, Lebanon, Proceedings of the Third International Congress on Construction History, Cottbus, May 2009, p. 959 – 966.

UNESCO World Heritage Centre, Nomination of Baalbek, <http://whc.unesco.org/en/list/294/documents/> (accessed: May 30, 2010)

Van Ess, M. “Heliopolis Baalbek: 1898 – 1998: Rediscovering the Ruins”, Deutsches Archaologisches Institut Orient-Abteilung and the Directorate General of Antiquities of Lebanon, Beirut 1998.

A P P E N D I X

1. RISK PREPAREDNESS STRATEGY

2.1. SURFACE CONDITION – FINAL REPORT (BAALBEK, LEBANON - GREAT COURT NORTH-WESTERN SEMI-CIRCULAR CHAMBER)

2.2. ATLAS OF SURFACE DEGRADATIONS (BAALBEK, LEBANON - GREAT COURT NORTH-WESTERN SEMI-CIRCULAR CHAMBER)

3. STRUCTURAL PATHOLOGY INTERPRETATION

4.1. PROCEDURES FOR THE CREATION OF ORTHOPHOTOGRAPHS BASED ON THE POINT CLOUD USING CYCLONE

4.2. PROCEDURES ON GENERATING A MESH AND CREATING SLICES USING THE GEOMAGIC SOFTWARE

5.1. MISION REPORT: ACTIVITY 1: ASSESSMENT OF EXISTING INFORMATION

5.2. MISION REPORT ACTIVITY 1: 3D HERITAGE RECORDING PROCEDURES

5.3. MISION REPORT ACTIVITY 2: PROCEDURES FOR THE PREPARATION OF MEASURED MAPS

5.4. MISION REPORT: ACTIVITY 3 & 4: CAPACITY BUILDING AND DEGRADATION ATLAS AND MAPPING

5.5. MISION REPORT: ACTIVITY 4: DEGRADATION MAPPING

5.6. MISION REPORT: ACTIVITY 3: CAPACITY BUILDING

5.7. MISION REPORT: ACTIVITY 4: CONTROL OF INTERACTION 3D SURVEY & MAPPING

5.8. MISION REPORT: ACTIVITY 5:: RISK PREPAREDNESS STRATEGY MISSION

5.9. ACTIVITY 5:: REPORT ON DIGITALIZATION OF SURFACE CONDITIONS