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**CONFERENCE**  
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**BOOK OF ABSTRACTS**

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## **Session 1**

# ***Impact of Space Technology on Natural Sites: Monitoring and Management***

## Monitoring the Ancient Countryside: Remote Sensing and GIS at the Chora of Chersonesos (Crimea, Ukraine)

Jessica Trelogan<sup>1</sup>, Melba Crawford<sup>2</sup>, Joseph Carter<sup>1</sup>

In 1998 the University of Texas Institute of Classical Archaeology, in collaboration with the University of Texas Center for Space Research and the National Preserve of Tauric Chersonesos (Ukraine), began a collaborative project, funded by NASA's Solid Earth and Natural Hazards program, to investigate the use of remotely sensed data for the study and protection of the ancient agricultural territory, or *chora*, of Chersonesos in Crimea, Ukraine.

The site is comprised of approximately 400 km<sup>2</sup> of the area known as the Heraklean Peninsula, located on the southwestern tip of Crimea, surrounding the modern city of Sevastopol. Greek settlers colonized the region in the mid 5<sup>th</sup> century B.C., leaving behind the most lasting and distinctive feature of the ancient landscape: a highly visible system of orthogonal roads and agricultural plot divisions. A major agricultural production center, the site remained an important trade emporium during the Roman and Byzantine periods and was continuously occupied until the 14<sup>th</sup> century A.D.

With its rich history of occupation, Chersonesos represents one of the best-preserved examples of an ancient agricultural landscape known today. In its modern history, despite centuries of highly destructive warfare, it has remained remarkably well preserved until the last few decades, when rapid urbanization has taken its toll on the fabric of this unique historic landscape. These facts have led to the site's repeated inclusion, since 1996, on the World Monuments Watch *List of 100 Most Endangered Monuments of World Cultural Significance*. Application for the permanent designation of Chersonesos as a UNESCO World Heritage site is also in progress, with the site currently on the tentative World Heritage list.

Although Chersonesos and its agricultural territory have been the object of extensive investigation by Ukrainian and Russian scholars for over a century, for reasons of Cold War secrecy, no accurate maps of the area have been published. The site's contemporary strategic military position (located on the outskirts of modern Sevastopol, an important naval base) has also limited access to many of the important ancient sites. Remote sensing, therefore, offers a valuable, cost effective, and reliable means of mapping the ancient landscape, as well as of monitoring the effects upon it by recent changes to the modern landscape.

An extensive multi-temporal, multi-resolution database of imagery has been developed for the project spanning the last half-century. A handful of historic aerial photographs from the 1960s, as well as a set of recently declassified CORONA satellite photographs from the 1960s and 1970s are being used to map the remains of the ancient cadastral grid. Landsat MSS, TM, and ETM+ data are being used to monitor land use and land cover change from the 1970s, 1980s, 1990s, and 2000. Multispectral and panchromatic ALI and hyperspectral Hyperion data were also acquired in 2001 as part of the EO-1 science validation mission. The data are being analyzed to investigate the

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<sup>1</sup> Institute of Classical Archaeology, University of Texas at Austin

<sup>2</sup> Center for Space Research, University of Texas at Austin

impact of the new technology for mapping the land cover and the geomorphology of the peninsula, as well as for continued medium resolution monitoring of land cover change. Information derived from high resolution panchromatic data acquired by the Indian Remote Sensing (1997) and IKONOS (2000) satellites is being employed for land use mapping, specifically for the designation of areas to be included in the plans – well under way – for the creation of an archaeological preserve. Finally, thanks to a grant from the European Space Agency (grant number ERS A03 – 365), a number of interferometric pairs of ERS SAR data were obtained for the creation of a DEM, hitherto unavailable for the site. Unfortunately, however, due to difficulties obtaining ERS data with appropriate baselines, as well as our inability to obtain permission to use GPS in the area, it has only been possible to develop a relative DEM. The best future hope for improving the DEM is with the release of Shuttle Radar Topographic Mapping (SRTM) data.

With a mapping base and spatial framework established from these data, the ability to integrate results from the last century and a half of interdisciplinary research at Chersonesos with the results of ongoing investigations has been greatly improved, as has our ability to quantify the effects of modern landscape change on the preservation of the ancient landscape. These results are now being integrated within a Geographic Information System (GIS) that is being used by our increasingly interdisciplinary and international team, which includes specialists from the fields of archaeology, engineering, geography, architecture and planning, from the University of Texas, the National Preserve of Tauric Chersonesos, and the University of Lecce.

The GIS has already proved to be an extremely useful tool for data management and analysis within our collaborative project, as well as for the presentation and publication of results. The ultimate goal is the widest possible dissemination of information and visualization through web-based publishing, which we hope will facilitate better collaboration with other projects being conducted in the Black Sea region and beyond.

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**INTEGRATION OF REMOTE SENSING AND GIS FOR MANAGEMENT  
DECISION SUPPORT IN THE PENDJARI BIOSPHERE RESERVE,  
(REPUBLIC OF BENIN )**

By

Vincent Joseph MAMA\*

\* *National Centre for Remote Sensing*  
*CENATEL [cenatel@bow.intnet.bj](mailto:cenatel@bow.intnet.bj)*  
*06 BP711 Cotonou Bénin*

Mohamed ABDOULA YE\*\*

\*\* *Direction des Forêts et des Ressources Naturelles*  
*[foret@bow.intnet.bj](mailto:foret@bow.intnet.bj)*  
*01BP 393 Cotonou Benin*

**Abstract**

Over recent years, remotely sensed data and spatial analysis techniques by providing timely and relatively inexpensive information, has proved useful for inventorying and monitoring of wildlife habitat in protected areas. To investigate on land cover pattern and the land use change in the Pendjari Biosphere Reserve , a time series of satellite imageries including LANDSAT TM and SPOT XS were used . Ancillary data were also used .The procedure of mapping land cover land use change involved three stages as follows:

- (i) data collection , preprocessing and visual interpretation
- (ii) defining land use land cover types
- (iii) Evaluation of land use change

In addition to land use and land cover mapping, decision support maps were elaborated using GIS. These maps included the following themes: infrastructure, monitoring, plan for protection etc.

The Biosphre Reserve of Pendjari is located in the West Northern part of Benin Republic. It constituted of three main parts: The Central part entirely protected (275, 000 ha) is located between two buffer zones: Zone Cynégetique de Pendjari (175, 000ha) and Zone Cynégétique de l'Atacora (122, 000 ha). This complex has been set up as Biosphere Reserve in 1986.

This study has demonstrated a method that can help to increase the quality and quantity of information needed for protected area management

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## Monitoring of deforestation invasion in natural reserves of northern Madagascar based on space imagery

Richard GUILLANDE  
director  
Geosciences Consultants sarl  
Rue des blains  
92220 Bagneux  
email : [101626.1445@compuserve.com](mailto:101626.1445@compuserve.com)

Northern Madagascar concentrate most of the remaining forest of the country. Since a decade, several national parks have been created to preserve the unique fauna and flora of the Madagascar forest ecosystem and save patches of forest from the accelerating deforestation phenomenon. This deforestation is mostly caused by burning of new spaces to produce charcoal and exploit new crops. Northern Madagascar is also affected each year by several hurricanes, some of them highly devastating. Heavy rainfalls on deforested land caused the classical chain of erosion and more powerful floods which destroy each time more the cultivated plain in flat valley bottoms.

During spring 2000, three strong hurricanes crossed northern Madagascar and hit seriously the north-western coast of the Island. Huge surfaces of forest were destroyed and most of valley bottoms were drowned by floods.

A monitoring of hurricanes and flood impact on agriculture was designed by GSC for the account of ECHO and CARE MADAGASCAR to experiment the input of satellite imagery for the post-crisis management and reconstruction in terms of lost crop surfaces, damages infrastructures.

A set of ERS images acquire before (1995) and after (200) the hurricanes were used. The area correspond to 3 images aligned on the same orbit covering approximately to 35 000 km<sup>2</sup>. The multi-temporal analysis of the images revealed most of the flood plains and damages areas. The level of detail was not precise enough to reveal the types and level of damages on roads, crops and deduce areas necessitating more assistance than others.

A very impressive contrast was observed on hilly areas on the western part of the area. This intense and massive change on backscattering properties of images was covering only some parts of the territory and seemed to have a relation with topography. The images of the changes were geocoded and overlaid on several layers of land use in Madagascar (roads, villages, rivers, population, parks, etc.). Local correspondent in Madagascar informed our team that the area was the site of massive deforestation since years.

A clear relation appeared between deforested areas and high concentration of villages and a dense road and track network linked to main exchange N-S trend of Madagascar. To the opposite of the devastated region, many villages not linked by road with the rest of the country were not surrounded by deforestation, meaning clearly, isolated populations do not devastate their environment, and that commercial exploitation of forest to supply central and southern Madagascar with charcoal is the main cause of the phenomenon.

The footprint extent of burned or deforested area was clearly delineated and affected areas were intersecting many border of parks. It appeared clearly the parks were absolutely bot sanctuaries with respect to fire propagation that may start far from parks but can spread widely very far and cross completely parks. The morphology of deforested zones let suspect that most of them were born during fires extending form East to West pushed by trade winds in E-W valleys.

Analysing the official figures on remaining forest in this part of the country, the rate of deforestation during the interval 1995-2000, meant 5 more years before complete disappearance of forest in this region.

Radar imagery appears and ideal mean for monitoring large environmental changes and the status of objects such as natural parks.

# Cartography and land use change of World Heritage areas and the benefits of remote sensing and GIS for conservation.

*Conference Space Applications for Heritage Conservation (Strasbourg)  
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Philippe De Maeyer – Ghent University  
Rudi Goossens – Ghent University  
Liesbeth Vansteenvoort - Ghent University  
Joris De Man - Ghent University  
Ruvimbo Gamanya – Ghent University  
and:  
René Beyers – Wildlife Conservation Society  
John Hart - Wildlife Conservation Society

This paper presents a part of a pilotproject that was *conducted* on the Kivu region in the D.R.Congo and includes the area of the Kahuzi-Biega National Park. For this area, that is difficult to access, no recent covering cartography exists. The aim of this project is to set up a production line for base maps of the area, which can be used for *monitoring land use and vegetation changes*.

In this framework the possibilities of remote sensing data were investigated to produce recent base maps.

For difficult accessible regions almost no recent field data is available. Therefore satellite images are a good alternative to become a complete inventory of the study area. To cover this region, we used the most recent, good quality, Landsat ETM+ images. To use as a basis for maps, the images have to be georeferenced and reliable ground control points are needed. Because no systematic fieldwork could be executed, most of the ground control points were derived from the geodetic survey "Le Canevas Planimétrique du Kivu-Maniema" of 1968. Only a very limited number of survey points could be used because most of the points weren't identifiable on the image.

The additional topographic data, like roads, rivers, names of villages, etc., were extracted from the existing available maps of the region, dating from the late fifties. Because most parts of these maps are obsolete, the extracting of topographical data has to be done with great care.

By combining remote sensing data with existing data, it is possible to make recent satellite image maps of an inaccessible area. Still, to become geometrical and thematical correct base maps, field verification is necessary.

The base maps are also produced with an interpreted background. The available Landsat TM and ETM+ images were classified using 9 different classes. This classification of two images of the same area with a different acquisition data can be used to monitor vegetation changes in the studied area. These thematic baseground

information combined with other cartographic information layers gives the opportunity to manage the park in an efficient way.

These satellite base maps are very helpful for monitoring World heritage sites. The Wildlife Conservation Society is currently coordinating a biological monitoring programme in the Kahuzi-Biega National Park with UNESCO. Accurately georeferenced basemaps are indispensable for this project. GPS positions of survey data and law enforcement monitoring data can be easily plotted on the basemap using GIS. Wildlife survey results can thus be correlated with vegetation and other thematic features (such as roads and villages) on the map. The temporal analysis of satellite images provides an assessment of human encroachment and vegetation changes in the park.

Prof. Dr. Philippe De Maeyer Krijgslaan 281 S8 9000 Ghent 0032 9/264.46.88 <a href="mailto:Philippe.demaeyer@rug.ac.be">Philippe.demaeyer@rug.ac.be</a>	Lic. Joris De Man Krijgslaan 281 S8 9000 Ghent 0032 9/264.46.88 <a href="mailto:Joris.deman@rug.ac.be">Joris.deman@rug.ac.be</a>
Lic. Liesbeth Vansteenvoort Krijgslaan 281 S8 9000 Ghent 0032 9/264.46.36 <a href="mailto:Liesbeth.vansteenvoort@rug.ac.be">Liesbeth.vansteenvoort@rug.ac.be</a>	Prof. Dr. Rudi Goossens Krijgslaan 281 S8 9000 Ghent 0032 9/264.47.09 <a href="mailto:Rudi.gossans@rug.ac.be">Rudi.gossans@rug.ac.be</a>
Rene Beyers Wildlife conservation society Bronx, New York 10460 USA 0032 9/293.50.03 <a href="mailto:Rbeyers@compuserve.com">Rbeyers@compuserve.com</a>	Rene Beyers Wildlife conservation society Bronx, New York 10460 USA (718) 220-5896 <a href="mailto:jhart@wcs.org">jhart@wcs.org</a>

## Cartography and land use change of World Heritage areas and the benefits of remote sensing and GIS for conservation.

*(Conference Space Applications for Heritage Conservation (Strasbourg)  
5 – 8 november 2002)*

Philippe DE MAEYER  
Peter BOGAERT  
Joris DE MAN  
Marc BINARD  
Fabrice MULLER  
Ruvimbo GAMANYA

In the framework of a UNESCO/World Heritage Centre pilot project we had to collect GIS and Cartographic data about some selected world heritage areas divided into natural and cultural environments. The selected natural areas are Virunga National Park (Congo), Ha Long Bay (Vietnam) and Niokolo Koba National Park (Senegal). The historical cities are the Marrakech (Morocco) and Warsaw (Poland).

The main goal of this project is to create an accessible and popular website with the available GIS and Cartographic data containing three themes. The first theme is the cartographic approach. According to the guidelines of the World Heritage Convention, each country shall provide, when proposing a site for nomination, precise information indicating the boundary of the site as well as the boundary of the 'buffer zone' surrounding the site. Unfortunately, (developing) countries do not have accurate maps available. This means that sometimes the provision of the site-boundaries information is either missing or is of very poor quality. One important aspect of maps is that they are a basic tool for any conservation activity, the main item to be aware of is the exact location of the site that needs to be protected! In this sense the creation of adequate cartography for World Heritage sites becomes a strong capacity building activity through which the less developed countries have an opportunity to use cartographic information in the development of site-management-plans.

The second theme is the monitoring of land use and vegetation changes using remote sensing over the last 10 years. Land use changes can be of great interest in monitoring natural and human hazards. Remote sensing was also used to produce the required thematic cartography in this project.

The third objective is to show how remote sensing and GIS can help with the management and the monitoring of world heritage sites. The combination of remote sensing and other thematic GIS data is of great interest to solve basic geographical questions about the world heritage areas to ensure efficient management.

To reach a large number of people and countries we had to build up a very accessible website. Therefore the website had to be platform independent and of limited size. The site can be viewed in all browsers and allows easy access by a basic modem connection

Prof. Dr. Philippe De Maeyer  
Krijgslaan 281 S8  
9000 Ghent  
09/264.46.88  
[Philippe.demaeyer@rug.ac.be](mailto:Philippe.demaeyer@rug.ac.be)

Lic. Joris De Man  
Krijgslaan 281 S8  
9000 Ghent  
09/264.46.88  
[Joris.deman@rug.ac.be](mailto:Joris.deman@rug.ac.be)

Lic. Peter Bogaert  
Krijgslaan 281 S8  
9000 Ghent  
09/264.46.88  
[Peter.Bogaert@rug.ac.be](mailto:Peter.Bogaert@rug.ac.be)

Lic. Fabrice Muller  
Université de Liège  
Département de Géomatique  
17, allée du 6-Août  
4000 Liège, Belgique  
04 / 366 57 45  
[muller@geo.ulg.ac.be](mailto:muller@geo.ulg.ac.be)

Lic. Marc Binard  
Université de Liège  
Département de Géomatique  
17, allée du 6-Août  
4000 Liège, Belgique  
04 / 366 53 13  
[binard@geo.ulg.ac.be](mailto:binard@geo.ulg.ac.be)

## Assessing and Monitoring Vegetation in Nabq Protected Area, South Sinai, Egypt, using combined approach of satellite imagery and land surveys.

Husam El Alqamy<sup>1</sup> and Hany El Shaer<sup>2</sup>

- 1- St. Katherine Protectorate, , Nature Conservation Sector, Egyptian Environmental Affairs Agency, St. Katherine, South Sinai, EGYPT.  
Phone : +20-69-470032, Fax : +20-69-4700332, email; alqamy@lycos.com
- 2- GIS unit, South Sinai Protectorates , Nature Conservation Sector, Egyptian Environmental Affairs Agency, Sharm El Sheikh, EGYPT.  
Phone : +20-69-660559, Fax : +20-69-660668, email: helshaer@hotmail.com

### Abstract

As part of the natural reserves network in South Sinai, Nabq Protected area is a distinguished natural reserves because of its unique assemblages of plant communities. Nabaq protected area contains about 16 species of plants that are not represented elsewhere in southern Sinai. The most northern community of mangrove *Avicennia marina* in the Red Sea is found on the coast of Nabq in addition to the *Salvadora persica* dunes not found anywhere else in southern Sinai. Dunes are also formed by *Nitraria retusa*. Moreover, smaller areas are covered with communities dominated by *Limonium axilare*. In addition to these a considerable area of sea grasses are recorded on the coast of Nabq in the shallow lagoons formed by the coast line. Vast number of animal species of reptiles and mammals inhabiting these plant communities are relying on them for food and shelter.

Therefore, continuous and efficient monitoring effort is necessary to provide an updated status of these floral elements as indicative of the ecosystem condition. Manpower of trained and skilful observers is limited, thus satellite remote sensing is a useful source of information as it provides timely and comprehensive coverage of large areas. Coupled with data gained from land surveys reliable condition of the floral communities could be attained. The purpose of the present work is to identify a procedures for analyzing the satellite images that are able to distinguish between different communities and to determine the approximate areas of these. Land surveys of GPS acquired polygons are used to compare the calculated areas and to provide an estimate of precession to the remote sensing based outputs. Final results are maintained through a GIS to compare with future survey to provide a time series for management purposes.

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**Evaluation of forage resources in semi-arid savannah environments with satellite imagery: contribution to the management of a protected area (Nakuru National Park) in Kenya.**

Nicolas Ganzin <sup>(1)</sup> and Martin Mulama <sup>(2)</sup>

- (1) *Groupement pour le Développement de la Télédétection Aérospatiale (GDTA), 8-10 Rue Hermès, Parc Technologique du Canal, 31526 Ramonville, France. [nganzin@gdta.fr](mailto:nganzin@gdta.fr)*  
(2) *Kenya Wildlife Service, PO Box 40241, Nairobi, Kenya. [bjomass@kws.org](mailto:bjomass@kws.org)*

**EXTENDED ABSTRACT**

*Protected areas such as national parks and natural reserves contain treasures of both animal and plant biodiversity which must be conserved at all costs. Managing the protected areas is therefore a priority, especially in a modern world with an increasing human population that puts more and more pressure on the remaining preserved natural ecosystems.*

*The management of protected areas and wildlife populations is a complex matter which includes, among other aspects, the management of the herbivore feeding resources (natural forage). Most of the National Parks and Reserves of Africa being located in arid and semi-arid areas, often referred to as savannah ecosystems, the vegetation resources are very variable in time and space, mostly depending on erratic rainfalls. They are therefore also fragile and easily subjected to potential degradation if over-utilised, especially when recurrent droughts occur and limit the grazing and browsing capacity of the land.*

*Degradation mostly corresponds to loss of potential of the land, either by decrease of fertility or by change in floristic composition (resulting in reduced quality of the pastures), phenomena which can lead to desertification in the long run. Adapting the animal load to the capacity of the land is an efficient form of management for conservation, but relevant decisions highly depend on a good and updated knowledge of the resources. The forage available for the wild herbivores therefore represents the baseline information for decision making, especially in protected areas with a limited surface and high herbivore population.*

*Information is nevertheless not easy to access on national parks and reserves. Data on vegetation production can be gathered in the field, but measurements are time consuming, work intensive, costly and not representative in time and space unless done very often and with a high sampling rate. Remote sensing, and especially wide field satellite imagery, offers a cheap, regular and reliable alternative source of data to monitor seasonal vegetation development and estimate forage production quantitatively with a fair accuracy. Satellite images, compared to field sample measurements, offer the advantage of a total geographic coverage which partly solves the problem of representativity in space. With data available since the early 1980's they also offer an appealing solution to take into account the great variability in time.*

*An attempt to generate information from satellite data and contribute to protected areas and wildlife management was done in Kenya in collaboration between GDTA and the Kenya Wildlife Service, under a cooperation initiative of the French Ministry of Foreign Affairs. NOAA AVHRR and SPOT/VEGETATION satellite data were used to compute pasture biomass production estimates in a case study on the management of the Nakuru National Park, a small entirely fenced park (no migration possible) with a high herbivore load. Biomass productions were estimated on a seasonal basis for a number of growing seasons, using the well documented Monteith model simulating the photosynthetic process with satellite vegetation indices as a main input. After integration into Geographic Information Systems (GIS), results were further processed in conjunction with ancillary information such as park boundaries and vegetation structure to improve the information's accuracy. Herbivore carrying capacity and total forage production of the park were then derived from the biomass production. Carrying capacity indicated how to adapt the animal load to the potential of the land, taking into account the inter-seasonal variability. Total biomass production was compared to forage requirements for the park estimated from yearly total animal counts carried out by KWS in Nakuru.*

*The accuracy and suitability of the products is discussed, as well as the potential use of the information for decision making, especially when integrated in GIS and mixed with various other sources of information useful for rational management.*

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## SURVEILLANCE OF GORILLA HABITAT (SOGHA) USING SPACE TECHNOLOGIES

Luigi Fusco<sup>(1)</sup>, Mario Hernandez<sup>(2)</sup>, Pedro Matos<sup>(1)</sup>

<sup>(1)</sup>European Space Agency, Via Galileo Galilei 00044 Frascati (Italy), E-mail: luigi.fusco@esa.int, pedro.matos@esa.int

<sup>(2)</sup>UNESCO World Heritage Centre, 7 Place de Fontenoy 75352 Paris (France), E-mail: Ma.Hernandez@unesco.org

### ABSTRACT

An 'Open Initiative' in support of the World Heritage Convention was launched by the European Space Agency (ESA) and UNESCO in October 2001. Through this initiative, ESA and other International Space Agencies agreed to support the efforts of States Parties of the World Heritage Convention in the monitoring of World Heritage sites using Space Technologies. Capacity building is the main component of this important initiative.

As an initial project, ESA and UNESCO, jointly with the Governments of Rwanda, Uganda and the Democratic Republic of Congo, have decided to make an assessment of the gorilla habitat in Eastern and Central Africa during the last 10 years. This paper describes the project detailed goals, as well as the expected results for 2002 and for 2003.

The World Heritage sites selected for this study cover the national parks of **Parc National des Virunga** (site classified as 'in danger' located at the Democratic Republic of Congo) and **The Bwindi Impenetrable National Park** (Uganda). In order to cover the whole areas of gorilla habitat in this region, the study includes additional World Heritage candidate sites: the **Parc National des Volcans** (Rwanda), and the **Mgahinga Gorilla National Park** (Uganda).

All of the above-mentioned areas host mountain gorillas, the *Gorilla b. beringei* living in the vulcanous region, and a small population of eastern lowland gorilla *Gorilla b. graueri*.

During the last years the region has suffered a series of wars and as a consequence a large arrival of refugees. All these actions have become an enormous threat for the area in particular for the survival of the gorillas. Therefore an overall assessment of the vegetation cover over time is required. This is the scope of the UNESCO and ESA defined

SOGHA (Surveillance Of Gorilla Habitat) project.

Due to the mountainous nature of the terrain, inaccessibility and to the unstable atmospheric conditions over the area preventing the existence of good optical images, combined efforts between different space agencies and organisations working on the field are essential.

In order to have direct access to ground data ESA and UNESCO have established a consortium of collaborating institutions. With this consortium the project has direct access to user needs and fieldwork. Currently the International Gorilla Conservation Programme, WWF Africa, The Wildlife Conservation Society, the Institute for Tropical Forest Conservation of Uganda and the University of Ghent have agreed to join efforts in the use of space technologies to strengthen the conservation activities to protect the gorillas in Central and Eastern Africa.

In close cooperation with the NGOs (Non Governmental Organizations) and key local users, ESA and UNESCO decided, as a first step, to produce accurate maps of the region integrating available satellite images with ground measurements. In fact, the 1:200,000 map of the Virungas is being elaborated jointly by ESA and the University of Ghent, thanks also to a generous support from the Government of Belgium. The work related specifically with the elaboration of this map is presented in a separate paper in this workshop.

As a second action, ESA and UNESCO are integrating a GIS system to support gorilla conservation activities. This SOGHA information system includes field data as well as a series of multi-temporal satellite images. Using all available information, the 1:200,000 vegetation and land use cover changes for the

region during the last 10 years will be assessed.

Finally, a second initiative under discussion aims to produce 1:50,000 detailed maps for the areas of gorilla habitat.

All the resulting maps will be provided to Park authorities and NGOs that are assisting the

local government in the conservation of the precious biodiversity of this area.

Overall the work described herein is a good example of the importance of an international cooperation to make use of sophisticated space technology to preserve the Heritage of our World.

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Space Applications for heritage Conservation Conference  
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### **Application of remote sensing to monitor the Mont-Saint-Michel Bay (France)**

Jean-Paul DEROIN, Professeur, Institut EGID, Université Michel de Montaigne, 33607 Pessac cedex, France, mail : [deroin@egid.u-bordeaux.fr](mailto:deroin@egid.u-bordeaux.fr), phone : 33(0)5 56 84 80 76, fax : 33(0)5 56 84 80 73

Fernand VERGER, Professeur émérite, Ecole Normale Supérieure, Ulm, Paris, France.

The coastal sectors of epicontinental shelves such as the English Channel show exceptional tidal amplitudes, with the tidal range often exceeding 10 metres. Thus, in certain areas, the foreshores can be exposed over several hundreds of square kilometres, reaching a maximum during low spring tides. These zones are highly sensitive to the accumulation of sediments, which varies considerably in time and space.

In spite of frequent aerial photograph missions, only satellite imagery is capable of providing a regular and global monitoring of the modifications that occur in such an environment. These data have been used for the geological mapping of the region. Satellite scenes cover several thousands of square kilometres and their geometric distortions are easily corrected in optical imagery. The spatial resolution of modern optical sensors is adequate for a cartographic approach to the phenomena. The spectral characteristics, in particular in the IR range, make it possible to obtain information, either directly or through the use of ratios, in the mineral and plant domains. Surveys of the littoral zone by multispectral imagery allows investigation of extensive areas having a purely, or at least predominately, mineral response that is unique in a temperate zone. Moreover, the landscape units are homogeneous over large areas, which is compatible with the pixel size.

Mont-Saint-Michel Bay, at the base of the Gulf of St-Malo dividing Normandy from Brittany, covers some 500 km<sup>2</sup> at the heart of the Armorican Massif, in an oceanic temperate climate. It is characterized by an exceptional tidal amplitude: 15 m during spring tides. Associated with a very slight northwest-trending slope (3‰ on average) the width of the foreshore reaches 15 km along the long axis of the bay which opens into the Gulf. The emerged foreshore can then be as much as 250 km<sup>2</sup>, i.e. half the bay. Three rivers, the Sée, the Sélune and the Couesnon, form a pre-estuarine delta in the innermost part of the bay, to the east-southeast. The polders are contained by dikes.

The land surrounding the bay is made up of recent alluvial deposits in the lower parts. Schistose Upper Proterozoic formations, overlooked by a few granodiorite massifs crop out abundantly to the east (Cotentin Peninsula) and to the west on around the Saint-Malo gneiss massif. The two leucocratic granite outcrops of Mont-Saint-Michel and Tombelaine emerge through the beaches of the pre-estuarine delta. The landscape of the bay is wadden type, i.e. an ample sandy foreshore. The clayey-silty deposits of the upper part (or schorre) are colonized by pasturable

halophytes. The middle part of the foreshore consists mainly of "*tangue*", a specific carbonate material with alternate silty and sandy layers related to the tidal cycle. Shelly banks, swept by the swell, overlie this unit in the western part. A reef of Polychaeta annelids known as Les Hermelles lies in the central part of the bay. This acts as an effective breakwater and is associated with a bank of shell sand. The Bec d'Andaine, in the northeast of the bay, is the only zone facing the open sea and is thus subjected to the action of swell from the northwest. The result is a range of dunes isolating the salt marshes.

Remote sensing and aerial photographs as well have been used to study the evolution of the Bay at least since 1950. Those data are essential for evaluating the predictive evolution of the bay and the future of the islet which is dominated by the famous abbey. Remote sensing played an important rôle in the project for "*Rétablissement du caractère maritime du Mont-Saint-Michel*", which had important consequences for the nature and for the world heritage as well.

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**Application of Remote Sensing & Geographic Information System (GIS) for the Conservation of Natural & Cultural Heritage Sites of the Southern Province of Sri Lanka**

By

M.J.J.Fernando

Deputy Director, Research and Special Projects Unit,  
Head/GIS centre

Environmental Management & Assessment Division,  
Central Environmental Authority, 'Parisara Piyasa', Battaramulla, Sri Lanka

Tel: 0094-74-411213 or 0094-31-55630

Email: jjayavilal@hotmail.com

**Introduction:**

The human population in Sri Lanka is increasing at an alarmingly rapid rate, while food production has not been able to keep pace both in nutritional terms & in terms of quantity. Next to food security, the problem that causes a tremendous pressure on the environment is the sheltering or finding a plot of land to live in.

These basic human requirements have been the major reasons for rapid degradation of the environment & the depletion of natural resources that have been going unabated. The challenge of providing adequate productive land for the people to produce their food and livelihoods is in conflict with the need to protect the forest cover, the soil & water relationships, cultural sites & wildlife. The development process too, calls for large areas of land. It is essential that adequate lands are provided for establishing new industries & factories in order to ensure the economic growth of the country.

Unfortunately, the natural heritage sites, to a greater extent & the cultural heritage sites, to a lesser extent are the victims of these demands and they are increasingly being threatened by the ever increasing population.

It is important to know that formulation of policy frameworks and implementation of sound conservation oriented management tools based on the proper environmental management principles could contribute towards arresting these problems while securing the existence of those invaluable natural & cultural sites.

The National Environmental Act No. 47 of 1980 (NEA) as amended by Act No. 56 of 1988 and No. 53 of 2000 is the basic national charter for the protection and management of the environment in Sri Lanka.

As per the provisions of Part IV C of the National Environmental Act of Sri Lanka, No. 47 of 1980, all projects/undertakings beyond a certain size, magnitude or production capacity require to undergo the Environmental Impact Assessment (EIA) process. These areas are listed in the Part I of the gazette (extra ordinary) No. 772/22 of 24.06.1993.

However, if such projects/undertakings are planned to be located wholly or partly within the environmentally sensitive areas, as specified in part III of the same gazette notification as amended by extra ordinary gazette No. 859/14 of 23.02.1995, then an EIA has to be carried out prior to the establishment of such project/undertaking, irrespective of their size, magnitude or production capacity. Following is a list of such areas falling into the category of cultural & natural heritage sites.

- *100m from the boundaries of or within any area declared under the National Heritage Wilderness Act No. 4 of 1988* (Ex: A world heritage site known as 'Sinharaja - a virgin tropical wet evergreen forest having a very high endemism and biodiversity in the South-East Asia)
- *100m from the boundaries of or within any area declared under the Forest Ordinance (Chapter 451)* (This includes a large number of Forest Reserves & Proposed Forest Reserves in the country)
- *any archaeological reserve, ancient or protected monument as defined or declared under the Antiquities Ordinance ( Chapter 188 )* (these are mostly the cultural heritage sites come under the jurisdiction of Archaeology Department of Sri Lanka)

- *any area declared under the Botanic Gardens Ordinance ( Chapter 446).*
- *within 100 meters from the boundaries of, or within , any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance ( Chapter 469).*
- *Within a distance of one mile of the boundary of a National Reserve declared under the Fauna & Flora Protection Ordinance. (The term National Reserve includes natural heritage sites such as Strict Natural Reserves, National Parks, Nature Reserves, and Elephant Corridors/jungle corridors)*

The purposes of the EIA are to ensure that the development options are environmentally sound, sustainable and that the environmental consequences are recognized and corrective or mitigatory measures are taken into account early at the project planning stage in order to take actions that protect, restore & enhance the environment.

Having considered the above situation, the GIS centre of the Research & Special Projects (R&SP) Unit of the Environmental Management & Assessment (EM&A) Division of the Central Environmental Authority decided to develop a database in the GIS environment to assist potential developers/project approving agencies to identify the need to undergo the EIA process right at the early stages of the project planning, depending on whether or not the proposed project is to be located in an area identified as an environmentally sensitive area.

As a first step of this endeavor this task was confined only to Southern Province of Sri Lanka.

#### **Objectives:**

- To map out the environmentally sensitive areas in Sri Lanka
- To assist potential developers/project approving agencies to utilize the database in order to ensure the need to undergo the EIA process, right at the early stages of the project planning process
- To develop a database in GIS environment, allow regular update and quick spatial reference
- To invoke first hand visual information and thereby assisting the conservation of environmentally sensitive areas of the country
- To safeguard, conserve and ensure the existence of invaluable cultural & natural sites of the country

#### **Methodology:**

Topographical maps (scale 1: 50000) required for preparation of the base maps were procured from the Survey Department of Sri Lanka. Landuse, roads, water ways, administrative boundaries and important locations available in the topographic maps were digitized as separate layers, using Arc/Info (3.4.2b version) software to prepare a series of coverages.

Information gathering was done by collecting the recent available information in the form of gazette notifications, sketches, and maps (drawn to scale or not) pertaining to Southern Province from the relevant Departments / Institutes / Statutory Boards etc and these information was incorporated into base maps in order to prepare the sensitive area maps in the GIS environment. Global Positioning System (GPS) was used to collect primary data of cultural heritage sites such as archaeological reserves, ancient or protected monuments, of which secondary data was not available at the time of carrying out this mapping exercise. Finally, the environmentally sensitive areas were mapped in the GIS environment using ArcView (3.2a version) software.

The development of this data base will establish cooperation & collaboration amongst the respective implementation authorities and thereby help conserve natural & cultural heritage while at the same time protecting the environment of Sri Lanka.

SOCIAL AND ENVIRONMENTAL MONITORING OF A UNESCO BIOSPHERE RESERVE  
CASE STUDY OVER THE VOSGES DU NORD AND PFALZERWALD PARKS USING CORONA AND  
SPOT IMAGERY

S. Clandillon, C. Meyer & P. de Fraipont  
Service Régional de Traitement d'Image et de Télédétection (SERTIT),  
Pole API, bv Sébastien Brant, F-67 400 Illkirch Graffenstaden, France  
Ph: +33 (0) 3 90 24 46 47, Fax +33 (0) 3 90 24 46 46  
sertit@sertit.u-strasbg.fr <http://sertit.u-strasbg.fr>

A densely forested area this mountainous region has witnessed a major reduction in agricultural activity, with many formerly tilled lands being left fallow and gradually being colonised by wooded plants. Consequently, forestation has increased and much land gone wild. This has all occurred since the intensification of agriculture in more favourable areas and the application of the European Union's Common Agricultural Policies.

The study area is comprised of sections of the Sauer and Lauter river valleys both of whom cross the Franco-German border and comprises two parks covering the equivalent area of Luxembourg. The park administrations are charged with the thorough revaluation of the parks' socio-economic activities and natural heritage. They must therefore avail of information relating to past and present landuse and ascertain the dynamics of landuse change within this vast area of approximately 400,000 ha. Encroaching woodlands and wild, scrub strewn landscapes are causing a phenomenon that concerns the management teams namely the closing-in of the landscape, with reduced area to area inter-visibility villages seem even more isolated. Moreover, isolated villages have seen a decrease in population.

Considering the vast area and lack of existing information, satellite data and value added products seems to be a viable manner of deriving the necessary information especially bearing in mind the availability of declassified Corona Programme American defence satellite data, dating from the early 1960's (1962) and data of similar resolution from the SPOT Panchromatic sensor (1996). Hence the French and German space agencies (CNES and DARA) put together a programme with the park administrations (SYCOPARC and VNP) and SERTIT to apply remote sensing technologies to meet the geo-information needs of the parks.

This paper highlights the depth and richness of satellite remote sensing data archives with this study of landcover change over a three decade period, using a multi-temporal, Earth Observation (EO) database to analyse the landscape's dynamic over this long period. This time period is in accord with woodlands dynamics which occur over 30 years and more. It also highlights the drastic landscape changes that this area has undergone since the early 1960's which has had a major effect on the inter-visibility and feeling of isolation within certain mountainous valleys. The socio-economic effects of this human and then natural change are considerable leading to lower tourist interest and a reduced likelihood of industrial implantation to keep the population at work. The park administrations are keen about using remote sensing data to aid in resolving certain of their regional territorial planning problems and this paper touches on certain of these issues.

## Satellite Remote Sensing as a tool to monitor Indian Reservation in the Brazilian Amazonia.

P.R.Martini

I.M.Souza

Brazilian Institute on Space Research-INPE

Minister of Science and Technology-MCT

Astronautas Ave. #1784

12227-010 São Jose dos Campos SP Brazil

Phone 5512.3945.6470 Fax 5512.3945.6488

[martini,fris@ltid.inpe.br](mailto:martini,fris@ltid.inpe.br)

The Enawene-nawe Reservation in the Southern margin of the Brazilian Amazônia, State of Mato Grosso was created in the early seventies and is being submitted to deforestation and farming from outsiders according to local NGOs and newspaper statements. In order to know more about the real situation a satellite based Remote Sensing investigation is being undertaken. Multi-temporal images are being used and geo-referenced procedures are being adopted to verify more precisely the land use patterns around and within the Reservation boundaries. Geo-coded and geo-corrected images are being registered to detect the changes in the forest cover. LANDSAT-5 frames collected in 1987 are combined with LANDSAT-7 and CBERS-1 images in order to map deforestation patterns. The current results show that cattle raising patterns are entering the borders the Reservation coming from the Northwest. The Northwest region is occupied by land settlers that left the South of the country in the early eighties. They are now expanding their claims from the city of Juina following the road MT-34 that links the city in the State of Mato Grosso with Vilhena in Rondonia. Their lands are distributed over very high relieved granite-bearing terrains. They have settled for cattle not for cropping and now they are prospecting for gold. They are explorers. The South and Southeast borders of the Reservation are surrounded by extensive crop-fields again occupied by settlers that move from the South of Brazil. These Southern borders are not trespass by the cropping patterns even though that the low relieved morphology help to improve the dissemination of crops inside the Reservation. The Southern settlers are producers not explorers. It can be noted that the land management in the North is rough and hard while the procedures in the South of the Reservation is lighter and more productive. Satellite data collected by LANDSAT and CBERS are giving a date viewing of the region helping to verify the Enawene-nawe Reservation six times every 32 days. They are proving to be the cost-effective data to protect all reservations in the Amazonia as others sites that are asking for protection around the world. Satellite images can be the only easier way to approach preservation to the wild and remote lands of the raging third planet.

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**Remote Sensing and GIS Technology for Monitoring  
UNESCO World Heritage Sites--A Pilot Project  
Derrold Holcomb**

*Special Applications, Leica-Geosystems, Inc.  
2801 Buford Hwy NE, Atlanta, GA 30329 USA  
404-248-9000 X2203 holcomb@erdas.com*

**Rationale**

The use of remote sensing and GIS for various monitoring tasks is well established. Worldwide, agricultural crops, coastal zones and forests, among other subjects, are routinely imaged, classified and even managed using these new technologies. The use of satellite imagery for survey and mapping of archaeological sites has been growing, as has its use in environmental applications. This growth of use and applications is, in part, due to the positive synergy of increasing computer power and decreasing costs of this technology. However, like so much of the IT revolution, these technologies are rapidly advancing in the developed world and little understood in the less developed regions of the world.

Many of the World Heritage Sites (hereafter, Sites) are today under threat due to habitat destruction and human encroachment. And, unfortunately, as time passes these slow losses become the status quo. Some areas are difficult to visit or evaluate due to difficult terrain, natural or man-made disasters or political constraints. An underlying thesis of the World Heritage Sites is that they are everyone's heritage and responsibility. The recent destruction in Bamiyan, Afghanistan, underlines what can happen if the World relinquishes that heritage.

**Geographical Information System (GIS)**

The use of a Geographical Information System (GIS) as a database management architecture is increasingly common in many diverse fields. At its simplest, this merely implies that all data is tied to a common geographical basemap and is accessed by referencing the geographical location of the feature of interest. Clearly, this is a natural approach for the World Heritage Sites. The power of a GIS data storage architecture is that all information relevant to the Site will be linked geographically. Ancillary imagery (such as photographs), text files (e.g. reports) and vector layers (roads, infrastructure) are all stored within the GIS and accessed on the basis of their geographic location. The nature and "depth" of these GIS layers will vary with the Site. Remotely sensed imagery logically falls into such a database and, in fact, often forms the basemap for a GIS. Reports, photographs and other data can then be referenced and accessed within the database on the basis of the geographic location to which they are applicable. A common data layer for any GIS is a digital elevation model (DEM) that maps the terrain. This data is often used to correct or interpret other data layers.

**Remote Sensing Imagery**

Perhaps the most important advantage of RS imagery is that it allows any site to be observed from space, regardless of the situation on the ground. The most obvious circumstance requiring this capability would be war or similar hostilities at or en-route to the site. But other man-made or natural situations, such as floods or fires, could also limit the access of observers, especially in their ability to reach the site in a timely fashion. RS imagery of any area is freely available for purchase and subsequent analysis. Thus, "access" to the site cannot be denied and differing statements can be independently verified.

An interesting possibility relating to many of the Sites is that historical imagery of them may already exist in data archives. Many satellite-receiving stations have been collecting imagery worldwide on an opportunistic basis whenever the satellite was not specifically tasked. For the American Landsat satellite, this archive goes back to 1972. Thus it may be possible to assemble a picture of the changes at some Sites over nearly 30 years. Additionally, a lot of high-resolution imagery from American reconnaissance satellites has recently been declassified and is now available.

## Pilot Project

To demonstrate a number of the issues and advantages discussed above, a pilot project was undertaken. Within the WHS catalog of Sites, a small number are classified as "endangered"; these require the most immediate responses from the WHS Centre. From this "endangered" list, three WHS areas were selected within the Zaire/Congo basin. The three are; Salonga National Park, Okapi Faunal Reserve and Garamba National Park. Together these parks cover over 5 million hectares.

For these three Sites, a search of several Landsat imagery archives was undertaken. In an effort to limit the expense of this pilot project, not all archives were searched. After the searches, a total of 8 Landsat MSS, 4 Landsat TM and 1 Shuttle radar images were ordered at a total cost of \$US195.

For each Site, one image was rectified to map coordinates and all others in that set were then rectified to the georeferenced image. By using 30-50 tiepoints in coregistering the images, the coregistration between images was accurate at the pixel level. After all images for a Site were coregistered they became the GIS for that Site.

Each Site GIS was then visually analysed and interpreted within ERDAS IMAGINE image processing software. Use of viewing tools that allowed interactive zooming, roaming, overlaying, multi-band display and image linking greatly facilitated efficient investigation of the multiple images of each Site.

This preliminary evaluation of the imagery yielded some interesting insights into changes within these parks over the past two decades. For example, in Okapi a number of villages were seen to have grown steadily over the study period. New small "clearings" were noted throughout the park. It is uncertain from just the imagery what these "clearings" are. In an operational mode, these are the type of features that would be marked for ground investigation by a patrol circuit.

The changes in Garamba are more worrying. Because only two images, 1986 and 1990, were available for this study, conclusions must be tentative. Never the less, the two images were strikingly different. In the 1990 image, large areas within the park seemed to have been burned. Since these often occurred near areas outside the park showing similar burning, it is suspected that these areas were being illegally prepared for cultivation. The imagery of this park shows an area of vast wetlands, the sort of ecosystem easy to destroy and difficult to replace.

Interpretation of the Salonga GIS was the most perplexing. The park itself showed little alteration of the vegetation and forestry; this was reassuring. However, in several locations the villages seemed to have decreased in size. Evaluation of surrounding villages did not suggest that they had dramatically increased in population, nor were new villages seen. These observations have led to the conclusion that population has decreased in the area of this park. Several reasons for this could be proposed, the most ominous being AIDS-related deaths. Recent reports of AIDS-ravaged areas in nearby Uganda returning to a natural state support this interpretation.

In all the above analyses, interpretation was confounded by the prevalence of cloud cover in the area; some scenes had as much as 80% cloud. This also defeated attempts to classify the images using unsupervised classification techniques. The use of radar imagery circumvents this problem.

## Conclusions

The pilot project is presented here to prove the feasibility of a concept; the concept is large in scale. One can envision, a decade from now, an image processing and data handling facility dedicated solely to the World Heritage Sites. This facility would archive data on all Sites, train Site personnel in the use of this technology for their applications, develop regimens and protocols for Site monitoring and protection and coordinate these efforts between all member countries. Further, this facility could assist in opening channels for funding to support Sites or aid in resolving disputes concerning Sites near political boundaries.

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## **Session 2**

# ***Impact of Space Technology on Cultural Sites: Monitoring and Management***

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## Space Application For Heritage Conservation

Urban green spaces: modern heritage

Christiane Weber, Jacky Hirsch, Anne Puissant, Emmanuelle Brun, Cyrille Brichtler  
IMAGE et VILLE UMR 7011 CNRS / ULP  
3 rue de l'Argonne  
67000 Strasbourg  
[christiane.weber@lorraine.u-strasbg.fr](mailto:christiane.weber@lorraine.u-strasbg.fr)

Since 1987, "sustainable development" has appeared under the Brundtland report umbrella and many actions emerged locally to favor a result at a global scale. Several strategies have occurred protecting natural resources (water, air, soils etc.) and attempting to prevent from the anthropogenic threats. As such urban green spaces are considered as a heritage that has to be preserved at the same level as monument or industrial buildings. Environmental issues have placed the urban green areas on the stage. Among the protection decisions, the Agenda 21 initiative for instance, has especially focused on urban environment, land cover-land use change and sustainable urban development. Several cities have promoted green areas development and protection in order to enhance the quality of life of their citizens. The EU community in "the Environment 2010 programme" has stressed upon four thematic domains: climatic change, health, nature and biodiversity, and finally natural resources.

Since the Aalborg (Denmark) convention in 1994, numerous cities have signed the "environment charte" (1000 in 2001, Lettre d'information 2001) attempting so to introduce environmental issues into legal development tools like, in France the PLU (Plan local d'urbanisme) or the SCOT (Schéma de cohérence territoriale). In an European point of view some tentatives have appeared under the Danish Forest and Landscape Research Institute activities which has gathered competences and knowledge about urban green spaces and especially urban trees in cities. A COST (Cooperation européenne dans le domaine de la recherche scientifique et technique) network has been set up gathering about 25 countries to improve the development, design and management of urban forests in Europe. The Tree-ROUTE-Network as such, deals with all aspects of green areas: from inventory to management, from species selection to profitability and so on.

All of these actions are built on the principle of a good level of green areas observation. Meaning the design of an up to date information system gathering all green information. But one of the major problems in this case is to observe and identify the urban green spaces. The cities have a large amount of data on public areas, meaning build up areas, roads network, public open areas (green or not), but green areas are far more larger than the one collected. A spatial inventory of all green places need good observation tools to locate and identify the different types of green areas (forest, park, bank, meadow) that could be merged within a Geographic Information System (GIS) to separate public and private areas. Space born data (aerial or remotely sensed) provide a good image of this green heritage. Various aspects might be covered by the satellite image information: the location, the type, the biomass indication, the health etc. Evolution of urban pressure over green or natural areas is also a fundamental input that image could provide for planners or local authorities.

The new generation of sensors provides more precise information on urban green areas. High spatial resolution satellite data allow enhancing our knowledge on urban areas, and on green spaces especially.

Two methodological approaches have been set up over the Strabourg urban area: Observation and definition of urban green spaces: they have been studied through several satellite products (Landsat, SPOT, Quickbird data). The results of green space extraction have been compared and analyzed.

Some specific applications have been realized to produce to provide some insight support to urban development management: a connectivity map of the urban areas, i.e. the continuous green areas paths around the city, and a proximity map i.e. the amount of population which may take advantage of the green spaces location.

Specific aspects have been also taken into account like the importance of green areas for atmospheric pollution or the social interest of green areas for urban quality of life.

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2p.

**Monitoring of the technical condition of the St. Sophia Cathedral and related monastic buildings in Kiev with Space Applications, geo-positioning systems and GIS tools.**

*Dr. Ing. Y.A.Maslov,*

*National Architectural and Historical Conservation Area "St. Sophia of Kiev"*

*Dipl. Ing. A.P.Dyshlyk,*

*State Scientific and Production Company "Kievgeoinformatica"*

*Dipl. Ing. E.A.Kojan,*

*National Architectural and Historical Conservation Area "St. Sophia of Kiev"*

In the very historic centre of Kiev towers a Cathedral, which was erected in the first half of the 11<sup>th</sup> century in honour of Saint Sophia - God's of Wisdom. In 1990 the Saint Sophia Cathedral of the 11<sup>th</sup> century together with its ensemble of monastic buildings in its territory was included on the UNESCO World Heritage List. The outstanding universal importance of this monument is that the architecture of the Cathedral has been almost completely preserved since the 11<sup>th</sup> century.

Today the technical condition of these ancient buildings causes a great anxiety. The monuments suffer both from a destructive action of time, and from damage caused by the influence of the environment and by technogenic factors. First of all this concerns directly the Cathedral and its Bell Tower (76 m height), which is a main architectural dominate of Kiev. The problems presenting themselves are numerous rents, cracks and cavities in the ancient walls and vaults of buildings, and a deviation of constructions from a vertical line. All of that testifies the deformations development of ancient buildings.

To observe and to prevent the development of the negative tendencies it was required first of all to elaborate a technology of the ancient buildings measurement and their documentary fixation in a system of local topographic coordinates, and also in a system of international spatial coordinates.

Such technology (know-how) has designed now. It uses essentially the data received from satellites, data of a large scale aerial photo shooting, and also data of a spectral shooting. These data will be used in a complex with the data of ground level shooting for development of geo-positioning systems to assist in the elaboration of digital topography for historical territory and periodically observation of processes of the buildings deformation by usage of GIS toolkit.

The tendered technology includes the following sequence of operations:

1. Creation of a backbone of geodesic points at the territory of the architectural ensemble of the St. Sophia Cathedral with a usage of GPS.
2. Large scale aerial photo shooting of the territory of the architectural ensemble of the St. Sophia Cathedral.
3. Creation of a network of geodetic points inside ancient buildings.
4. Phototheodolite shooting of facades and interiors of ancient buildings.
5. Photogrammetric fixing of the monumental wall painting inside of the Sofia Cathedral with a usage of photo and total station data.
6. Observation over the top motion of the Bell Tower and cupolas motion of the Sofia Cathedral with a usage of the aerial photo data.
7. Developing the facilities and skills-base required to store, process and facilitate the usage of all data for the deformation analysis and decisions making.

A dense building surrounds the historical centre of Kiev with the territory of the architectural ensemble of the St. Sophia Cathedral. And so it is extremely inconvenient and expensively to fulfil the activities on a creation of the geodetic network by ground-level methods. Therefore it was selected methods grounded on usage of the data from satellites as most effective from the point of view of accuracy and cost.

The geodesic network at the territory of the architectural ensemble of the St. Sophia Cathedral serves as a coordinate system, in which one the spatial models of all buildings of the architectural ensemble are placed. Besides there are internal geodesic networks inside each building. They serve as internal coordinate systems inside each building. They bound with an external geodesic network at the territory. Thus spatial models of all ancient buildings are fixed both in a system of local coordinates, and in the international system of spatial coordinates.

The geodesic network consists points, each of which represents a concrete monolith arranged in a definite place at the territory of the architectural ensemble. Each monolith is buried in ground. A bottom of each monolith is arranged below than depth of freezing, the upper surface coincides with a level of a daylight area.

The activities on definition of spatial coordinates of points of the geodesic network were executed with two pairs GPS- receivers. The one pair consists a single-wavelength receiver Trimble 4600 LS, another pair consists two-frequency receivers Trimble 4800.

It was selected the static method of shooting with fixed arrangement GPS-receivers, which one provides high-precision outcomes.

The periods of supervision sessions were planned with a prediction. It was used the Trimble Geomatics Office Software. It was used as output parameters for planning the following quantity of satellites and boundary value of a factor of the reduction of an accuracy of the coordinates setting. It was defined a most favourable interval, which one was prolonged from 10:30 a.m. and up to the end of a light day. The receivers were set on supports above each monolith during the shooting and they were centred with the optical accessory with accuracy  $\pm 1$  mm. It was conducted every day the preliminary equalization of the data for removal of appreciable errors and for the data filing. The data processing implemented with usage of the Trimble Geomatics Office Software.

The offered technology is used in Ukraine for the first time. It is a new development in the domain of the monitoring of a technical condition of architectural monuments.

#### Full details of authors:

Dr.Ing. Y.A.Maslov, Correspondent-Member of Construction Academy of Ukraine, Leading research worker of the National Architectural and Historical Conservation Area "St. Sophia of Kiev", address: 24, Volodymyrs'ka St., Kyiv, 01034, Ukraine, Tel.: +38 (044) 228 57 38, E-mail: stsophia@i.kiev.ua

Dipl.Ing. A.P.Dyshlyk, Deputy Director of the State Scientific and Production Company "Kievgeoinformatica", address: 54, Popudrenko St., Kyiv, 02094, Ukraine, Tel.: +38 (044) 55 22 54, E-mail: dyshlyk@geomatka.kiev.ua

Dipl.Ing. E.A.Kojan, Department Chief of the National Architectural and Historical Conservation Area "St. Sophia of Kiev", address: 24, Volodymyrs'ka St., Kyiv, 01034, Ukraine, Tel.: +38 (044) 228 57 38, E-mail: stsophia@i.kiev.ua

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**Family Name** : Barbara  
**First Name** : Cerasetti  
**Citizenship** : Italian  
**Position** : PhD  
**Organization** : Department of Archaeology, University of Bologna  
**Address** : piazza S. Giovanni in Monte, 2  
**ZIP** : 40124  
**City** : Bologna  
**Country** : Italy  
**Phone** : +39 0512097700  
**Fax** : +39 0512097701  
**E-mail** : [ma14259@iperbole.bologna.it](mailto:ma14259@iperbole.bologna.it)

**Paper Title** : The Murghab delta palaeochannel reconstruction on the basis of remote sensing from space.

The aim of the present research is the reconstruction of the palaeochannel network of the Murghab delta (Turkmenistan) and the water supply process of the major sites, using *Remote Sensing* data like satellite imagery (*CORONA 1964 – Landsat-7 2001*) integrated by other vertical platforms like air photos. The integration of the resulting data with the GIS of the area will be used to reconstruct the settlement distribution in a virtual archaeological landscape of the Murghab delta and to understand the complex processes characterizing the culture development in that area and in the neighbour regions from 3000 BC to XIII century AD.

The Murghab delta, of which the Merv oasis is the eastern part, extends for a 20000 km<sup>2</sup> area between the Amu-darya river and the Tedjen delta in the Karakum desert. The hyper arid climatic conditions and the following evaporation process of its water made during the time the terminal part of the delta covered by sand. This phenomenon begun already during the Late Bronze Age period (1800-1400 BC) and the delta went back to the south progressively. After World War II the Soviet Union, which included Turkmenistan during those years, purposed to build a great irrigation system for making the desert area of the Murghab delta a precious resource for the agriculture. The modern works destroyed a lot of sites, dated chronologically from the Late Chalcolithic to the Islamic period and situated in the ancient riverbed of the Murghab.

In the first time the reconstruction of the palaeo-system has been based on a Vectorial Historical Cartography, dated before the building of the modern irrigation system. The integration between raster and vectorial data and the following visualization in a virtual three-dimensional landscape has made possible a multidimensional and multi-temporal pattern of a typical geoarchaeological landscape of Central Asia. A preliminary territory observation and reconstruction of the palaeo-delta have been managed using *Soyuz KFA 1000* and *ERTS-1* satellite imagery. The *ERTS* images testify the regression step of the Murghab delta because of the desertification process. The main aim of the present research is to complete the reconstruction of the ancient geo-hydrological landscape by using multi-spectral *Landsat-7 (2001)* and panchromatic *CORONA (1964)* bands with a contribution of aircraft and kite photos. The last *Landsat* images from *Enhanced Thematic Mapper (ETM)* sensor, with a 10 m. geometric resolution on the ground, represent a fundamental instrument for the interpretation of the ancient landscape. The *Landsat-7* panchromatic version make clear the meanderings of palaeochannels and the high capacity of the

salty sedimentations to reflect the sun light make possible to recognize ancient landscape. The photo observation is fundamental to study the areas not investigated by survey. The *CORONA* bands employment needs to observe the present areas covered by vegetation on *Landsat* images.

The satellite photo-mosaic are integrated by aircraft and kite data from Merv oasis sub-delta, the northeastern region of the Murghab delta. The *Side-Looking Airborne Radar (SLAR)* is able to take photos from oblique angle for the observation of earth morphology. A first application of aerial photos on the Murghab delta is the geomorphologic map of Merv oasis, constructed on the basis of aerial photo-mosaic. The map represents one of the main cartographic layers of *Geographical Information System*. The black/white and infrared or pseudocolor films are mainly used for aerial photos. By 1940 the infrared films are used by military corps to recognize the artificially camouflaged objects and they are fundamental for researches on regions covered by sand and vegetation like the Murghab delta. At this moment the acquisition of aerial photos and cartographic maps lower than 1:200000 scale is forbidden by National Agencies for the security of Turkmenistan. For this reason the allowed material is precious for a reconstruction of ancient palaeochannel network and the relation of main channels with archaeological settlements for the water supply.

The integration with *GIS* applications could represent a significative development to realize a new three-dimensional product of a digital archaeological map to understand the dynamics of ancient population.

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Title: Acquisition, registration and application of IKONOS space imagery for the cultural World Heritage Site at Merv, Turkmenistan.

Authors:

Dr. Peter Dare  
Chair  
Department of Geodesy and Geomatics Engineering  
University of New Brunswick  
PO Box 4400  
Fredericton  
New Brunswick  
Canada  
E3B 5A3  
Tel: 1-506-453 4698  
Email: Dare@unb.ca

Dr Georgina Herrmann  
Honorary Professor  
Institute of Archaeology  
University College London  
31-34 Gordon Square  
London  
England  
WC1H 0PY  
Tel: 44-20 7679 4753  
E-mail: tcfa249@ucl.ac.uk

Tim Williams  
Senior Lecturer  
Institute of Archaeology  
University College London  
31-34 Gordon Square  
London  
England  
WC1H 0PY  
Tel: 44-20 8520 1680  
E-mail: tim@archcollab.freereserve.co.uk

Dr. Marek Ziebart  
Research Fellow  
Department of Geomatic Engineering  
University College London  
Gower Street  
London  
England  
WC1E 6BT  
Tel: 44-20 7679 3638  
E-mail: marek.ziebart@ge.ucl.ac.uk

## Abstract

The Merv oasis lies astride one of the main arms of the ancient Silk Roads that traversed half the world, from the Far East to Europe and Africa. The ancient cities of Merv, a succession of flourishing administrative and trading centres for nearly 1,700 years, became one of the most important cultural centres in the Islamic world. The Turkmenistan Ministry of Culture made the far-sighted decision in 1990 to establish an Archaeological Park to protect the walled cities and the principal outlying monuments within the oasis. This has already done much to improve the basic condition of the cities, removing modern agriculture from within the walled areas, and generally improving access to the monuments. However, there are daunting conservation issues facing the Turkmens. In 1999 the site was declared a World Heritage Site and in 2000 Merv was placed on the list of the world's 100 most threatened sites by World Monuments Watch \* it remains on that list today.

Panchromatic 1 m-resolution imagery for the site area was acquired from the IKONOS satellite during 2001. The acquisition epoch for the black-and-white data was selected to minimise masking due to vegetation and cloud cover. The precise locations of points of detail in the imagery, required for spatial registration of the remote sensing data, were determined by a Global Positioning System observation campaign. These locations were computed using the globally consistent International Terrestrial Reference Frame and projected using the appropriate Universal Transverse Mercator zone. The fieldwork, computational procedures and reasons for choice of reference frame and projection are described. The results of the spatial registration, and their implications for the accuracy of the mapping data are discussed.

The cities of Merv have been the subject of many years of investigation, including fieldwalking, geophysical surveying, detailed archaeological excavation, and building recording. Future work will include further excavation, geophysical and topographic survey, aerial photography, conservation and the monitoring. The satellite imagery provided the basis by which all the disparate elements undertaken thus far could be integrated into a single spatial framework, and a means by which all future work could be co-ordinated.

The image also provides an important record of the condition of the site at a point in time. Given the scale of the ancient cities of Merv (c 1,000 ha of enclosed urban space, with additional extensive suburban activities), the field monitoring of every track, pathway, drainage channel, field, erosion gully, etc, would be a huge undertaking. The satellite image provides a comprehensive base map that enables these aspects to be rapidly and accurately documented, and future changes to be measured. The geo-referenced image has provided, for the first time at Merv, a base map capable as acting as the platform for integrating and acquiring spatial data, providing the platform for the development of a GIS for the Archaeological Park.

This project demonstrates how several rapidly developing branches of technology can be brought to bear on the management and analysis of a site of international importance in a cost-effective and efficient manner. These technologies are great enablers, and although the acquisition and registration of the data are quite complex tasks, the final product, in the form of a digital map base, is readily accessible to archaeologists and other heritage management professionals.

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## Remote Sensing and VR applications for the reconstruction of archaeological landscapes

Maurizio Forte  
Senior Scientist, CNR-ITABC, National Research Council, Institute of Technologies Applied to the Cultural Heritage, Roma

**Keywords:** VR, Remote Sensing, Mindscape, Archaeology.

### Abstract

Knowledge and diachronic interpretation of an archaeological landscape depends on factors of perception, self-referring, interaction (“feedback”) and cultural learning. The paper describes a new approach for the reconstruction of archaeological landscapes using virtual reality technologies, remote sensing techniques and GIS data within an eco-environment of simulation.

“Landscape ecology is a branch of modern ecology that deals with the relationships between man and his open and built-up landscapes” (Naveh, Lieberman, 1990). The landscape classification of Naveh and Lieberman is the following:

1. Ecotope (or site), smallest holistic land unit, characterized by homogeneity of the least one land attribute of the geosphere—namely, atmosphere, vegetation, soil, rock, water, and so on, with non excessive variations in other attributes.
2. The land facet (or microchore), a combination of ecotopes, forming a pattern of spatial relationships and being strongly related to properties of at least one land attribute (mainly landform).
3. The land system (or mesochore) is a combination of land facets that form one convenient mapping unit on reconnaissance scale.
4. The main landscape (or macrochore) is a combination of land systems in one geographical region

What space does the archaeology occupy within the landscape ?

### Mindscape

This neologism has been used, at the beginning, in sociological field for describing, generally, the mind landscapes in terms of cognition/perception of the world. In our case we want to introduce this concept for showing the importance of the mind perception for describing and interpreting the archaeological landscape or, simply, a human landscape. So, the mindscape is a connective space of perceptual information, it is a self-organised world in which the human complex societies grow and develop. Our theory is that for reconstructing and trying to learn an archaeological landscape it is fundamental to construct a virtual digital environment of simulation using neural networks and virtual reality systems. Neural networks are needed for constructing intelligent avatars and behaviors.

Keywords and key concepts of this theory are concerning the following issues:

- Self-organization
- Digital evolution of an ecosystem for simulating factors of interaction
- Real time 3D navigation through the landscape
- Interaction between observed landscapes (remote sensed) and perceptual landscapes (virtual reconstructions)
- The map is not the territory in the Reality
- The map is the territory in the Virtuality

“The map is not the land” and, in digital language, a GIS is not the landscape, because it cannot represent such a complex dataset as a landscape. The archaeological landscape is a content of multidimensional and diachronic information: multidimensional because it concern bi and three dimensional geometries, diachronic because it shows the evolution of the territory. The archaeological landscape is a representation of invisible data that, for having a cognitive significance, must be virtually represented. In recent years the relationships between landscape and cognitive archaeology have been studied, with some significant contributions such as *The ancient mind* (Renfrew, Zubrow, 1994), *The phenomenology of landscape* (Tilley, 1994), *Semiotics of Landscape: Archaeology of Mind* (Nash 1997), *Archaeologies of landscape* (Ashmore, Knapp, 1999). How can we represent the archeological landscapes? What is the perception of the landscape? What is the difference between the real and imaginary landscape? How is it possible to describe an archaeological landscape? The complexity of the problem is evident: for analyzing, describing and representing an ancient landscape, spatial techniques, and epistemological and anthropological approaches are needed. Indeed, observation and interpretation of the landscape depend for a significant part on the remote sensing classifications, so the final interpretation is a bridge between old (virtual) and modern landscape (remote sensed, observed).

The current research activity of our Lab is focussed on these national and international projects: Terramare (North Italy), Aksum (Ethiopia), and INTAS-Kazakhstan; in this paper we will present mainly the scientific results of the Aksum project.

The Archaeological Expedition at Aksum (Ethiopia) of the Istituto Universitario Orientale, Naples (Italy), and Boston University, Boston (USA) resumed investigations at Bieta Giyorgis, a hill to the NW of Aksum, in the period 1993-2002. The general goal of the IUO and BU Expedition is to study the development of complex societies in Tigray from

late prehistoric (3rd-2nd millennia BC) to medieval times (14th century AD). The current stage of the project is mainly interested in the rise and development of the Aksumite state (late 1st millennium BC- early 1st millennium AD). Particular emphasis was also given to the study of the involvement of Aksum in the trade network from the Mediterranean to the Indian Ocean. Excavations at Bieta Giyorgis were aimed at testing the hypothesis, based on traditional Ethiopian sources, that the hill was an area of early development at Aksum. An important goal of this project is to investigate the origins and urban development of Aksum within its environmental setting. The project includes research in archaeology, paleoethnobotany, archaeozoology, ethnoarchaeology, history, geology and geomorphology, digital technologies as well as systematic mapping and conservation. In particular we will present the preliminary results of GIS and Remote Sensing applications concerning the area of Aksum, comparing in 2D and in 3D digital data such as: aerial photos (1:10.000), satellite images (Landsat TM, SPOT XS), cartography, landscape documentation. Remote sensing and pedology could further enhance existing knowledge about the landscape characteristics on and around Bieta Giyorgis.<sup>1</sup> The main objectives of these studies included:

- (1) Relating different land-cover types to the spectral signatures found with Landsat ETM+ and SPOT XS for an area in and around Bieta Giyorgis;
- (2) Identifying characteristics of the soil land-cover types found on Bieta Giyorgis;
- (3) Assessment of a possible soil study in order to be able to relate soil characteristics with archaeological findings and structures.
- (4) Reconstruction of micro-DEMs. of the landscape using DGPS in kinematic way.

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<sup>1</sup> Remote sensing and pedological analyses were conducted by Magaly Koch and Thomas Schmid, respectively.

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## ARCHAEOLOGY THROUGH SPACE: EXPERIENCE IN INDIAN SUBCONTINENT

P.S. THAKKER

Forestry and Environment Division (FED),  
Forestry, Land use & Photogrammetry Group (FLPG)  
Space Applications Centre, ISRO, Ahmedabad, India

The emergence of our own species remains one of the most elusive problems in palaeo anthropology. According to Arch Bishop Usshers' chronology man was created in 4004 B. C. on March 23<sup>rd</sup>. The total age of man and also of the earth was just about a few thousand years as per the story of Adam and Eve according to western theory. In the east, the people, particularly Hindus, believed that man existed on the earth since countless ages. Man has lived on this planet for more than a million years (perhaps even much longer) and yet this fact was not known to us till just about a hundred and fifty years from now.

Prehistoric man lived mostly on the banks of the rivers so that he could easily avail of one of the necessities of life, the water. At the time of the floods he left the riverside, but in the process of leaving he left behind inadvertently his belongings and imperishable stone implements. Gradually as the water receded these implements got stuck or embedded in the clay. As this process was repeated again and again, a variety of stone tools made by prehistoric man were left behind in the terraces of riverbeds. It is they that provide clues to his antiquity.

About a century back, no one knew the existence of the prehistoric man in India and great civilization that had existed over the northwestern region of the Indian subcontinent. The first two sites of this great civilization, Harappa and Mohenjodaro were discovered during 1921-22. Harappa thus became the first and Mohenjodaro the second to be discovered as the sites of this great civilization in India, now in Pakistan. Another major site of this civilization was discovered at ChaunoDaro in Sindh in 1935. Indian Archaeologists found many more sites of this civilization in Punjab, Uttar Pradesh, Rajasthan and Kachchh & Saurashtra region of Gujarat State. Lothal, Rangpur, Rojhadi, Dholavira of Gujarat and Banavali of Rajasthan are most important sites discovered on Indian soil.

Excavations at Mohen-jo-daro and Harappa and later at other sites revealed a highly developed urban civilization organized in cities and towns whose wealth was derived mainly from agriculture and trade. The cities were well planned and had straight wide streets. Burnt bricks and stones were used for every type of construction. The residents seem to have enjoyed a degree of comfort, luxury and hygienic environments not observed in any other parts of the world. There seems to have been an effective civil administration and governance, which controlled the activities at the major cities. Granary buildings have been discovered at Harappa.

An attempt have been made to compare the sites described in the available literature and sites excavated by different archaeologists using Indian Remote Sensing (IRS) 1C/1D LISS III data. In addition to this unexplored probable archaeological sites were located and identified using certain parameters and were confirmed on ground later on. Extension of excavated known site like Dholavira was also suggested using remote sensing data and was confirmed on ground.

According to prescriptions of certain theoretical texts/shastras, Hindu cities were to be laid out in cosmic patterns or diagrams (mandalas), like rectangle, square, triangle, swastika, semi lunar and circular in shape. Known excavated sites like Lumbini, Harappa, Kosambi, Ahichhatra, Sisupalgarh, Nalanda, and Dholavira clearly shows certain shapes like triangle, square, rectangle, semi lunar and certain patterns on IRS 1C/1D data which confirms the description given in the literature that of even 6<sup>th</sup> B. C.

It is inferred that, like the present, the societies at different developmental stages co-existed in the Indian subcontinent. Remote sensing technology can play an important role in understanding the past in the context of available historical and ancient literature. Remote sensing data can successfully be used for building up historical records and changes might have taken place on the surface of the earth in the past. Space science / remote sensing is non-destructive technique for archaeological studies.

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## THE CREATION OF A GIS ARCHAEOLOGICAL SITE LOCATION CATALOGUE IN YUCATAN: A TOOL TO PRESERVE ITS CULTURAL HERITAGE

Archaeologists: Jose Huchim Herrera  
Diana Trejo Torres  
Miguel Covarrubias  
Centro INAH Yucatan  
Km. 6.5 antigua carretera a Progreso,  
Merida, Yucatan, Mexico.  
Tel./Fax (999)9440033, 9440043  
e-mail: [covarub@sureste.com](mailto:covarub@sureste.com)

Archaeological site location and registration in the Northern Maya Lowlands of the Yucatan Peninsula has been an interrupted process, despite the fact that in the past there have been numerous regional projects focused on locating and documenting characteristics of prehispanic settlements.

The first systematic site location and registration project was developed during the 1970's, creating a catalogue with more than 1,120 sites (Garza and Kurjack, Atlas Arqueologico del Estado de Yucatan, 1980). This project, unfortunately, was discontinued. After the publication of this work, there were carried out several other smaller regional archaeological survey projects (Andrews, Gallareta and Cobos, 1989; Kepecks, 1990; Dunning, 1992; Andrews, A.P., 1995; Robles and Andrews, 2000), but their results were never added to the existing data corpus.

A new project, called Atlas Arqueologico Nacional (Velázquez y Lopez, 1988) reused the earlier material of Garza and Kurjack and complemented it, reaching a total of nearly 1500 sites registered. This project, however, did not consider the results of the other small regional survey projects, nor was a catalogue published with a list of their own data.

During the development of a later project, called INAH-PROCEDE Yucatan (Huchim, Trejo and Covarrubias, 1996-2000) all the information of former investigations and that produced by the project itself, were unified in a single data base, which now contains more than 1,970 records (one for each site). An important data corpus about Maya archaeological site locations was created, divided into three kinds of files:

- 1) Catalogue of Yucatan's Archaeological Site Location (data base file).
- 2) Topographic maps covering the entire Yucatan State with site locations indicated on them, as well as polygons for surveyed sites and contemporary land tenure where they are located.
- 3) Individual files with polygons that establish protected areas for more than 200 sites surveyed and complementary information about each one.

This important information has already demonstrated its utility in archaeological surveys required before any kind of constructive activity can be undertaken and

has contributed directly to the preservation of cultural heritage. This is why we are concerned that this data corpus must be maintained in adequate condition for future use and consultation, currently most of it is stored physically on paper, which is not a permanent material. We are also worried because this INAH-PROCEDE Project has been suspended. There is great danger if this valuable information will not be updated regularly, and will lose its utility as a tool to help us protect Maya cultural heritage in the most efficient and permanent manner.

Modern technology can be used to solve this problem. The use of a Geographic Information System (GIS) would be the most accurate mean to store the INAH-PROCEDE information in a digital format, providing permanent and constant update.

GIS is a computerized system that records, stores and analyzes information about features that cover our planet's surface. Data bases that feed GIS consists in information groups called "layers". Each "layer" represents a specific kind of geographic feature, which can be combined to permit us the appreciation of all features in a single view. GIS presents information in a graphic manner, spatially referenced, so the observer can understand the relationship between different attributes that make up this information. A GIS can combine as many as a hundred layers in one image.

Right now it is difficult to use INAH-PROCEDE's information in a simultaneous way because the information is stored in separate digital and analogic files. With GIS this will not only be possible, but with all data gathered in a single image, we can count on a higher analysis level that will enable us to make many kinds of observations and interpretations.

GIS will allow more efficient archaeological survey activities because we can establish relationships between site locations and/or features with other kinds of environmental data like soils, vegetation, hydrology, altimetry. Also cultural information, like ceramic or any kind of artifacts distribution, architectural styles, sculpture, ethnohistoric and epigraphic data can be related to our database.

For the archaeologist, this is a tool to sample, analyze and generate maps with the required information. GIS also makes easier the decision-making task in planning the construction of modern facilities without damaging cultural resources. In addition, one can quickly analyze different kinds of information in a single visual operation. This system can save time and money in data generation and allows a rapid reproduction of data.

It is possible that the capacity to upgrade vital archaeological data into a more complex system is the main advantage of GIS, since it can be operated with a PC platform (as we are doing in Yucatan) and then later can be translated into a UNIX system, capable to cover the whole nation.

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**ABSTRACT**  
**Mapping the Ancient Anasazi Roads of Southeast Utah**

Ray A. Williamson  
&  
Michael Jeffe  
The George Washington University  
Winston Hurst  
College of Southeastern Utah

About a decade ago archaeologists became aware for the first time of the existence of Ancestral Pueblo (Anasazi) roadways within the canyons of Southeast Utah. By walking many miles of canyon landscape, they have tentatively identified an extensive network of "road" segments—well-defined pathways up to 10 meters wide—connecting the major Anasazi settlements of Southeast Utah. The discovery of road network, which now total over 100 kilometers in length, led to the identification of other previously unknown archaeological sites associated with it. These include nearly two dozen shallow depressions up to 20 meters in diameter, likely to contain the remains of large ceremonial rooms (great kivas) typical of the late 11th and early 12th century AD Ancestral Pueblo culture.

The road network, which resembles the Ancestral Pueblo roads in and near Chaco Canyon, New Mexico, has never been fully delineated, in large part because of the extensive labor involved to verify the road segments on foot, but also because they are often too shallow to see from ground level. Because these features extend over a wide geographical expanse, remote sensing from spacecraft is an ideal technique for mapping them, preparatory to detailed ground examination.

This paper describes the use of high-resolution Ikonos satellite imagery to document the roads and the significant archaeological features found along or near them. It also explores the use of these techniques for managing significant cultural landscapes in the face of substantial destructive pressures.

The project employed a combination of intensive ground examination using a digital video system incorporating precise geographic coordinates by means of the Global Positioning System (GPS). We used the GPS-video camera not only to record the appearance and position of road segments, but also to document natural landscape features but also each item of archaeological significance associated with them. Archaeological features include simple rock circles, herraduras (thought to be ceremonial features), small and large dwellings, great kivas, and rock art sites. This technology allowed for the first time the rapid acquisition and incorporation of varied types of natural and archaeological data into digital databases. Further, because position data were acquired as an integral part of the data collection process, they were readily incorporated

into the geographic information system (GIS) that we used in analyzing and displaying the satellite data.

For the central part of the study area, we also carried out a detailed land cover and classification study, allowing us to develop baseline data on the types of vegetation currently found in and among the major archaeological sites. This information will be of considerable utility to the archaeological crews working in the area now and in the future.

This multidisciplinary project involving remote sensing, geographic positioning technology, and archaeology is significant because it is demonstrating linkages among far flung ancient communities helping researchers reach a much better understanding of Ancestral Pueblo settlement patterns in Southeast Utah. The project has also provided insights into how the Ancestral Pueblo Indians might have viewed the relationship between their dwellings, ceremonial sites, and the landscape and offered clues concerning the role of ceremonialism in the region. It is also particularly timely. Most of the possible road segments lie on public lands managed by the U.S. Bureau of Land Management or the State of Utah. Many of the road segments have already been obliterated by grazing, urban development, and recreational uses of Southeast Utah lands. The remaining ones are under significant stress from increased population and tourist visitation. Having detailed maps of the road segments will assist federal and state agencies in protecting these highly significant manifestations of the ancient landscape.

Submitted by:

Dr. Ray A. Williamson  
Research Professor  
Space Policy Institute  
2013 G St., NW, Suite 201  
The George Washington University  
Washington, DC 20052  
202-994-6451; fax 202-994-1639  
email: rayw@gwu.edu

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## Abstract

# Remote Sensing and GIS Technology for Identification of Conservation and Heritage sites in Urban Planning

by  
Nisitendra Nath Som

### 1. Introduction:

Documenting cultural landscapes around the objects of cultural heritage has often been neglected because of the high surveying and mapping expenditure. With modern techniques documentation has become cost effective, which can be a powerful means to monitor and manage conservation and development of heritage sites. Remote sensing technology through the use of aerial photographs and satellite images could be used to identify sufficient details even the boundary walls of archaeological sites, which are otherwise difficult to identify from the ground.

Inherent properties of remote sensing image make the data derived from it extremely useful in building a broad base, namely, (a) the wider environmental perspective provided by remote sensing techniques than ground surveys, and (b) the imagery provides a perspective of increasing historical value over fixed time and space. This may be a recent approach towards the study of archaeological and historical sites, that integrates information of all the techniques available to restore, preserve, and discover any unknown remains of archaeological and cultural importance. It is believed that the new technology will save time, budget, and human resource to discover unknown archaeological sites. In India fascinating history, supported by geological, hydrological and archaeological evidences of heritage as well as the application of most modern tools, such as remote sensing and GIS could be revealed.

### 2. Application:

Application of remote sensing techniques in the planning for urban region include monitoring of land use/land cover changes, identification of archaeology and heritage sites and would likely to fetch economic benefits through reduction of costs of survey. Remote sensing technique can increase efficiency and speed in data extraction at all stages of research. This may, in fact, be one of the best justifications for publicly funded remote sensing based programme in the field of natural and cultural heritage.

Launching of high resolution PAN and IRS-1C satellite data has tremendously enhanced the application capability for thematic mapping in the urban planning process. There is very little published literature on application of this technology in the field of conservation and heritage. The PAN data has a large spatial resolution with broader synoptic and repetitive coverage. Hence, large archeological areas can be observed with good spatial resolution. Further, expert knowledge can also be used to deduce the signature of known sites for searching the unknown area. An integrated approach using collateral information along with remote sensing data in GIS environment is ideal for this type of study. The data collection when supported by Global Positioning System (GPS) will be more accurate and precise.

Application of Remote Sensing data in the field of land information system by using the high resolution LANDSAT MSS, LANDSAT TM, SPOT, SPANS, IRS LISS II and IRS-LISS III has been so much known to day that they can play a very fruitful role for preparation of land cover maps to indicate the spatial pattern of physical growth in terms of urban built upland.

The main advantage of Remote Sensing data is its repetitive and synoptic coverage that facilitate preparation of updated spatial maps even from the most recent pictures.

This is also a cost-effective technology. It has also been seen that the cost of a project covering 50 x 50 sq. km. came to about Rs.15000/- in India. For data procuring and processing that also linked. It could be seen, when examined through a cost-benefit studies, that this technology is also cost-effective, timely and accurate. The images from digital sensors allow automatic Digital Elevation Model (DEM). Cultural heritage objects may be too small, covered by soil or vegetation or may be covered for any other reasons. To show these objects, 2-D or 3-D symbols can be generated and stored in separate overlays in the DEM.

### **3. Kolkata Case Study:**

Study on the Monitoring Urban Sprawl (MUS) was conducted for Kolkata Metropolitan Area (KMA) by the author, in collaboration Space Application Center (SAC) at Ahmedabad during late eighties, being assigned the job by Kolkata Metropolitan Development Authority (KMDA). Now, this will be applied in the City of Kolkata including both its old historic core and natural wetlands in the fringes, particularly at its eastern fringe.

The use of remote sensing helps to bring the target area nearer, but potential of such application has hardly been recognized anywhere in cultural heritage documentation. IKONOS data with one meter resolution are now available for application where textures of high quality can be used even if the aerial photographs are not available. All data have to be geo-referenced in the same coordinate system. If high resolution IKONOS images are used, it may be seen that the result of using LANDSAT and SPOT images did not have sufficient quality.

Geographic Information Systems (GIS) is an ideal means to manage data of cultural landscapes or cultural heritage objects, and also provides tools to store, manage, analyze and visualize spatially related data. If a GIS with temporal dimension is chosen, the evolution of a cultural landscape can be studied.

### **4. Conclusion:**

Conservation and heritage issues have been considered one of the important component as dealt in the Interim Draft of VISION: 2025, 'A Perspective Plan of KMA-2025', prepared recently in KMDA. Presently the author is also engaged in procuring and using IKONOS data of 1m resolution in the urban planning process in KMDA, in which identification of conservation and preservation of heritage buildings and sites in Kolkata Metropolitan Region shall be attempted in the paper proposed for presentation in the conference. The study is likely to be made with the application of such tools of Remote Sensing data and GIS.

#### **Details of Submitter:**

<b>Name:</b>	Nisitendra Nath Som
<b>Professional address: and Position</b>	Director of Planning, Physical Planning Unit, Kolkata Metropolitan Development (KMDA) 4 <sup>th</sup> Floor, Unnayan Bhawan, Salt Lake City, Kolkata – 700 091, West Bengal, India.
<b>Telephones:</b>	(91) (033) 337 2403 (office) (91) (033) 550 6461 (residence)
<b>FAX:</b>	(91) (033) 359 3563
<b>e-mail:</b>	<a href="mailto:nisitsom@vsnl.net">nisitsom@vsnl.net</a>

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**Abstract for Space applications for heritage conservation,  
novembre 2002, Strasbourg**

**Mapping Angkor,**

*For a new appraisal of the Angkor region*

By Christophe POTTIER

PhD. in History and Archaeology, Architect DPLG,  
Member of the French Institute of East Asian Studies (Ecole  
Française d'Extrême-Orient - EFEO).

Address: EFEO, p.o. box 878, Phnom Penh, Cambodia.

Email: < efeo.angkor@camintel.com > & < cpottier@ext.jussieu.fr >

Dr. Pottier, Member of the EFEO, based in Angkor (Cambodia) since 1992, will present various results of the research he conducted on ancient urban planning in Angkor region.

His research initiated with his participation to the ZEMP (Zoning and Environmental Management Plan for Angkor Region), a multi-disciplinary study organized by UNESCO for the inscription of Angkor on the World Heritage list. Analysing the impact of future developments on archaeological and architectural sites conducted him to build on a new cartography of these numerous sites. Bad security conditions and landmines restricting at that time any possibility for ground inspections, this first mapping of the whole region has been made possible with the use of a recent Finnish aerial photographs. The most astonishing result has been the identification of hundreds of "new" archaeological sites, recording finally around twice the number of sites one would have expected with previous inventories... High density of sites sprayed in the whole region showed a new light on how Angkor was organized and deeply integrated in its environment, opening new and promising opportunities of research on a key subject.

Since 1993, Dr. Pottier developed this preliminary study into an extensive research, first focusing on the central and south area of Angkor (600sqm), completing a new archaeological map crossing information from existing archives, remote sensing and systematic GPS ground checking. During this first phase, more than 500 archaeological sites and features have been inventoried and precisely mapped. 60% of these sites being previously unknown, the mapping offered a new appraisal of territorial management, urban planning and chronological sequences. A second phase is in progress since 1999 in collaboration with the University of Sydney, combining GIS and a September 2000 airborne radar (AIRSAR NASA/JPL) of the entire region of Angkor. This new remote sensing tool doesn't replace the aerial photographs, but it shows clearly that great detail could be acquired from aerial radar both on features, such as ancient rice fields which can be seen in the aerial photograph, but also on environmental phenomena such as partially concealed water flow and on vegetation regimes. Most important, it offers an observer an integrated view in which scattered parts of a whole become understandable as one phenomenon.

The ongoing project is actually focusing on the analysis of the radar, combined with the older aerial photographs and fieldwork where safe, concentrating on the area north of Angkor in order to complete a comprehensive new plan of Angkor, an gigantic low density and open city stretched across the thousand square kilometres of the area inscribed on the World Heritage list.

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Angkor and Radar Imaging: Seeing a Vast Pre-Industrial, Low-Density,  
Dispersed Urban Complex

ABSTRACT

An AIRSAR radar survey in September 2000 of 3000 sq km of the region around central Angkor in Cambodia has revealed that the urban complex covered approximately 1000 sq km with most of the major temples located within the central 200 sq km. The radar survey completed by NASA/JPL for the Greater Angkor Project has now shown that a network of roads and canals extends for at least 15-20 km out from the centre. It overlies but does not mesh with the dispersed distribution of inter-visible residential mounds and local shrines that was first identified by Christophe Pottier of EFEO in the mid 1990s. The radar has also revealed local shrines and occupation sites on the lower slopes of the Kulen hills far away from the centre of Angkor.

The radar shows that Angkor was the largest, low-density, dispersed pre-industrial urban complex. This has substantial implications for the interpretation and conservation of Angkor.

Roland Fletcher (Dept of Archaeology, University of Sydney)

## **Technical and methodological aspects of archaeological CRM integrating high resolution satellite imagery.**

Anthony Beck  
PhD Research Student  
Department of Archaeology  
University of Durham  
South Road  
Durham, UK  
Tel: 01904 332709  
e-mail: a.r.beck@durham.ac.uk

Until recently the spatial resolving characteristics of satellites were too crude for archaeological site prospection although sensor systems such as Landsat did provide contextual thematic data. However, declassification of historic military imagery (the American Corona and the Russian KVR missions) and high resolution commercial satellite systems (such as Ikonos and Quickbird) provide archaeologists with satellite imagery that can be used for both site prospection and Cultural Resource Management (CRM).

Satellite imagery can provide an informative backdrop for archaeological landscape studies, particularly those where the archaeological resource is poorly understood or accessing contemporary or historic landscape information can be difficult. This is the case for the *Settlement and Landscape Development Project in the Homs Region, Syria* (SHR). Typical of many parts of the developing world, there is neither a systematic regional database of archaeological remains, ready access to topographic mapping at scales greater than 1:50,000, nor is aerial-photography available. This provides a variety of challenges for archaeological research and management which can, in part, be addressed by the utilisation of satellite imagery.

This paper will outline the technical and methodological issues in integrating and analysing these different data sets. Issues such as creating CRM data infrastructures, ground observation (using integrated GPS recording), image preparation and geolocation, spatial and a-spatial analyses using GIS and the future potential of the satellite systems will all be addressed.

## The contribution of satellite imagery to archaeological survey: an example from western Syria

Satellite imagery offers immense possibilities in terms of its deployment in the context of archaeological survey and Cultural Resource Management (CRM) applications. This is particularly the case in areas where the traditional archaeological desktop resources of cartographic and air-photographic data are sparse. This paper demonstrates a number of ways in which satellite data can be employed as an aid to archaeological survey and CRM operations in the light of experience gained during four seasons' of fieldwork in the Orontes Valley region of western Syria, in which remotely sensed data have played a fundamental role. In particular, the paper will focus upon the information potential of several well-known commercially available datasets, and their strengths and weaknesses.

The paper will discuss the value of imagery for:

1. The provision of environmental data, through which the landscape context of past human activity can be explored
2. The monitoring of landscape change, and the identification of threats
3. The development of refined sampling strategies, for example by enabling the estimation of the effects of masking of ground-surface by vegetation
4. The location and mapping of different kinds of sites and structures

The paper will also report upon the results of the field-testing of intensive surface collection undertaken to identify those categories of archaeological remains which are less readily identified using imagery, and on the physical and geochemical characteristics of those plough-soil scatters which are most apparent using panchromatic imagery. The paper will conclude with a brief overview of the way in which imagery has been integrated with other forms of spatial and aspatial data within the project GIS, in order to provide a multidimensional desktop resource, and a quantifications of the costs involved, in terms of imagery, software and the input of staff-time.

Please note that this contribution is intended to lead into the paper offered by Mr Anthony Beck; the two papers should therefore be seen as forming a pair.

Presenter's details:

Dr Graham Philip,  
Senior Lecturer,  
Dept. of Archaeology,  
University of Durham,  
South Road,  
Durham DH1 4NF, U.K.  
Tel: 44-191-374-3644  
Fax: 44-191-374-3619  
graham.philip@durham.ac.uk

## **The use of satellite images, digital elevation models and ground truth for the monitoring of land degradation in the “Cinque Terre” National park.**

*L. Montanarella, E. Rusco, F. Salina and M. Besio\**

European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy  
Università di Genova, Facoltà di Architettura, Dipartimento POLIS, GENOVA, Italy

### **Abstract**

The area of the Cinque Terre (five lands) includes the five communes of Levanto, Monterosso Vernazza, Riomaggiore e La Spezia. Since 1997 it is classified as a UNESCO world heritage site. The Committee decided to inscribe this site considering that the eastern Ligurian Riviera between Cinque Terre and Portovenere is a cultural site of outstanding value, representing the harmonious interaction between people and nature to produce a landscape of exceptional scenic quality that illustrates a traditional way of life that has existed for a thousand years and continues to play an important socio-economic role in the life of the community. A unique characteristic of the area are the terraced vineyards sustained by dry walling, a perfect example of landscape architecture created by man in inaccessible surroundings.

The recently created National park, has as one of its main tasks to develop strategies for the protection of this cultural heritage. Land abandonment is threatening the stability of the terraced areas, leading to extensive soil erosion and landslides. A shifting economy from agriculture to mass tourism is at the origin of these negative trends. The development of options for a sustainable tourism in the area requires also a constant monitoring of this very fragile landscape.

High resolution satellite imagery (IKONOS) can provide a valuable tool for the monitoring of land use changes and consequent land degradation phenomena. The combined use with detailed digital elevation models and ground truth can also identify major areas at risk of slope instability.

A prototype system for the regular monitoring of land degradation in the area of the National park will be presented.

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## REMOTE SENSING AND GIS APPLICATIONS FOR PROTECTION AND CONSERVATION OF WORLD HERITAGE SITE ON THE COAST – CASE STUDY OF TAMIL NADU COAST, INDIA

R. Krishnamoorthy\*, G. Sachidanantha Bharathi and P. Periakali

Department of Applied Geology, School of Earth & Atmospheric Sciences, University of  
Madras, Guindy Campus, Post Bag 5327, Chennai 600025

Phone: 0091-44-2351629 Ex:219 Fax: 0091-44-2352870

Email: krishr64@rediffmail.com

### Abstract

More than 1000 km length coastline of Tamil Nadu in Southeast India is very important due to its unique character of housing important coastal ecosystems, tourism centers, protected areas such as marine biosphere reserve, UNESCO's World Heritage site, etc. Considerable amount of studies are carried out for Tamil Nadu coastal zone to estimate its resource potential including the preparation of Integrated Coastal Zone Management strategy using remote sensing and GIS technology tools. The present study is focused to the 60 km length coastline just below the Chennai (Madras) capital of Tamil Nadu State where the World Heritage Site – Mahabalipuram is located. The shore temples of Mahabalipuram was built by an emperor of the Pallava dynasty in seventh century AD are recognised as UNESCO's World Heritage Site. Due to various coastal zone issues/problems especially the human activities and biophysical processes are found to be severe threat to protect this heritage site. Severe shoreline erosion, land use changes due to growth of urban centers and tourism activities around this site and pollution due to unsustainable tourism and industries are the main underlying causes for the damage to this heritage site.

In this study the areas of severe shoreline erosion, changes in shoreline configuration, coastal geomorphology, change-detection of land use pattern are studied in detail using multivariate multisensors remote sensing data particularly the Indian Remote Sensing Satellite (IRS) data together with the analysis of spatial data using a Geographical Information System (GIS). The coastal zone information derived from remote sensing platforms are found to be more useful to protect this heritage site and also monitor the damages. The areas of severe shoreline erosion has been demarcated using the GIS overlay analysis. The Coastal Zone Information System (CZIS) created using GIS is found to be more suitable for coastal managers and planners to conserve this heritage site. This study also highlights the important benefits of high spatial resolution sensors data such as IRS-LISS-III and TM for the quantitative studies on various coastal environmental problems, which has direct impact on the heritage site located on the coastal zone.

The protection and conservation of this heritage site could be possible only through the implementation of people oriented Integrated Coastal Zone Management plan where the main information source is space technology. The salient results obtained from this study concludes that the remote sensing and GIS applications are very vital in protection and conservation of heritage sites located on the coastal zone where high population pressure, economic activities, rapid industrial development and tourism activities are taking place.

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\* Presenter of the paper and whom all correspondence should be sent

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## Multispectral high resolution satellite imagery in combination with "traditional" remote sensing and ground survey methods to the study of archaeological landscapes. The case study of Tuscany

Riccardo Francovich<sup>1</sup>, Stefano Campana<sup>2</sup>

<sup>1</sup> Ordinary professor of Medieval Archaeology and Head of Department of Archaeology and History of Arts - University of Siena

Via Roma 56, 53100 Siena, Italy  
Tel. ++0577/233670, Mobile ++335/5404149  
francovich@unisi.it

<sup>2</sup> Ph.D. candidate at Department of Archaeology and History of Arts, Section of Medieval Archaeology - University of Siena

Via Roma 56, 53100 Siena, Italy  
Tel. ++0577/234614, Mobile ++347/9193050  
campana@unisi.it

### Abstract

There is increased interest today in making scientific progress through the use of remotely sensed data in social science research. On this topic it is important to remember that remote sensing is not a new technology. Archaeological studies have a long tradition of aerial photography application, from the earliest air photographs taken from balloons at the end of XIX<sup>th</sup> century to the crucial works of O.G.S. Crawford and many others aerial archaeologists, until the actually National Mapping Programmes. What is changed in recent years about remote sensing application it is the development of new sensors (in particular multi-spectral, hyper-spectral, microwave) and the availability of new tools for the management and for the integration of spatial information.

The Department of Medieval Archaeology at the University of Siena has been actively engaged in programmes of landscape archaeology for over thirty years. Territorial studies have been based for the most part on three methodologies of investigation: field survey in sample areas (with 20-30% of the total landscape and replicated collection); field examination to assess the significance of individual monuments (known roman villa, medieval castles, churches, etc.); and analysis of vertical air photos combined with selective ground-truthing (VALENTI 1999, pp.10-14; FRANCOVICH-VALENTI 2001, pp.83-116; CAMPANA 2001, pp. 47-71).

In the last ten years one of the principal scientific objectives in the research programmes of the Department of Medieval Archaeology has been achieved through the construction of a management system for all of the archaeological information (VALENTI 1998, pp.305-330; FRANCOVICH 2000, pp.45-62).

Since the end of 1998 we turned the attention to increase our experience in remote sensing techniques (CAMPANA-FORTE 2001). Within the Department of Medieval Archaeology, the Laboratory of Aerial Photographic Interpretation has been active since 1984. The Laboratory is dedicated to the stereoscopic examination of vertical aerial photographs and in twenty years it has carried out numerous research projects, leading to the identification of over 5000 air-photo anomalies in Tuscany alone (COSCI 2001, pp.55-64). Despite good archaeological results, we have been conscious throughout of the inherent limitations of this method of survey. The main problem is the cartographic nature of the data and the impossibility of planning the flights to coincide with times when conditions for the detection of archaeological features are at their best. In addition, there are other problems with vertical photographs, such as the inherent inflexibility of paper documents, the difficulties of magnifying details, and the limited capacity to distinguish between tones of grey, etc. To try and overcome these limitations in pursuit of our own objectives we have changed our focus to the experimental application and evaluation of new techniques in the study of the Tuscan landscape. After looking at experience elsewhere, we realized that there was not an ideal technique able to exclude all the others. Each data source has its imperfections. In short we started from known concepts summarised by Lillesand and Kiefer as "more information is obtained by analysing multiple views of the terrain than by analysis of any single view" and that "successful application of remote sensing is premised on the integration of multiple, interrelated data sources and analysis procedures" (LILLESAND-KIEFER 1994).

This is the reason why we turned to oblique aerial photography, to the latest generation of multi-spectral high-resolution satellite imagery (Ikonos-2 and QuickBird-2), to geophysical survey and to micro-digital terrain modelling using differential GPS.

Our progress in developing this approach can be highlighted by looking at five sample areas, representative of the landscape complexities and settlement patterns of Tuscany. The total extent of these sample areas is around 670 square km. All areas have recently been the subject of numerous socio-archaeological studies, field-walking surveys, excavations, vertical air-photo interpretation, geological and geomorphologic analysis. When setting up the research project we paid particularly close attention to the systematic collection of data. The first methodological objective of the operation was to arrange the greatest possible number of elements for comparison - using GIS technology - with satellite imagery and with oblique aerial photographs. In a second stage it will be useful to integrate the whole information and propose new settlement patterns.

The methodological approach to Ikonos-2 and QuickBird-2 imagery has been focused on 2D visual interpretation

and the exploration of 3D representations. The procedure followed in processing the Ikonos-2 imagery falls into two main phases, both taking into consideration the existing remote sensing techniques.

The first phase consists of a series of standard transformations of the whole image. In this stage of the processing some of the most commonly used techniques have been contrast stretching, density slicing, RGB colour composites of the original bands (3-2-1; 4-3-2; 4-2-1; 3-4-1) and arithmetic manipulation, in particular averaging (to reduce the noise component) and rationing (especially Normalized Difference Vegetation Index).

At the second phase of image processing, the focus of view was narrowed in order to isolate homogeneous textures around individual anomalies. The processing was carried out using Principle Component Analysis (PCA), Tasseled Cap Transformation (TCT), Decorrelation Stretch (DS) and RGB colour composites of the results of the various transformations. On completion of the image processing we are able to recognize some trends. As we expected, all of the best results come from transformations in which the near infrared band plays a primary role, especially in NDVI, Principal Component Analyses, brightness and Wetness Transformation and relative colour composites. Certainly there is no single ideal technique, but rather a spectrum of techniques producing variable results. An approach based on visual detection is affected by subjectivity, and the perception of anomalies varies from individual to individual.

To tackle this problem we are developing supervised classification of the image data. To overcome the limitation of the high correlation between the Ikonos-2 bands we have recently been trying to apply a classification using synthetic imagery PC1, PC2, PC3 and PC4. We now believe that an alternative and perhaps better approach to data interpretation should also be taken into consideration. A second procedure that we are currently testing is based on good results obtained with Wetness transformation. It is known that a textural discrimination based on soil wetness is strictly season-dependent, and any procedure used to map different deposits from remotely sensed data fails when the acquisition time is not appropriate. The proper time is generally different for the various sediments in a study area. Hence the need for a multi-temporal approach (CAMPANA 2002).

The evaluation and use of Ikonos-2 imagery, oblique aerial photography, geophysics and differential GPS forms part of a wider strategy aimed at understanding the peculiarity of every single source so that we can on each occasion employ the appropriate combination of remote sensing techniques to maximize our understanding of the ancient landscape.

By applying multistage sensing techniques to our landscape projects we are beginning to develop a system of modular prospecting. Starting from a broad over-view of the survey area, we move through a series of steps, ultimately to a level of detailed definition. The use of different data-sources allows us to work at a variety of spatial resolutions. But it also introduces two other key factors: spectral and temporal resolution. "Spectral resolution" refers to those parts of the electromagnetic spectrum that are employed in each technique: black-and-white panchromatic for vertical photography, colour or near infrared for oblique photography, and blue/green/red/near-infrared for Ikonos-2 satellite imagery.

Even at this early stage we can say that the introduction of this approach to landscape analysis, running hand in hand with continuing programmes of field-walking, has transformed both our way of working and our understanding of ancient landscapes increasing the value and impact of our research (CAMPANA-FRANCOVICH 2002).

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## **Session 3:**

# ***Potential for Education***

## **The Use of Remotely-Sensed Imagery in Cultural Landscape Characterisation at Fort Hood, Texas**

*by Glynn Barratt, Lucie Dingwall, Simon Fitch and Cheryl Huckerby*

The Fort Hood Cultural Landscape Characterisation Project is utilising an approach to archaeological assessment known as cultural landscape characterisation to provide a framework for cultural resource management (CRM) at Fort Hood, a large military training facility in Central Texas, USA. The project is based around the use of remotely-sensed data and GIS technology, using Landsat TM satellite imagery as the primary data source for the initial identification and mapping of the landscape types, supported by aerial photographic cover, digital environmental data including elevation, geology and soils, existing land cover data, historic mapping, databases of recorded archaeological sites and ground truthing in the field using GPS. All the data is stored and manipulated within a single project GIS, which will allow full integration with the rest of the CRM programme, and with other environmental management programmes at Fort Hood.

The Cultural Landscape Characterisation approach has been pioneered in the UK over the last decade, and as a result of its success, is now being applied at a national level as a fundamental part of the UK's CRM strategy. The approach has been found to be a practical, robust and cost-effective method of assessment, appropriate to the needs and requirements of managers of large areas of land. The *cultural landscape* can be defined as a spatial and temporal entity, which reflects a number of different factors. These include the physical evidence of human interaction with nature, the role of prehistoric and historic processes in shaping the present landscape, and the inter-relationship and distribution of features within the landscape. It encompasses topography, habitats, semi-natural features and palaeoenvironmental deposits as well as archaeological sites, sacred sites, historic buildings, and the modern built environment. Cultural Landscape Characterisation is about recognising the ways in which the present landscape reflects how people have exploited, changed and adapted to their physical environment through time, with respect to different social, economic, technological and cultural aspects of life.

A semi-objective approach to the analysis is employed, allowing the definition of cultural landscape types with respect to major human interfaces with the environment (settlement, farming, woodland and water management etc.) subdivided as necessary by characteristics reflecting particular influences such as chronological origins. The unsupervised classification of remotely-sensed imagery to define the cultural landscape types in the Fort Hood project is a very different approach to that of many of the British landscape characterisation projects, which is a reflection of the nature of the cultural landscape in Central Texas, and the types of cartographic and documentary data sources available.

The final phase of characterisation will be to use the created landscape types in combination to identify fundamental character areas, with associated written and tabulated interpretative information supporting the characterisation. This text will consider the processes which have created the components giving the landscape its distinctive character. It will also consider past and present relationships between zones,

sustainability, survival and subjective reaction to landscape and provide recommendations for the implementation of the characterisation as an active CRM tool. Consideration will also be given to future possibilities for modeling the resource based upon the completed project. It is important to regard such a characterisation programme as a starting point and not as an end in itself.

The strengths of the approach are:

- **Managing change**

It allows recognition of the fact that landscape is the product of dynamic and change, and provides a way of managing future change

- **Increased understanding**

Consideration of the cultural landscape as a whole, and the group value of sites, will lead to a better understanding of the significance of individual sites, and therefore improve their protection. This is a particularly suitable approach for the cultural resources at Fort Hood, given the holistic relationship of aboriginal people and their land. It would also allow the unique military character of the landscape to be accorded due value and significance

- **Cost-effectiveness**

It will allow better targeting of financial resources towards significant areas. By enabling a range of different management options and mitigative strategies to be implemented for different areas of the landscape, it will be more likely to be effectively and flexibly integrated both with other conservation strategies such as natural resource management, and with military training requirements

- **Framework for future work**

It will provide a hitherto missing analytical framework within which future archaeological and historical assessment can be fitted, and will generate future research agendas

- **Education**

It will help raise awareness of the cultural environment among contemporary communities by forming the basis for new ways of telling the story of what is contained within the cultural landscape to the communities which occupy it today

Glynn Barratt (Research Fellow)  
Lucie Dingwall (Research Associate)  
Simon Fitch (Computing Assistant)  
Field Archaeology Unit  
University of Birmingham  
Edgbaston  
Birmingham B15 2TT  
UK  
Tel: +44 (0)121 414 5513  
email: l.m.dingwall.20@bham.ac.uk  
email: g.barratt@bham.ac.uk

Dr Cheryl Huckerby  
Cultural Resource program Manager  
Directorate of Public Works  
Attn Environmental Division  
III Corps and Fort Hood  
4612 Engineer Drive Room 76  
Fort Hood TX 76544-5028  
USA  
Tel. (254) 287 1092  
email: cheryl.huckerby@hood.army.mil

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# HERITAGE LEARNING AND DATA COLLECTION: WORLD HERITAGE, ENVIRONMENTAL EDUCATION AND BRIDGING THE DIGITAL DIVIDE

## A collaborative project by UNESCO's World Heritage Center (WHC) & The GLOBE Program

Natarajan Ishwaran, Chief, Natural Heritage Section, World Heritage Center, UNESCO  
7 Place de Fontenoy, 75007, Paris, France. P: 33 1 45 68 15 59; F: 33 1 45 68 55 70; <n.iswaran@unesco.org>

Randi L. Stone, Senior Analyst, International Programs, The GLOBE Program  
1800 G Street NW, Suite 800, Washington, DC 20006, P:202-501-3200, F:202-501-5060, Home office P:212-721-7004, Home office F: 212-721-9796, <rstone@globa.gov>

UNESCO's World Heritage Center and The GLOBE Program<sup>1</sup> are collaborating to bring together students, teachers, heritage site managers and scientists to study and monitor World Heritage and other natural and cultural sites internationally. The pilot countries are India, Jordan, Madagascar, Mexico and Russia.<sup>2</sup>

**Background:** This collaborative effort capitalizes on UNESCO's World Heritage Network of sites, site managers and schools, and on the GLOBE Program's international network of primary and secondary school students and teachers and principal investigators. Project participants take GPS measurements of the sites and collect Earth Science data -- Atmosphere/Climate; Hydrology; Land Cover/Biology & Biodiversity; Soils; Phenology/Budburst -- according to precise scientific protocols and equipment specifications. Students and teachers use their measurements and observations to ground-validate satellite imagery while using Multispec (an image analysis freeware, developed by Purdue University) to further analyze LANDSAT satellite images. They also use Geographic Information Systems (GIS) software to further understand their sites. The students then send these data for archiving in a database that is freely accessible to scientists for use in their research. Students use these data for student research in collaboration with scientists, as well as for classroom studies and international school-to-school collaborations.

Environmental change and trend-analysis is a complex area of educational work that challenges youth to understand, analyze and interpret complex processes, their interactions and consequences. In attempting to analyze and present the results of their analyses to others, youth learn important technology, communication and networking skills. As local environmental changes become increasingly linked to regional and larger changes, education involving hands-on science for rural youth challenges the imagination of educators. Information technology as a tool has significant potential

for linking efforts to meet this educational challenge by bridging the digital divide. Furthermore, by having participating students take GPS measurements of the sites and using their measurements and observations to ground-validate satellite imagery -- while also using Multispec to further analyze LANDSAT images -- there is an invaluable "space" related element to this educational Program.

UNESCO's more than 725 World Heritage sites provide an ideal setting to demonstrate the benefits that youth obtain through use of information technology to interpret the environment. In exchanging their views and understanding of the environment that encompass their world heritage, and imagining how environmental change, at the local, regional and global levels, could impact the future of that unique Heritage, youth will gain valuable insights. Specifically, they will understand how they can contribute to the long-term conservation of their Heritage, as well as gain an understanding of others' cultures and heritages. As part of this process they are also likely to explore new ways of developing the socio-economic potential of their regions that are complementary to long-term heritage conservation needs.

**Need:** Education and access to a healthy environment are essential components of fundamental rights.

**Education:** UN and other development cooperation agencies recognize literacy and investment in education by governments as indicators of human development. A sound education is one of the necessary conditions for acquiring the skills and capacities for sustainable development. Furthermore, this initiative targets K-12 students, where research shows -- especially for the 10-14 yr olds -- that creativity is most at risk and where vital skills in science and math must be established.

More than 113 million children remain out of school, and in countries like India, 48% of the population is illiterate. In Madagascar, 70% of population lives below the poverty line.<sup>3</sup> According to the Girls Global Education Fund, two-thirds of all children who are out of school internationally are girls. Improving the education of women and girls is therefore an important means to ensure future all-round development of families, communities, and nations. Furthermore,

<sup>1</sup> GLOBE is a US interagency program of NASA, NSF, EPA and the Department of State.

<sup>2</sup> The five pilot countries are all Parties to the World Heritage Convention and The GLOBE Program and have a number of designated World Heritage sites. (The US GLOBE Coordinator has expressed interest in the project, but has not yet committed to it.)

women are generally under-represented in science and related areas of study and employment. Few young women choose science subjects, and even fewer take science-based degrees and choose science-related careers.

*The “digital divide”*, whether between developed and less developed nation states or between urban and rural areas of less developed countries, is growing and is threatening to become a new limiting factor on aspirations for economic prosperity and environmental well-being of people from less developed nations. Access to information technology, in particular, lags far behind what is needed to produce a globally competitive workforce of citizens able to guide their countries to a prosperous future. The ratio between Internet access in the United States and in countries such as Jordan, is over 9000 to 1.<sup>4</sup>

The development role of technology, especially information and communication technologies, is most critical to the generation who is now in secondary schools. They are getting ready to emerge into a challenging market place for jobs that will demand computer-use and technology-based communication and networking skills. While formal educational authorities recognize this need, in many countries, monetary and human resource shortages prevent government and non-governmental educational groups from meeting this demand. This is particularly true in rural and marginal areas far away from nations’ capitals and other city centers.

*Access to a healthy environment:* Appreciation of global conservation needs by youth from rural and marginal populations living near conservation areas is necessary for sustaining these areas into the future. Educational practice in schools around Heritage sites and other conservation areas, rarely attempts to interest children in the environment, in understanding how their local environment has changed and been impacted by larger environmental changes of the past, or how such inter-related changes at local and global levels could affect their lives in the future. Without such understanding of their local surroundings, odds are that once adults, these citizens will not make lifestyle and policy decisions that will preserve the quality of their environment and sustain their access to a healthy future.

Finally, students lack opportunities to collaborate with their peers, and with adults from science and environmental stewardship professions, and the corporate world. As a result, they do not have the means to share learning experiences and gain a broader understanding of the world and their place within it.

#### Project components:

*Duration:* 4 years (Pilot – 1.5 years); *Expected Start Date:* January 2003; *Target Audience:* Students 12 –18 years old

<sup>4</sup> The International Education and Resource Network (IEARN) estimates that access to the Internet in the low- and middle-income countries of the Middle East is 0.01 percent, compared to 94 percent in the US. (1 to 9400).

#### *Objectives:*

- Improve student achievement in geography, mathematics, science and technology, while increasing their interest in pursuing science related careers;
- Increase the number of students who are studying the Earth as a system;
- Provide data for Earth Science research;
- Ground-validate satellite data;
- Enhance the environmental and cultural awareness of individuals in and around World Heritage and other sites;
- Contribute to increased scientific understanding of the sites;
- Increase student and surrounding community interest in the sites;
- Promote field-based environmental learning as a tool for understanding heritage of varying (local, national, global etc.) significance;
- Instill environmental sciences -- emphasizing measurement, analysis, interpretation of results and forecasting future scenarios -- as a basis for youth appreciation of heritage and learning about issues and problems related to their sustainability;
- Promote technology-based data and information analyses and exchanges to create a global forum for youth to understand and describe heritage conservation issues;
- Familiarize youth to interactions with their colleagues and peers, nationally and internationally, focusing on heritage conservation and management issues;
- Promote voluntary and paid internships for youth involvement in heritage management, establishing environmental monitoring and assessment tools and systems; And,
- Increase the pipeline of researchers for government, industry and academia.

#### *Expected outputs:*

- Otherwise unavailable scientifically valid data from the sites;
- Scientifically peer-reviewed descriptions of the physical (topography, temperature, rainfall, humidity, soils etc.) and biological (selected taxa of fauna and flora) of at least 5 World Heritage sites and 20 other sites of local, national and/or regional significance;
- Technology-based scenario building of past and future scenarios of at least 10 heritage environments, by youth under the supervision of scientific mentors, to demonstrate the role of environmental change in heritage management;
- A minimum of 5 in-country rural-urban youth electronically linked networks to exchange information and knowledge on heritage environment;
- An international network of youth from rural, urban and marginal areas participating in the project for exchanging views and opinions of heritage conservation issues;
- At least 500 youth from rural and/or marginal zones trained in computer operation skills and software skills; at least 50% of whom will be adolescent women;
- At least 25 youth from urban and rural areas from each participating country trained in transferring

information technology skills for environmental studies to other schools and youth-institutions;

- A range of information materials produced for the public, specific target audiences such as secondary schools, heritage site visitors, etc., based on project data collection, analysis and related activities;
- An increased level of awareness among youth of the environment and its role in heritage conservation as a theme for international co-operation;
- Closer links between rural and urban youth and research scientists and heritage site staff, and increased interest of youth to undertake voluntary and paid internships in heritage sites as part of their career development; And,
- A critical mass of rural and urban youth networked with internationally recognized scientists, exchanging ideas and information on heritage conservation issues.

#### Expected outcome:

- A replicable model of project design, development and financing for promoting environmental education, for heritage conservation and cultural understanding;
- A long-term partnership arrangement between UNESCO-WHC and GLOBE (see below) that will lead to the replication and adoption of the project model to other countries;
- A demonstrably higher level of youth appreciation of local and global environmental characteristics and implications of changes in those characteristics to the maintenance of their heritage and to others' heritage;
- Youth understanding and appreciation of the environment as the context for the identification and description of all cultural and natural heritage; And,
- Heritage management as a theme for international co-operation and as a future career option promoted amongst the youth.

#### Innovation:

**Student collection of scientifically valid data:** Perhaps the most essential innovation of the project is that the participating students will collect data for legitimate scientific research. This will promote a better scientific understanding of some of the most culturally valuable sites in the world, which will include ground-validation of satellite data. They will be *learning by doing*. They will interact with site managers and scientists, gaining a better appreciation for not only the importance of the data/the science "content", but also for the scientific process and some of the professions that use these skills.

**Establishing Invaluable Links:** Other innovative core features of the initiative include linking students and teachers to natural site managers, rural youth to urban youth and communities in and around various heritage sites in 5 different countries to each other, and to the US. This will happen while simultaneously linking international scientific researchers to project participants and their surrounding communities. Thus, students will use environmental science to learn about their and others' cultural and natural heritage and about temporal environmental changes that have and are occurring.

**IT Access and Education:** The final core innovation will be the technology aspect of the project. This project will enable youth from rural and marginal areas to use Multispec and GIS software and to establish technology-based links with their counterparts in different parts of the world, as well as with urban areas within their own countries.

**Heritage Awareness of Youth:** Using technological tools, the participating youth develop an understanding of the past, present and future environmental contexts of their natural heritage. They learn the value of their heritage for the whole world, and hence begin to understand their commitments and responsibilities to the global community. The skills enable them to access and use computer software, websites and other Internet based tools to greatly expand their knowledge about heritage.

#### Lead Organizations:

**UNESCO World Heritage Center:** This Center serves as the Secretariat for coordinating all international cooperation for the conservation of sites designated as World Heritage. Since the mid-1990s the Center has executed with financing from NORAD and the Rhone-Poulenc Foundation a "World Heritage in Young Hands" project and has considerable experience in coordinating activities in about 173 countries which have ratified the Convention until now. The "World Heritage in Young Hands" Project was implemented in cooperation with UNESCO's Associate Schools Program where the number of participating schools throughout the world number is above 3000.

**The GLOBE Program:** This non-advocacy, global environmental science and education program brings together research scientists and students and teachers from over 12,000 schools in 100 countries. The Program increases both scientific understanding of the Earth and environmental awareness, improves student achievement in math and science, expands the pipeline of future scientists and technically proficient citizens, and advances international, multi-cultural, understanding. GLOBE enables students to collect and analyze data to better understand their local environment, how it may be changing and how it relates to nearby ecosystems, as well as to the larger environment. Nearly all communications between participating school students from different parts of the world and their scientific peers in US and elsewhere occur via the Internet.

**In-country institutions – schools and World Heritage sites:** The project is a networking and learning initiative that will link national GLOBE Programs to World Heritage sites.<sup>5</sup> Schools in the immediate vicinity of the sites will be chosen and will be networked with sister-institutions in national capitals and in other parts of the world.

<sup>5</sup> Countries join GLOBE by signing bilateral agreements with the US government.

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**Practical Remote Sensing Activities in an Interdisciplinary Masters-Level Space Course**

**J. Farrow<sup>1</sup>, F. Becker<sup>1</sup> and S. Clandillon<sup>2</sup>**

**1 International Space University, Strasbourg;**

**2 Service Régional de Traitement d'Image et de Télédétection, SERTIT, Strasbourg**

- Title of Conference: Space Applications for Heritage Conservation  
(<http://www.eurisy.asso.fr>)
- Key Words: Space education; Remote sensing
- Full contact details of main author: John Farrow Resident Faculty  
Address: Strasbourg Central Campus,  
Parc d'Innovation,  
Blvd. Gonthier d'Andernach,  
67400 Illkirch-Graffenstaden, France  
Phone: 03 88 65 5025  
Fax: 03 88 65 5447  
e-mail: [farrow@isu.isunet.edu](mailto:farrow@isu.isunet.edu)

**Abstract, June 2002**

The International Space University (ISU) encourages the creation and expansion of knowledge and the exchange and dissemination of ideas in all fields of space. The central campus is in Strasbourg, France and there is a world-wide network of faculty, alumni, sponsors, students and affiliates who share ISU's broad vision. Our programs emphasise the so-called '3Is' spirit in which interdisciplinary, international and intercultural aspects are the hallmarks of the curricula. ISU programs include the year-long Master of Space Studies (MSS) based at the campus site in Strasbourg, the two-month Summer Session Program (SSP) hosted each year at a different site around the world, research activities undertaken by faculty members, short courses and symposia (for further details see <http://www.isunet.edu>).

Remote sensing is an important component in the MSS and SSP programs. This paper focuses on the MSS program in which the one-year duration affords the opportunity for students to gain some practical remote sensing experience and two well-established activities are described.

First we will give some details about an assignment in which students attend a workshop on image interpretation, ground truthing and the use of GPS and then put these skills into practice in a field trip in the Vosges region close to Strasbourg. The main site for study is Mont St Odile, which has a very rich heritage from both natural and cultural perspectives and is one of the best-known tourist attractions in the area. Optical images from Landsat and SPOT plus radar images from ERS and Radarsat are compared with large-scale maps and ground observations. A convent whose origins date back to 700 AD is located on the summit (750 m) of Mont St. Odile from where students make comparative visual observations of the surrounding hillside, forests, a quarry and, further off, the Alsace plain. Completely surrounding the summit and stretching for over 10 km in perimeter through dense woodland are the remains of the Mur Paien (Pagan Wall). This is the largest walled enclosure in Europe and its origins and purpose remain something of a mystery to this day. Parts of the wall, 2 m thick and up to 5 m high when it was built, probably in the late Bronze Age around 1000 BC, still remain largely intact. During the field trip the students examine a section of the wall and visit the remains of one of several ancient fortresses close by. These 'Chateaux Forts' date back to around 1200 AD but have stood in ruins since the late 17<sup>th</sup>

century. A final and popular component of the trip is a visit to one of the local producers of the famous Alsace wines.

The second project described here allows ISU's students to gain 'hands-on' experience in image processing and interpretation techniques using facilities available within SERTIT (Service Régional de Traitement d'Image et de Télédétection) a remote sensing consultancy that occupies the same campus site. SERTIT's activities, described in more detail elsewhere at this conference, are of particular interest in studies of the effects of natural hazards (floods, gale damage, etc) on the regional environment. In the course of the workshop ISU's students gain familiarity with the tools and techniques used in the remote sensing sector. Some students go much deeper into this area by carrying out their 3-month long placements with SERTIT.

According to feedback, the practical activities described in this paper are well appreciated by students. Clearly they help to consolidate what is taught in lectures and workshops and the basic ideas could be carried over to other courses in the space domain. Furthermore the field trip provides an early introduction for our students to the natural and cultural heritage of a very beautiful region of Alsace to which many of them return in any free time later in their year here.

## **Supporting Environmental Treaties with Remote Sensing Data** **An example of a MEA application : The Kyoto Protocol**

The rapid growth in the number of *multilateral environmental agreements* (MEAs) treaties since the 1972 Stockholm Conference on the Environment has been an encouraging sign of international commitment to protecting the environment. The Earth Summit in 1992 provided added impetus to the establishment of MEAs with the formation of three major conventions : the Convention on Biological Diversity (CBD), the Convention to Combat desertification (CCD) and the United Nations framework Convention on Climate Change (UNFCCC). The proliferation of treaties has resulted in an attendant need for spatial data on the health of the Earth's biophysical systems, and for better understanding of the socio-economic processes and government policies that affect the environment. This information contributes to the design of improved policy instruments (*de Sherbinin and Chandra Giri 2001*). Earth Observation systems can provide reliable, factual, consistent recurrent and timely information on a global scale that may be used to map areas of interest, and can also provide measurements of certain key parameters, and monitor evolution of studied phenomena. Although the existing satellites were not designed to meet the information requirements of environmental treaties, they can be used to generate key information necessary for developing and implementing MEAs (*de Sherbinin and Chandra Giri 2001*). Earth Observation systems are tools that have become essential for effectively conducting many types of environmental management and research applications. They can prompt new agreements, influence behavior under existing agreements, and evaluate past performance and effectiveness. However despite the fact that Earth Observation systems are capable of assisting the MEA process, there are a number of significant problems. These include lack of consistency and standardization of data sets and fragmented and inadequate data archives.

The main purpose of this poster is to present the link between Remote Sensing in support of Multilateral Environmental Agreements, with the study of an example of a "MEA application" : The Kyoto Protocol. The Kyoto & Carbon Initiative is a project launched by National Space Development Agency of Japan (NASDA) in 2001, with the aim to provide adequate data and information in support to the terrestrial carbon cycle science and international treaties, and particularly the Kyoto Protocol. It is based on the conviction that remote sensing data and specifically ALOS PALSAR and ADEOS II GLI data can play a significant role to support, partly or fully, some of the information needs by provision of systematic, consistent and repetitive high resolution data of the global land areas. The Kyoto & Carbon Initiative aims to respond to this need through the establishment of a Dedicated Data Acquisition Strategy in which spatial and temporal consistency, adequate repetition frequency, timing are taken into account as far as possible. It is duty acknowledge that Kyoto reporting requirements can not be fully met with ALOS PALSAR and ADEOS II GLI data. Kyoto relates to changes in total carbon (above ground, below ground, soil and litter), while remote sensing at best can provide info about the above-ground component. Remote Sensing is however more suitable for providing information about land cover spatial repartition and temporal dynamics.

The Kyoto & Carbon Initiative is an example of “MEA application” focusing on the Kyoto Protocol. This project is unique by several points : by its vision of a global data acquisition plan with high resolution on an annual basis over a long time period and also by its synergy between several sensors types (optical – radar) with different resolutions : spatial and temporal (coarse and high, bi weekly or monthly). This project is a leading example for the potential link between Remote Sensing and Multilateral Environmental Agreements, and may also be helpful to partly support others MEAs than the Kyoto Protocol.

Keywords : Kyoto Protocol, Kyoto & Carbon Initiative, land use monitoring, data acquisition strategy, remote sensing.....

**Family Name: PETER**

**Given Name: Nicolas**

**Institution : International Space University (ISU)**

**Address : International Space University Parc d'Innovation. Boulevard Gonthier d'Andernach. 67400 Illkirch-Graffenstaden**

**Country: France**

**Email Address: Peter@isu.isu.net.edu**

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## AVAILABLE SATELLITE TECHNOLOGY FOR DISTRIBUTING EDUCATIONAL PROGRAMMES

Ulla Birnbacher<sup>(1)</sup>, Otto Koudelka<sup>(2)</sup>

<sup>(1)</sup> University of Technology Graz, Department for Communications and Wave Propagation,  
Inffeldgasse 12, 8010 Graz, Austria, E-mail: birnbacher@inw.tu-graz.ac.at

<sup>(2)</sup> University of Technology Graz, Department for Communications and Wave Propagation,  
Inffeldgasse 12, 8010 Graz, Austria, E-mail: koudelka@inw.tu-graz.ac.at

### ABSTRACT/RESUME

Distance education comprises many applications which differ regarding communication network requirements. Although the Internet is becoming a common platform, in various regions users do not have adequate access to the Internet and to educational information. By using geostationary satellites, users in a wide geographical area can be reached, also in areas with poor telecommunications infrastructure.

Distance learning comprises two communication directions. The forward direction from the distance learning organisation to the students, mainly in order to provide teaching material, and second the uplink direction, which is the communication direction from the student to a teacher / specialist for asking questions.

Content distribution may include distribution of video, audio files or textual material. In order to use satellite capacity in an efficient way, a broadcast technology with economic end user equipment is suggested. Digital Video Broadcast technology over satellite (DVB-S) is proposed for the forward communication channel, because an unlimited number of users within the coverage area of the satellite can receive the information and low cost DVB receivers are available off-the-shelf. The support of multimedia is achieved by the DVB multiplexing technology, where video, audio and data streams are encoded separately and multiplexed together before transmission.

The degree of interactivity determines the requirements of the return link. If no interaction is required, no return channel has to be set up. In the case of low data rates on the return channel for sending emails or requests for content, a common dial-up modem connection over a terrestrial telephone network (or over a mobile telephone or satellite telephone network) is sufficient. If high data rates have to be transmitted over the return channel, a broadband return channel (e.g. over an interactive satellite network) has to be integrated.

Three different scenarios are presented and described regarding the technology of the required

communication networks. Additionally, possible applications are pointed out.

Scenario 1 describes a solution for distribution of teaching or information material. Using satellite communications, a DVB-S broadcast channel and data push-technology on the central server can be used for transmitting the information to the users. No return channel is needed.

Scenario 2 enhances the distance learning applications with interaction. Teaching material located at the central server can be requested from the user and the exchange of information by email and by newsgroups is possible. To set-up the communication network for this scenario all the equipment from scenario 1 can be reused, supplemented with return link capability at the user terminals. Common Internet access with a telephone modem dial-up connection or data connections over mobile/sat-phone networks are sufficient to send emails or to request selected information on a web page.

Scenario 3 considers full interactive distance learning. Interactive lectures can be held using video conferencing, for which symmetric data rates in both communication directions are necessary, hence a broadband return channel is needed. This scenario can be realised by DVB-S broadcast on the forward link supplemented by a broadband satellite return link network.

All three scenarios can be implemented in parallel using the same DVB-S forward channel, which makes the use of booked satellite capacity even more efficient. Furthermore, user terminals from one scenario can be upgraded to the other, protecting the previous financial investment. Therefore the network and the applications for a distance education programme can be implemented step by step adjusted to the needs of the users.

Hence, satellite technology can be a helpful technological means, for diffusing educational programmes all over the world.

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## **Poster Session**

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## **The Remote Sensing Imagery The Support Of The Thematic Data Within The "Apuseni" Project.**

Authors : Dr.Alexandru Badea\*, Prof. Dr Albert Reif \*, Dr. Evelyn Rusdea\*\*

\*Romanian Space Agency, Director of the Space Applications Research Programm, address: 21-25, Mendeleev st., sector 1, 701681, Bucharest, Romania, tel. +40 1 2128723, fax. +40 1 3128804, e-mail : [badea@rosa.ro](mailto:badea@rosa.ro)

\*\*Waldbau- Institut: Abt. Vegetations-und Standortskunde, Universität Freiburg Forstwissenschaftliche Fakultät, Tennenbacher Str. 4, 79106 Freiburg, Tel: 0761/203-3634, Fax: 0761/ 203-3638

### **Abstract :**

The specific objective of the study is to create a model of the village settlement, integrating traditional designs, modern technology, and long-term improvements in economic development resulting from the project. The project multi-disciplinary German and Romanian researchers team analyses the land tenure, local economic development, the construction of sustainable housing, and restoration of links to the natural environment to promote a sustainable lifestyle. In the same context the project will realize the integration of the information concerning the local community infrastructure facilities and services necessary for economic development and job creation purposes, including water resources, buildings, equipment, machinery, land, natural site development.

At the end of the project is foreseen that the control of the rural population over natural resources will increase enhancing their capacity to discuss the policy and programmatic basis for building enduring relations between local sustainable development, environment, social and human rights, tacking into account that the members of the collectivity own the land on which it is situated in order to protect the many unique plants and animals found in the area. The forest, the main resource of the collectivity and the tourism have to be developed encouraging and rewarding the best practice : nature and ecotourism.

The inventory of all those aspects is facilitated by the integration of the thematic data in a GIS. The archive aerial photos and maps at different scales together with recent satellite imagery (Landsat TM, SPOT and IKONOS) constitute the basic layers for the integration of the thematic data. The interim results demonstrated that a monitoring system remote sensing based offers the possibility to point out uncontrolled tendencies of the forest exploitation. It was demonstrated that the rural population of this region use the forests and other ecosystems in an unsustainable manner for their livelihood.

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## SPACE APPLICATIONS FOR HERITAGE CONSERVATION

### **GPS and photogrammetric methodologies for an archaeological survey.**

( Astori, B. - Bezoari, G. - Guzzetti, F. )

#### **Abstract**

The problems of survey in Ventimiglia's archaeological area are described in the report, with particular attention at the significant elements of archaeological approach, for descriptive characteristics and for metrical qualities.

The list below concerns different surveys carried out:

- topographic survey of different elements existing in the area;
- GPS network for linking various parts of the archaeological site;
- GPS geodetic network;
- use of aerial photos for inserting archaeological area survey into the fabric of the city;
- integration with close range photogrammetry.

The resulting survey consist in a three dimensional database that would be used for a thematic archaeological GIS.

Prof. Ing. Giorgio Bezoari

Full professor of Photogrammetry

Politecnico of Milano

Tel. 0039 02 23996515

Fax 0039 02 23996550

E-mail: giorgio.bezoari@polimi.it

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## STEREO APPLICATIONS OF CORONA, AND THE USE OF IKONOS FOR GROUND CONTROL: case study from Orontes valley, Syria.

Nikolaos Galiatsatos, PhD student  
University of Durham - Department of Geography  
Science Laboratories, South Road, Durham DH1 3LE, United Kingdom  
Tel: +44-7968-091474; Fax: +44-191-3742456; Email: nikolaos.galiatsatos@durham.ac.uk

CORONA was a program for the support of U.S. Intelligence, which took place between 1958-1972. It officially started with the formal endorsement of President Dwight E. Eisenhower on 8<sup>th</sup> of February 1958. The launch operations began on 25<sup>th</sup> of June 1959. The first CORONA image of an intelligence target was acquired during Mission 9009 on 18<sup>th</sup> of August 1960. The camera carried on that Mission would be retroactively designated the KH-1 (KH for KeyHole). The next successful CORONA Mission would be conducted on 7<sup>th</sup> of December 1960. This time a more advanced camera system, the KH-2, would be on board. From that time, through to the end of Corona program on 4<sup>th</sup> of June 1972, there would be a succession of new camera systems – the KH-3, KH-4, KH-4A and KH-4B. The best ground resolution was 6ft (1.8m). Finally, CORONA would acquire over 800,000 frames of photographs. On 22<sup>nd</sup> of February 1995, President Clinton signed an executive order that declassified those images. The public access to the imagery began on 1<sup>st</sup> of March 1996.

KH-4 was the first camera from space to provide stereoscopic coverage (27/02/1962). It consisted of two KH-3 cameras on a common mount of “M” shape, one looking 15 degrees aft from the vertical and the other 15 degrees forward. KH-4A and KH-4B provided stereoscopic coverage with better ground resolution, reaching 6ft (1.8m) in many KH-4B frames. The big baseline arc of 30 degrees, combined with the high ground resolution, offered a good potential for the creation of a highly accurate digital elevation model (DEM). With the use of a simple stereoscope, one can recognise terrain features as high as 2-3 metres. But the machinery to process the analog photographs does not exist today. With a high quality photogrammetric scanner, the photography can be transformed into digital format and be processed with digital image processing techniques. The method of photographic enlargement of the film onto photographic paper is not suggested, because of the random errors that can be created in radiometry and geometry of the photograph. Next problem is the lack of software specialised on space panoramic photography. A relative referencing is a common feature in most image processing software today, but it will not compensate for the distortions of the panoramic imagery. The distortions can be corrected with the use of attitude and ephemeris data, which in the case of CORONA are not easily obtained and decoded. However, when sufficient ground control is available, then the attitude and ephemeris are not required.

For KH-4, KH-4A, and in particular KH-4B space photography, sufficient ground control can be achieved with the use of large-scale aerial photography, large-scale maps, or differential global positioning system (DGPS) measurements. But in many developing countries, aerial photography or good maps are not accessible and the use of DGPS is forbidden. Such a country is Syria. The advent of IKONOS in September 1999 offered a solution in the ground control problem. Although the precision of the orbital model was not better than 10m, IKONOS seemed to be the best solution in matters of geometry (distortions of panoramic imagery) and in matters of ground control.

The aim of this study is to create and assess a digital elevation model from CORONA space photography with compensation for the distortions of panoramic imagery, to illustrate the use of IKONOS as the best solution for ground control where common ways of ground control are not allowed. The DEM assessment will be based on site detection in the area of Orontes valley, in Syria. The ground control assessment will be based on the creation of a basemap for the archaeological record in the area.

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**Christine JACQUEMINET**

Maître de Conférences  
CRENAM – CNRS 5600  
Université Jean Monnet  
6, rue basse des rives,  
42023 Saint-Etienne  
Tél : 04 77 42 19 25  
Fax : 04 77 42 19 24  
christine.jacqueminet@univ-st-etienne.fr

**Sandrine GILL**

Docteur en Etudes Indiennes  
Université Paris III  
62, rue d'Hautpoul  
75019 Paris  
Tél : 01 42 00 33 61  
sandrine.gill@club.lemonde.fr

**Mahasthan (Bangladesh), an ancient Indian city (4th c. BC/ early 3rd c. BC) :  
the use of SPOT satellite images to study the palaeo-environment**

Framed by a monumental brick city-wall, 1,5 km long and 1 km wide, this ancient city of Indian Empires was rediscovered in the early 19th century. Archaeological exploration of Mahasthan, started in the late 19th/early 20th century. Since 1993, a France-Bangladesh joint venture organises annual archaeological soundings and excavation of the site, completed by environmental studies.

Established on the western bank of the river Karatoya, Mahasthan, now located in North Bangladesh, was once one of more eastern urban centres of Indian Empires. Although its political connection with the Mauryan and Sunga Empires is not firmly established, the wealth of the cultural remains of Mahasthan, ancient Pundranagara, have confirmed the assumption of a monumental development of the city between the 3rd cent. BC and mid 1st cent. BC. These dates have been confirmed by a series of radiocarbon dates. Moreover, the earliest epigraphic document, an inscribed stone slab from 3rd-2nd cent. BC refers to a period of starvation when food was stored in Pundranagara. These data match perfectly the traditional picture of Mahasthan being the « capital city » of a realm extending all over the Ganges valley. The first attestation of a city wall in the restricted area of excavation dates from 2nd cent. BC/1st cent. BC. This brick wall was then reconstructed several times during the history of the city. The rather poor cultural remains of the period dated 1st cent. BC to late 2nd cent. AD suggest a mouvement of decline, or regional isolation.

From 200 to 600 AD, the dull remains of the excavated area of the city do not fit with the brilliant sources (epigraphy, written sources, history of art) related to this period which includes the « golden age » of Indian History, the Gupta period. However the remains of a huge Buddhist monastic complex in the surroundings of the city, visited by the chinese monk Hiuen Tsang in mid 7th century, testifies the dynamism of the city at that time.

From Pala - Sena rule in Bengal to the Islamic conquest in early 13th century Mahasthan remains an important centre. A 12th century sanskrit poem, the Karatoya Mahatmyam, allegedly attributed to the last Pala king of Pundranagara, Parasuram, celebrates the nineteen specialities of the city. Archaeological remains dated from 16th -18th century testify a late occupation of the site."

The city of Mahasthan lies on the upper terraces of the Barind tract, upstream from the present junction of the Ganges and the Brahmaputra rivers. The Karatoya river, a tributary of

the Brahmaputra river, flows at the foot of the rampart, at a few meters below. The Karatoya river was formerly fed by the Tista river and therefore used to have a heavy flow. Flowing from north to south, the Tista-Karatoya river system was one of the major rivers of Bengal. Nowadays, however, the Tista flows directly into the Brahmaputra river and no longer feeds the Karatoya river. The latter has therefore become a very small river which dries up at the end of the dry season.

Located at the interface between the high terraces and the ancient alluvial plain of the Tista-Karatoya rivers, the site benefitted from diverse ecological conditions which seem have been well exploited in the past. Ancient testimonies describe this region in term of a granary. The fluidity of the river, environmental constraints on urbanisation, and the agricultural potential and development during the period of Mahasthan's prosperity are still little known.

Satellite images provide plentiful information concerning the palaeo-environment of this ancient city. Numerous objects are apparent on SPOT satellite images : manmade structures (the rampart, villages, tanks, dykes, roadways), the hydrographic system (contemporary river courses and the lines of ancient river courses, dead river branches, pools, zones of waters) and agricultural activity which today is omnipresent (field systems, the type of agriculture practised). These images give an exhaustive and detailed view both of the contemporary organisation of the terrain and the traces of past landscape cover, neither of which are observable on the ground.

Two topics are studied : the changes of the hydrographic network and the agro-ecological potentialities of the landscape. On satellite images, river systems can be estimated in their spatial dimension : the past and present courses of the rivers, their size and their pattern (straight, meandering or braided). Studies of fluvial morphology reveal major changes in the function of the water system and allow us to develop hypotheses concerning the manner in which the water course of the rivers has fluctuated and the causes of these fluctuations.

The city of Mahasthan is in contact with two different geographical entities : the Barind high terraces and the Tista-Karatoya alluvial plain. The nature of the soils, the topography and the condition of flooding are different from one place to another. On these flat and relatively uniform landscapes, the slight differences in the environment can be revealed by human occupation and agricultural exploitation. Although contemporary agricultural exploitation uses modern techniques, it still indicates how the ancient inhabitants were able to take advantage of the ecological diversity of the Mahasthan region, despite the many environmental constraints.

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## Assessing integrity in cultural landscape: a case study from Japan

Mikio Kamei & Nobukazu Nakagoshi

Graduate School for International Development and Cooperation, Hiroshima University

1-5-1 Kagamiyama, Higashi-Hiroshima City, Hiroshima 739-8529 JAPAN

Tel & Fax: +81-824-24-6957

E-mail: [kamik@hiroshima-u.ac.jp](mailto:kamik@hiroshima-u.ac.jp)

This paper investigates the concept of integrity to assess the condition of cultural landscape. Integrity concept usually refers to a system's wholeness, including presence of all appropriate elements and occurrence of all processes at appropriate rates (Angermeier & Karr 1994). Angermeier and Karr (1994) suggest a high state of biological integrity can be determined for a system that has little or no human influence. If the reference condition is pegged as an unaffected system, or even that which existed before widespread human modification, then invariably the condition of the human-modified landscape has deteriorated. However, human-modified landscape also has outstanding universal value to be conserved. For example, IUCN(1994) has identified the following definition of a Protected Landscape/Seascape as one category of protected area: "area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area". This paper attempts to make a contribution toward application of the integrity concept to cultural landscape. In addition, we discuss the potential of assessment methods through the use of Geographic Information Systems (GIS) based on findings from a case study in Japan. A framework for assessing integrity of cultural landscape is three-step process. First, the actual landscape condition is compared by some reference period (historical reference) to depict landscape transformation. It seems inappropriate to use specific period as reference condition, because the conservation goal of cultural landscape is not preservation but management of change such that the qualities of the landscape are conserved for future generations. However, historical reference is supported by the recent studies that many of cultural landscape have deteriorated with development and/or abandonment in our modern era. Without understanding landscape transformation and historical developments, it is impossible to determine the appropriate context for assessing integrity. Second, several attributes or indicators are selected that adequately identifies the patterns and processes needed to conserve the entire landscape over time. They are ideally sensitive to a range of stress, relevant to societal concerns, and easy to measure and interpret. Third, integrity is interpreted through comparing between actual condition and reference condition, which is formulated by historical reference, type-specific reference, and theoretical reference. Type-specific reference is to look for existing similar type-specific conditions, i.e. sites that have best conserved their integrity. If both historical and type-specific references are missing, reference condition can also be based on theoretical models. In this paper, land cover data serves as the core information source. Integrity encompasses element composition and process performance over multiple scales. In practice, elements are used more frequently than processes as indicators of integrity because elements are typically more sensitive to degradation, more fully understood, and less expensive to monitor. However, landscape qualities cannot be judged from land cover characteristics alone. The land cover derived cartographic products should serve as bases for further evaluation using such techniques as field surveys, cultural and historical assessments, etc.

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## **Airborne Thermography of the Vegetation-soil interface for Detecting Shallow Ground Disturbance**

**K.McManus (1), D.Donoghue (1), C.Brooke (2), S.Marsh (3)**

(1) Dept of Geography, University of Durham, Science Laboratories, DURHAM, DH1 3LE

(2) University of Nottingham and (3) British Geological Survey

Thermal prospection techniques have application for detecting shallow ground disturbance that result from a differential heat flux in soil and vegetation canopies. Previous published research has evaluated airborne multispectral imaging for archaeological prospection and landscape assessment and results of that work have concluded that (1) high resolution vertical aerial photography can yield excellent results, but in intensively farmed areas the crop and soil mark response is very dependant on the time of imaging, (2) near and short-wave multispectral images can help with crop mark detection and the imagery is often less seasonally constrained however these wavelengths usually only add a few details that are additional to a good aerial photograph survey and (3) thermal infrared imagery is sensitive to emitted rather than reflected radiation and this wavelength range has been little studied in the context of shallow ground disturbance, and our own research suggests that thermal imagery significantly enhances soil marks and can detect features hidden under vegetation.

This paper reviews the potential of airborne thermal prospection and then presents an investigation of measured thermal response over an archaeological target at Bosworth Field, England. The results show that the potential of thermal prospection for detecting buried structures is limited to the top 50cm layer and we investigate thermal models, including day-night thermal inertia, and report on the optimum image processing techniques for geophysical interpretation. Finally, we compare the results with magnetic and resistance surveys.

Although airborne thermal prospection is a technique in its own right and an area where technology is improving rapidly, with improvements in spacebourne technology, thermal spacebourne imagery will have important applications in cultural resource management in the future.

**Abstract:****A poor man's use of CORONA images for archaeological survey in Armenia**

To date, archaeology in Armenia has been earthbound. Most work has been excavation and most known sites are monumental. In 2000, following a request from Prof Hayk Hakobyan of the Institute of Archaeology in Yerevan, I began to help get aerial survey off the ground. One way of making this beginning was to acquire CORONA images that covered an area of about 400 square km selected for preliminary examination.

KH-4B mission 1115 from 20 September 1971 was cloud-free – a rarity among the Armenian cover – and five consecutive strips of negatives were purchased. Unfortunately, the aft camera ceased functioning as soon as it reached my area so stereo cover is restricted to two overlaps. However, the negatives have the greatest resolution and clarity of any CORONA material I've seen.

I have no sophisticated technology so decided to examine the images in much the same way as I would conventional vertical photographs. Prints were made on 25x20cm paper where the 25cm dimension was the 6cm width of the negative. This gave about 4x magnification and high-quality prints were obtained. An advantage of doing this is that each frame can be dodged appropriately to produce an optimum print. These were scanned at 1200dpi on a Microtek X12 flatbed scanner. This resolution was decided after visual experimentation. Higher resolution gave bigger files but no appreciable difference on screen: at lower resolution some information was lost or indistinct. The resulting files were no larger than 15MB and were easy to manage without recourse to compression.

The study area includes three sites that I had seen on the ground and examination of these on the images provided a key of sorts to guide me through the rest of the images. These were examined using ERViewer with each image being enlarged on screen to about 4x. Features seen – whether archaeological or not – were tabulated using the on-screen co-ordinates to provide initial locations. This list, and the indication of locations on a 1:100,000 map (the best obtainable so far), has provided a guide for field examination of a sample of the 200 'sites' identified.

The unavailability of useful maps of Armenia means that the CORONA images will also be used as maps that ought eventually be transformed to match co-ordinates collected using GPS.

Field visits are scheduled for June and October 2002 – after submission of this abstract – and results are unknown. What I hope for, and may be able to speak about in November, is to begin compilation of a corpus of feature types that may guide further examination of the CORONA (?and other) satellite images and may provide a first few off-site features to complement the currently known citadels. In parallel with the field visits is the intention to begin our own aerial survey using a microlight to take oblique photographs of features identified from the air. These also should provide feedback to the higher altitude information.

Rog Palmer (Director)  
Air Photo Services  
21 Gunhild Way  
Cambridge CB1 8QZ, UK

Phone/fax +1223 572063

[rog.palmer@ntlworld.com](mailto:rog.palmer@ntlworld.com)

## Using GIS and Remote Sensing in the management of protected areas in West Africa; the example of the W National Park in Niger

The management and the conservation of protected areas is one of the great battle of the 21<sup>th</sup> century.

The Niger W National Park has been created in 1954, and successively obtained the label of MAB Reserve and World Heritage in 1996. This protected area contains 80 % of the biodiversity of the country, particularly with northern Sudanese savanna fauna and the only remaining populations of elephant *Loxodonta africana*, buffalo *Syncerus caffer* and Kob *kobus kob*.

The Park hosts the largest populations of ungulates in West Africa (Le Berre & Messan 1995), and wild plant species, which are important for conservation and genetic research. Moreover, the wetland area inside the Park presents a world importance for the conservation of birds, being recognised under the Ramsar Convention.

However, poaching, illegal grazing and annual migrations of Fulani cattle, uncontrolled bush fires has been occurring since the creation of the Park.

GIS and Remote Sensing techniques are used in cooperation to help survey and management in the protected area.

Remote Sensing can permit us the mapping of the Park land cover in order to localise suitable habitats of animals. It is also useful to find out the best sites for developments like new waterholes, tracks or survey posts.

Image processings of multitemporal remote sensing data enable the monitoring of interseasonal and interannual dynamics of landscape.

Consequently GIS and Remote Sensing are crucial to succeed in managing correctly all the area and to point out and measure the impact of anthropic and natural degradation of the habitats.

Two examples of using Remote Sensing and GIS in the management and the conservation of the W Niger National Park are described here :

- creating artificial waterholes to struggle against the dryness;
- setting up survey post to fight against poaching, illegal grazing and uncontrolled bush fires.

In order to respect the biodiversity and the tranquility of fauna, these developings should integrate different factors such as vegetation, existing tracks, proximity of rivers and waterhole, soils and anthropic pressure.

References :

Le Berre, M. & L. Messan (1995). The W region of Niger: assets and implications for sustainable development. *Nature & Resources*, 31(2): 18-31.

## IMPACT OF LAND USE CHANGES ON ROCK BUILT MONUMENTS -SATELLITE DATA BASED STUDY FROM WESTERN INDIA

*A.K.SINHA, S.P.YADAV and Anup Sharma*

*Environmental Geology Lab, Departmental Geology, University of Rajasthan, Jaipur-302004, India.*

*Email:sinhaaa@sancharnet.in and sinha\_1415@hotmail.com*

### ABSTRACT

The monuments are the cultural heritage which seems to have survived for ages and are aptly termed as our prized cultural heritage which provides us a glimpse of our history. They are very important to us as well as to our posterity.

The rock built monuments are impacted under all the natural environment with varying degree leading to the decay of such monuments. However they are found to decay much faster under the impact of changing and deteriorating geoenvironmental conditions.

The decay of the stone is complex phenomenon. The weathering and Decay of the building material of these monuments are controlled by the factors that are intrinsic of rocks such as chemistry of the rock, texture and structure, porosity etc and as well as by the influences that are external such as geoenvironmental set up which includes ambient air quality, Temperature, rainfall, land use/land-cover pattern, lithology, and the geomorphological setting around the monuments.

The objective has been to understand the causes of the decay of some of the historically, archeologically and culturally relevant monument of western India belonging to the medieval period. The present paper deals with case studies from western India where in Satellite data (IRS Ib LISS II FCC on scale 1: 50000) was used to prepare landuse and land cover map to understand the geoenvironmental impact on the decay process of the monuments. One of the temple complex has been found to have undergone significant abrasion due to the impact of the sand laden wind. Stabilised sand dune region turned into mobile sand dune zone after the changes in land use condition. The paper suggests the conservation measures on the basis of finding of the study.

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**Abstract: Defining the Minoan cultural landscape by the use of GIS**

**S. Soetens, S. Topouzi, A. Sarris**

Submitter: Steven Soetens

Professional Address: Institute of Mediterranean Studies,

N. Foka – Melissinou 130, P.O. Box 119, GR-74100 Rethymnon, Crete, Greece

Position: External Researcher at the Institute of Mediterranean Studies, PhD student at the Université Catholique de Louvain, UCL, Département d'histoire de l'art et d'archéologie

Telephone: +30831025146 & +30974238106

Email: ssoetens@yahoo.com

Minoan peak sanctuaries are located all over the mountain peaks of Crete and cover a period from  $\pm 2300$ BC to  $\pm 1500$ BC.

They are not very attractive for tourism, due to abrupt slopes, high elevations, and they often lack any architectural relics. Their remote location is also reflected in the poor record of intensive excavation activities. Antenna constructions, church building and illegal digging highly threaten the preservation of these sites.

Their archaeological importance however is significant. As indicated by previous research, a strong relation existed between the Minoan palaces and these sanctuaries, which is reflected in the occasional-rich artifact assemblage. It was also suggested that they played a critical role in the Minoan topography of power.

This project started with the recording of the exact topographical location of about 70 threatened mountain sites by high accuracy DGPS, as well as the location of many other important Minoan sites within the same projection system. GIS approach has further enhanced the sanctuaries' importance within the Minoan cultural landscape as well as the importance of the landscape itself, it has proposed new interpretations to the function and meaning of the sites, and it provides a means to predict most probable locations for unknown sites.

So far all peak sanctuaries as well as other relevant sites of the same periods were visited and coordinates were taken by DGPS (Differential Global Positioning System). The whole of Crete's topography, hydrology, geology, land use and land capability have been digitized on scale 1/50000. All these layers were georeferenced to a common projection system (EGSA87) together with a SPOT Stereoscopic Satellite Image, and its main derivate, a DEM with 50m pixel resolution.

Archaeological data and panoramic photographs have been collected and registered to an Access database, and can be queried straight in ArcView through an SQL connection.

The presentation and analysis of the layers was done by use of a variety of GIS programs, depending on their accuracy and usefulness (AutoCAD2000, TNTmips, ArcView 3.2).

The analyses of these information layers, combined with the archaeological data allow us to better understand the Minoan cultural landscape and the peak sanctuaries. The main techniques are spatial (viewsheds, nearest feature, cost surface) and multivariate analyses.

The present paper will show how the complex integration of archaeological, environmental and spatial data in a GIS environment and the analysis of these data can enlighten the meaning and function of the peak sanctuary and put in focus the cultural qualities of the Cretan landscape.

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**Attila J. Tóth**  
**National Office of Cultural Heritage, Hungary**  
1014 Budapest  
Táncsics u. 1.  
Head of the Department for documentation  
Tel.:+36-1-225-48-00  
Fax:+36-1-327-77-02  
[roncsok@yahoo.com](mailto:roncsok@yahoo.com)

**Underwater archaeological heritage of Hungary**  
**Working on the topography**

In 2002 the Scientific Directorate of the National Office of Cultural Heritage has started a project for the protection of underwater archaeological heritage. The first step is making an archaeological database, localising, determining the elements of underwater cultural heritage and working out the methods of survey. It fits well in the documentary strategy of the Office, which concentrates on a database of the cultural heritage, which is connected with GIS.

The problem is, that our sites situate in inland fresh-waters (lakes and rivers), where the visibility is reduced to quasi zero, the streams are strong.

The traditional sources of information are the materials from dredging, informations from divers, archival and literary sources, ancient maps. These informations are often inaccurate or limited. Our purpose was to complete the traditional sources with remote sensing methods: aerial photography and satellite images. There are succesfull examples from marine environments, but there were not experiments in the fresh waters of Hungary.

We would like to illustrate our research through two examples.

The first case is the lake Balaton with submerged island, portual construction and filled up bays. These are detected on ancient maps, aerial photograp, and in some cases satellite images and reinforced by field survey.

The second example is a river site, in the bed of a Danube branch. Here the problem was the relation of underwater archaeological remains (wall) and a terrestrial site (a roman wach tower, *burgus*). By the use of GPS and laser teodolit it was possible to define the relation of the two feature, separated by ca. 2m elevation, and vivid riverside vegetation.

In the protection of the underwater sites is important the communication and cooperation with the data bases of the national parks and the water conservancy offices. The rivers of Hungary are traditional communication lines and commercial routes of Central Europe, the underwater heritage of these waters are important elements of the European past. We are open to international cooperation.

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## **Discovering course of the palaeo river 'Sarasvati' from satellite data and its correlation with archaeological, hydrogeological and drilling data**

**A. K. Gupta and J. R. Sharma**

RRSSC/Department of Space, Jodhpur – 342003

### **ABSTRACT**

River Sarasvati, the mightiest river of the Vedic Period (10,000 – 8,000 BP), is vividly described in the Rigveda (oldest ancient Indian literature) as the 'Ambitame – Naditame - Devitame' that is the best of mothers, best of rivers and the best of goddess, indicating magnanimity of the river during that period. The mention of the river is also found in subsequent ancient Indian literature viz. Brahmana and Srautasutra literature, Bhagvat Purana, Vamana Purana, Ramayana, Mahabharata, and Upnishads etc. The river was holy and religiously adored, with seats of learning and Ashramas (Hermitages) of many Rishis (Saints) like Yagyavalka, Dadhichi, Parasurama etc., located along the banks of the river. The river became extinct during 4000 – 3500 BP due to tectonic and palaeo climatic changes in the region. The Harappan civilization thrived mainly along the course of Sarasvati as confirmed from the occurrence of a large number of archaeological sites discovered along Sarasvati course and near absence of the Harappan sites along the present day major rivers like Ganges and Indus located in this region.

A number of studies have been carried out by the researchers during last 25 years using remote sensing data to trace the course of palaeo river Sarasvati and map palaeo drainage courses. Most of these mapped courses have been linked to the different courses of extinct river Sarasvati and its tributaries. Varying number of courses of river Sarasvati have been suggested by the different workers. During last 20 years there have been significant improvements in fields of satellite and sensor technologies as well as in digital processing of satellite data. A need is therefore felt to re-establish the courses of river Sarasvati, through use of latest available digital remote sensing data and solve the controversy about the actual course(s) of the river.

A study is therefore carried out for mapping of the palaeo drainage network in the north-western region using digital data from IRS WiFS, LISS-I, LISS-III and PAN sensors. The study area comprise of the region, covering NW part of Rajasthan and Kachchh region of Gujrat states, apart from adjoining area in the Pakistan across the International Border (IB). The map prepared indicates five prominent NE-SW trending palaeo drainage courses, out of

which the first two courses pass closer to Aravalli Hills, while last two courses closer to IB with Pakistan. Out of these, the last two courses emerging from Ghaggar and passing further down through Jaisalmer district and further inside Pakistan territory (along IB) and finally meeting Rann of Kachchh are quite prominent (4-10 km broad) and conform to the magnanimity and description of river Sarasvati in the Rig Vedic literature.

Data available from a variety of ground investigations carried out by different agencies working in this area have been analyzed in support of confirmation of Sarasvati palaeo channels, along the courses mapped under the present study. *Litholog data from drillings* along palaeo channels by the Ground Water Department-Government of Rajasthan, data from archaeological finds in the region, age and quality of ground water, geomorphic image anomalies etc., together indicate that the river Sarasvati drained closer to the present day IB. It passed through river Ghaggar and did not drain along the Aravalli hills. Also it did not shift its courses drastically and continuously from east to west, as suggested by some of the earlier workers.

The image anomalies clearly indicate that river Sarasvati flowed parallel to the river Indus as an independent river system and did not flow through present day course of river Nara. The findings raise the doubt that "Rise along Delhi-Hardwar ridge" as suggested by **Bakliwal and Grover (1988)** and supported by **Valdiya (1996, 2002)** was the main cause for west ward shift of Sarasvati river and ultimate drainage desiccation in the NW Indian and adjoining Pakistan region. The analysis indicate towards rise in Himalyas/ Siwaliks and consequent displacements in the Siwaliks and its foot Hills region in the form of Yamuna and Satlej tear faults as the main cause for drainage desiccation and disappearance of river Sarasvati. The results of the study are presented in the paper.

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## **Space Technologies in Archaeological Research & CRM of Semi-Arid & Desertification Affected Regions. Examples from China & Greece**

**Apostolos Sarris & Sofia Topouzi**

*Laboratory of Geophysical-Satellite Remote Sensing & Archaeo-environment, Institute for Mediterranean Studies, Foundation for Research & Technology, Hellas (F.O.R.T.H.), Nik. Foka 130, P.O. Box 119, Rethymno 74100, Crete, Greece, fax. ++30-831-56627, [asaris@ret.forthnet.gr](mailto:asaris@ret.forthnet.gr)*

**Eleni Chatziordanou**

*Department of Mineral Resources Engineering, Technical University of Crete, GR-73100 Chania, Crete, Greece, [lena\\_hatziordani@hotmail.com](mailto:lena_hatziordani@hotmail.com)*

**Jianguo Liu & Lianggao Xu**

*Institute of Archaeology, Center for Archaeological Science & Technology, CASS, 27 Wangfujing Street, Beijing 100710, China, Fax: ++86-10-65135532, [gaolb@history.cass.net.cn](mailto:gaolb@history.cass.net.cn)*

Geographical Information Systems and Remote Sensing techniques were used as detection and monitoring means in the archaeological research and cultural resources management in semi-dry and desertification affected regions. Two pilot study areas were chosen, Lasithi in Greece and Zhouyuan in China, in order to take in account the diverse nature of monuments and sites (with respect to the area coverage, building materials, conservation status, etc), and the environmental setting of the surrounding regions.

The recent mapping of the archaeological sites of Lasithi district (almost 1000 sites dated mainly to the Neolithic-Roman period) through digitization and high-accuracy GPS and the construction of a digital WEB-GIS archaeological map introduced a new input for the management of cultural resources in the region. The need for the development of a CRM model is of critical value, since Lasithi is one of the less-developed and remote districts of the E.U. and at the same time one of the most archaeologically investigated areas in Greece. One of the directions of the current research is devoted in the risk assessment of the archaeological sites, taking in account natural and environmental hazards, such as earthquake activity, fires, soil erosion, landuse practices, geological characteristics, climatic conditions, population and tourist pressure, etc. SPOT and Landsat TM images were used for extracting the spectral signatures of the archaeological sites. GIS processing was carried out based on the geomorphological, geological and cultural characteristics of the sites in order to define archaeologically sensitive locations having a variable index of conservation due to the environmental variables.

Photogrammetrically processed aerial images and Landsat TM imagery were merged together to produce a high spatial and spectral resolution image of Zhouyuan, the ancient capital of China (B.C.1100 to B.C.700), in Shaanxi province. Processing of the above data and photo-interpretation of the images was able to detect a number of cultural features in the Zhouyuan site, including some important palace foundations, two of which were excavated, bringing to light important archaeological features. Further analysis of the landscape of the region is under progress, including the spatial analysis of the distribution of the tombs, palace foundations, bronze hoards etc., in an effort to infer the locations of other remains which will contribute to building a more synthetic image of the cultural landscape of the Zhouyuan site.

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## DEVELOPMENT AND IMPLEMENTATION OF AN INTERNET WEB MAP SERVER FOR WORLD HERITAGE SITES

B. Leppig <sup>(1)</sup>, Bernd Paulowitz <sup>(2)</sup>, Mario Hernandez <sup>(2)</sup>

(1) *Department of Engineering Geology and Hydrogeology, Aachen University of Technology, Lochnerstr. 4-20, 52064 Aachen, Germany, e-mail: [bjorn@ilh.rwth-aachen.de](mailto:bjorn@ilh.rwth-aachen.de)*

(2) *UNESCO World Heritage Centre, 7 Place de Fontenoy 75352 Paris (France), e-mail: [B.Paulowitz@unesco.org](mailto:B.Paulowitz@unesco.org)*

### POSTER SESSION

The World Heritage Convention came into effect in 1972. Since then UNESCO, and later on the UNESCO's World Heritage Centre, are collecting data and information with respect to sites to be proposed as World Heritage sites. Associated with the information for each site, there should be the corresponding cartography indicating the boundaries of the site as well as the protected area (buffer zone). However, site cartography is in many cases missing or inaccurate.

During the last three years the World Heritage Centre has been dedicating special emphasis to collect, from countries signatories of the Convention, the necessary cartography.

In close coordination with the University of Ghent an Internet map server is being developed. In order to be able to identify the precise requirements and technical specifications for such a map server, an operational map server has been developed by the World Heritage Centre.

The system is built on "open source" web-mapping software. Its objective is to be an Internet portal to visualize GIS-Layers (Geographical Information Systems). The main layers under consideration are the site boundaries plus a series of basic layers to better assist the user identifying the geographical area: main water bodies, international boundaries, administrative boundaries, main roads and towns. Internet users can either visualize the previously mentioned layers using a simple web-browser, and/or unload selected layers to their own computer for further integration into a more sophisticated GIS system. All this GIS data manipulation is possible only if all users make use of 'open-GIS standards'.

The system will be demonstrated at the poster session. A client can freely navigate and query

World Heritage site maps in different levels of detail. In addition basic layers can also be displayed. The system is based on a global-, national-, sub-national- and site-level approach, where each time the level of information is strengthened by additional layers of information.

This experience has been successful for the definition of the main requirements for such a map-server. As with all GIS applications, this experience has significantly assisted in order to implement common standards for all data layers. This approach will significantly assist States Parties of the World Heritage Convention in understanding, through the visualization of operational examples, the type of cartographic information required.

The poster session will demonstrate an on-line connection to the system described herein.

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## NEW AIRBORNE SAR FOR A NEW METHOD OF ARCHAEOLOGICAL PROSPECTION OF BURIED REMAINS

Rémy Chapoulié <sup>1</sup>, Michel Martinaud <sup>2</sup>, Philippe Paillou <sup>3</sup>, Philippe Dreuillet <sup>4</sup>

<sup>1</sup> CRP2A, Université Bordeaux 3, 33607 Pessac cedex, France.

<sup>2</sup> CDGA, Université Bordeaux 1, 33405 Talence cedex, France.

<sup>3</sup> Observatoire de Bordeaux, BP 89, 33270 Floirac, France.

<sup>4</sup> ONERA, 91761 Palaiseau, France.

The airborne P-band Synthetic Aperture Radar (SAR) called RAMSES, operated by ONERA, can be used for the detection of buried features thanks to its low central frequency (435 MHz). This system will enable fast archaeological prospecting of very large surfaces. This is a new potential application using this new high-resolution space-borne SAR for the preservation and the study of our buried cultural heritage.

### Why do archaeologists need prospection ?

1 - Preservation of cultural heritage needs previous prospection before a new construction is built. A buried historical or prehistorical site when it is known can be saved. This leads to a data base (archaeological map) everybody can use, specialists but also and more precisely decision-makers and building contractors.

2 - Scientific study with priorities defined by researchers in specific fields, has not to be guided by hazardous discoveries. In this case prospection monitors the historical knowledge of a region, a country.

### And what do archaeologists have at their disposal ?

Many prospecting methods can be used to study the human buried heritage without disturbing the ground.

1 - Usual approaches are : archive consulting, inhabitants interviewing, aerial oblique photography, walking survey.

2 - Non-destructive ground surface geophysical methods analyze the physical properties contrasts between buried vestiges and their surroundings : electrical prospecting (resistivity), magnetic prospecting (susceptibility, thermoremanent magnetization), electromagnetic SLINGRAM (resistivity), ground penetrating radar or GPR (dielectric constant)... In some cases, 3D imaging of soil reality can be obtained.

A number of archaeological sites have been successfully investigated throughout the world with these routine ground based methods (Clark, 2000).

### What about archaeological prospecting from the air ?

As opposed to what can be seen at the ground level, a global perception of the vestiges is obtained with increasing altitude, but only if some very specific marks show up. Nowadays three ways of aerial prospecting can be used.

1 - Vertical aerial photography reveals landscape patterns, such as ancient roads or medieval settlements, but not buried structures.

2 - Aerial oblique photography at low altitude is used on suspected archaeological areas. It is performed at defined moments in the seasons when typical marks, due to vegetation or ploughing, appear at the surface.

3 - Aerial thermography enables temperature gradient measurements after a climate change. This gradient is depending on the thermal properties of buried structures versus those of the surrounding ground.

### Improving archaeological prospecting from the air ?

1 - by exploring a physical property of the ground which was not utilized in this aim before,

2 - by improving an existing method by faster data acquisition or better ease of use, sensitivity, accuracy...

In this paper it is the second point which is going to be developed. Which characteristics can be improved ? investigation depth, horizontal resolution (pixel size), adapted moment, data recording speed, setting facilities ...

The airborne RAMSES SAR brings an extraordinary higher data recording speed as compared to the Ground Penetrating Radar (GPR).

### The GPR (ground penetrating radar) for archaeology

Basically the travel time of an electromagnetic pulse is recorded when reflecting on a buried interface. Depth can be measured after wave velocity calibration. An immediate visualization through a radargramme is easily obtained. Today, data processing enables to get a 3D description of the reflectors yielding original and essential results in many fields of soil investigation. Thus the GPR offers high resolution sounding capabilities with detection of features of the order of few centimeters thickness at ranges of several meters. It has been applied successfully in a

variety of burying conditions of archaeological structures and objects (Conyers and Goodman 1997). Notice that very wet or clayed soils are unfavourable media for the radar because of the strong attenuation of the waves.

### The SAR

Used within remote sensing facilities (space-borne platforms), it uses the surface backscattering to construct 2D image. In the case of RAMSES the collected signal include the backscattering from underground reflectors. This new P-band airborne SAR was manufactured and operated by the French institution ONERA. Its main characteristics for archaeological purposes are : full polarimetric response, a pixel smaller than 10 m<sup>2</sup>, and its penetrating capability (down to 5 meters in very dry soils) due to its low frequency.

### Can an airborne radar detect buried structures of interest for archaeology ?

The response is *yes a priori* provided that some fundamental conditions are fulfilled. These are : a spatial resolution fitted to the target size, a subsurface reflectivity (dielectric contrast) large enough to produce a significant signal, a high radar penetration depth and a sparse vegetation cover. The first famous examples come from the NASA Shuttle SIR-A and SIR-B missions when unknown patterns of stream valleys over Egypt and Sudan were detected (Mc Cauley et al. 1982). Some other sites of archaeological interest have been revealed in desert regions (Daniels 1996).

### An experimental test over an archaeological site

An experimental test over a Gallo-Roman site which fulfills the target size condition, has been carried out during the fieldwork validation phase of RAMSES, the so-called PYLA'01 experiment during April and May 2001 (Paillou et al. 2001). This experiment in the region near Bordeaux in France was planned within the "low frequency radar working group" set up by the French space agency CNES in order to explore potentials of low frequency radar for various thematic mapping including the archaeological one. The results will be used to promote future P-band RAMSES flights which should validate potentials of low frequency SAR in an arid context. The data quality of the PYLA'01 experiment was very good. Unfortunately, in spite of a rigorous methodology including GPR validation and ground truth from a 8 hectares electrical resistivity map, the archaeological experiment was fruitless (Chapoulie et al., 2002). Two main characteristics of the season leagued against the detection of buried structures at a 40 centimeters depth. The first is that the flight was performed during a very wet period, so the ground was saturated with water. The second characteristic was the presence of a dense grass cover which reinforced the surface scattering.

### What can be expected for archaeological purposes with the RAMSES P-band radar and what are the requirements ?

In temperate regions, it will be probably difficult to get positive responses except perhaps for dry summers on bare fields and features buried at very shallow depth. Necessary conditions are: a very low moisture content of the ground and a sparse vegetation cover. Further experiments are foreseen by the beginning of 2004 over arid regions such as the Egyptian desert. In these conditions with a likely uniform subsurface backscattering under a "transparent" sand cover, we can expect the detection of stony buried features. Buried features looked for are those of the ancient civilizations of Egypt for which dimensions fit the pixel size. Several archaeological test sites (Alexandria, Louxor) have already been selected for this future experiment.

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## **Landscape archaeological Heritage management in the Information Age Prospects for the Future Development of GIS in Iran**

Kamal Aldin Niknami  
Department of Archaeology  
University of Tehran

The advances which, have been made in the last few years in the methods of inventorying and documentation of archaeological sites, have taken place mainly due to advances in computer technology. This dynamically developing has supplied applications of a universal character, and thus of use to the archaeological profession, and especially the heritage management services. The appearance of a new operation system, Microsoft Windows based on a graphic environment, has allowed the linking graphic data in the database. This allows the enriching of the information in the archaeological database with drawing of artifacts photograph, etc. After the increasing widespread use of the new category of computer programs, defined by the term GIS, further development became possible which, relied on the creation with the aid of the computer of digital maps (the electronic equivalent of geographic and topographic maps). The archaeologists are using now the various types of cartographic material. The perspective is opened of the creation of specialist archaeological maps with the aid of the computer. In order to apply these innovations it is necessary to supplement the database on archaeological sites with information concerning the situation of the sites in the form of cartographic information. The fulfilling of this condition opens new perspectives in the use of the computer for archaeological conservation purposes including the possibility of the realization of a series of routine activities of the archaeological conservator. The GIS technology has not been applied in Iran (until recently with the present project) on a wider scale as a method of discovering and documenting archaeological sites. The scope of information on archaeological sites collected so far seems, to be insufficient to formulate a correct decision. When a powerful tool known as GIS becomes available, it becomes possible to integrate the products of this method with results of surface survey and geophysical examinations on the background of topographical map.