

## **Territorial domains – competences integration model: geographical and cultural data, archaeological heritage, urban reconstruction project through “*augmented reality*” techniques**

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### **ABSTRACT**

The present paper introduces the research and design initiative of the Politecnico di Milano – BEST Department in collaboration with MIRAS, concerning the application of an integrated set of technologies to the surveying and digital modeling of archaeological sites in Azerbaijan. The range of interested scientific and technological competences that are implemented in the data mining, data sets representation and elaboration into digital models, ambitiously aims at reconnecting a quantity of knowledge fragments concerning the ancient Capitol City of Shirvanshah Khanate Agsu and its history, the layout of which was lost through dramatic historical events, including the deportation of the archives by military occupants or political Institutions aiming at a strict centralization and banishment to exile of ethnic traditions. The synergy among technologies extended from the Geographical surveys and Information Systems towards architecture and engineering of building constructions is awaited to recompose the lost mosaic of this culture.

### **A SCIENTIFIC RESEARCH AND DESIGN PROJECT**

The goal of this presentation is to introduce to the audience of scientists and technicians a research experience that is moving its first steps towards an ambitious aim: to experiment the collaboration among different knowledge domains working around the reconstruction of a significant historical and cultural heritage, the major traces of which historical events have dispersed. The engagement of many holders of specialized competences operating together within the Politecnico di Milano - BEST *Building Environment Science and Technology*, is proposing a practical experimental model of knowledge synergy applied – to begin with a very relevant case in the history of Azerbaijan - to an archaeological theme situated in Azerbaijan: the lost city of Agsu, one of the capital cities of the old Shirvanshah Khanate. The base for this activity has been officially constituted by the “Framework Agreement” jointly signed between Politecnico di Milano and MIRAS - *Social Organization in Support of Studying of Cultural Heritage*, the Azeri Institution in charge of developing the archaeological exploration and cultural valorization of Agsu and other very relevant sites. The essential objectives of the “Framework Agreement” concerns the implementation of the Politecnico – and particularly of BEST Department – integrated technological competences’ system in supporting the development of specific applications in the domains of geographical data inquiry and collection by means of spatial and terrestrial surveys of archaeological sites, digital modeling and performance simulation for excavated remnants protection systems, updated high energy efficient envelopes’ conception and design, collaboration for technology transfer initiatives, cross exchange initiatives for the cultural heritages dissemination between Italy and Azerbaijan and for education for researchers and PHD students.

## **AGSU, THE ABANDONED REFUGE - CAPITOL CITY**

Extraordinary is the history of Agsu, since the reasons of the foundation itself by order of its Governor of Shirvanshah Khanate, who wanted to rescue his Capitol City from the military pressure of its very encumbering and arrogant neighbor, the Russian Zar Nicola th 1<sup>st</sup>. Thence Agsu – chronicle reports –was built in only two years of intense construction works, that resulted in the foundation of the city in a square settlement, applying the scheme of an ancient Roman *Castrum*, organized around the crossing of *Cardus* with *Decumanus* main streets (but here exactly oriented upon Mecca direction?), enveloped in its square scheme defense system, with walls and river – supplied ditches.

### **- RECONSTRUCTING A LOST IDENTITY**

One of the major peculiarities of the Agsu re-discovery project is the absence of a large number of evidences of its history – that normally guide the archaeologists’ research work – that political and natural events have cancelled, dispersed and exiled to the land of non-remembrance: from this removing of memory – of the Knowledge patrimony interwoven with the history of civilizations along this bridge-way territories – and the Country’s desire of re- knotting the warp and woof of the forgotten carpet configuring its identity, recognizing the scheme of its design with its special chromatics, specially moves this trial of knowledge contamination.



*Images 1&2 – Gobustan landscape: gigantic stones with alphabet inscriptions.*

### **- PRECEDENT EXAMPLES: GOBUSTAN INSCRIPTIONS**

A formidable example of reconstruction of the lost traces of a remarkable historical past is located in Gobustan Region, a wild land north of Baku, where the geological events of the glaciers descending the Caucasian Mountains slopes towards the Caspian sea. Here, a vast population of stone - carved inscriptions since Superior Paleolithic to recent times is spread upon the fragmented layers of huge stones that form the wild character of the landscape: drawings of totemic wild or domestic animals, magic symbols, human figures of soldiers or horse-mounted heroes, inscriptions in many different languages, from Arabic to Farsi to unknown alphabets. Among them one sounds extremely important for the understanding of the timeless tradition of commercial, cultural and political exchange between the West and the East: the Latin inscription carved by an ancient Roman Army officer Lucius Julius Maximus, stating the presence of his Legion – the “*Duodecima Fulminata*”, “The Twelfth Thunderbolt-decorated Legion” - , under the empire of Domitianus Caesar Augustus Germanicus.

The restoration and preservation of this historically fundamental inscription has been recently carried out by one of the authors of this paper, prof. Luigi Scrinzi, guiding an on purpose archaeological equip composed by Azeri personnel from MIRAS and the National Historical Museum of Baku.



*Images 3&4 – Gobustan: the Ancient Roman inscriptions reporting of 12<sup>th</sup> Legion Fulminata.*

- **THE SILK WAY BRANCH THROUGH AGSU**

The discovery of other relevant traces of the Azerbaijan history and civilization may occur travelling through the chain of Caucasian mountains north – west of Agsu, highlighting the fundamental character of this bridge- land between East and West. This case – extremely pleasant in addition to its great cultural interest – concern the un-awaited and surprising permanence of the traditions connected with the Silk Way tradition, *id est* the conservation of traditional artisan craft techniques for the silk fabrics decoration by natural colors dyeing derived by vegetal essences, applied by hand stamping by wooden blocks, composing natural dyed colors and decorative patterns by the “Batik” technique, inherited from ancient India.



*Images 5 – The silk decoration by wooden blocks and Batik dyeing technique.*

- **IMAGES FROM THE HIGH: RECONSTRUCTING THE TERRITORIAL INVISIBLE SUPPORTING STRUCTURE**

The fundamental contribution awaited from satellite picture-taking of the Agsu geographical area is the recognition of the pattern of physical characters that can describe the thick fabrics of relationships structuring the territory; thence becoming the supporting backbone to guide the reconstruction of the mosaic of connected material particles - tracks that evidence the passage of the historical events and, even more, configure the outline of an entire civilization located along the Silk Way, by its material culture and even more in the immaterial conception of its human population styles of life and believes.

Actual revelations are awaited by satellite surveys of the old Agsu city, the images of which will be analyzed in order to identify a number of data sets according to the city’s reconstruction hypothesis

that are being formulated by Azeri archaeologists and Politecnico researches: for instance the actual position of the ancient Agsu River bed – in charge of supplying water for defense ditches - but probably much more; *id est* to separate the city into a defensive creek, that made its military position much more defensible due to the presence of an ever changing stream and to the uneven terrain of its bed and banks.



*Images 6&7 – The ancient city of Agsu, before the archaeological excavations.*

#### - **TRACES OF THE URBAN MOSAIC**

But a number of further data are the objects of the scanning and analysis of the digital images that both satellite and terrestrial survey will supply to the researchers:

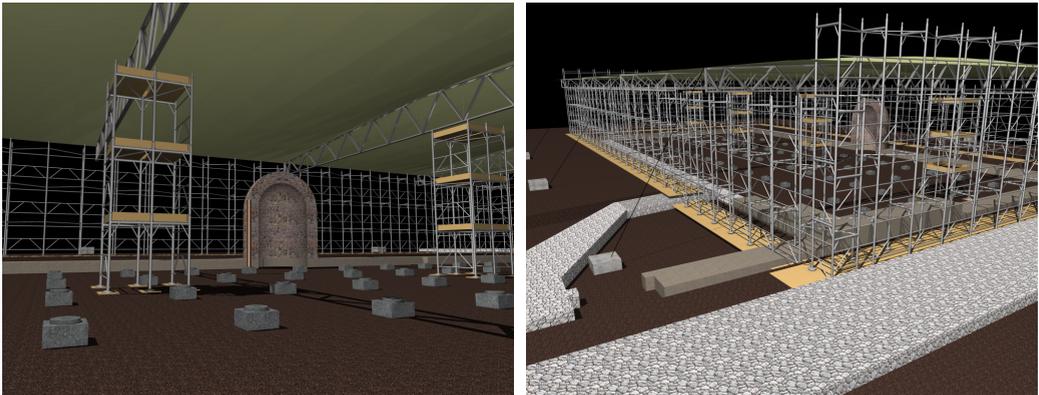
- which was the original layout of the road network connecting ancient Agsu to the Silk Way through its peculiar branch passing through the mountains' chain protecting the plan from the north, reaching the little town of Laich, religious and pilgrimage centre since very ancient times;
- which was the actual tracing of the road connecting Agsu to the mountains' passage related with the Agsu River contemporary bed; one or more bridge-ways and fords have to be identified, in order to correctly interpret the disposition of the city defense system, provided of one only access door, fortified by a ravelin: the reconstruction of actual tracings and their dimensions would make clear the whole defensive system scheme, proving the application of military techniques related to the use of available weapons and to the tactical actions of defenders against offending troops;
- how the essential communication and transportation system with the city was designed – considering the vital commercial role of the whole area and of this capitol city along the Silk Way – how it was peculiarly connected with a fundamental infrastructure like the local Caravansary, clearly identifiable traces of which are placed in front of the city access door, but at a non-negligible distance; once more a defense measure to be interpreted in connection with river stream;
- how correct is the geographical orientation to the Mecca, upon which the tracing of the whole city layout is planned, around the crossing of its main streets *Cardum* with *Decumanum* the central Mosque is located. The exact reconstruction of the layout would support the individuation of other main buildings' and infrastructures' most probable locations, guiding the excavation priorities for archaeologists.



*Image 8 – A view of the recently excavated Mosque site in Agsu, showing the columns' basements.*

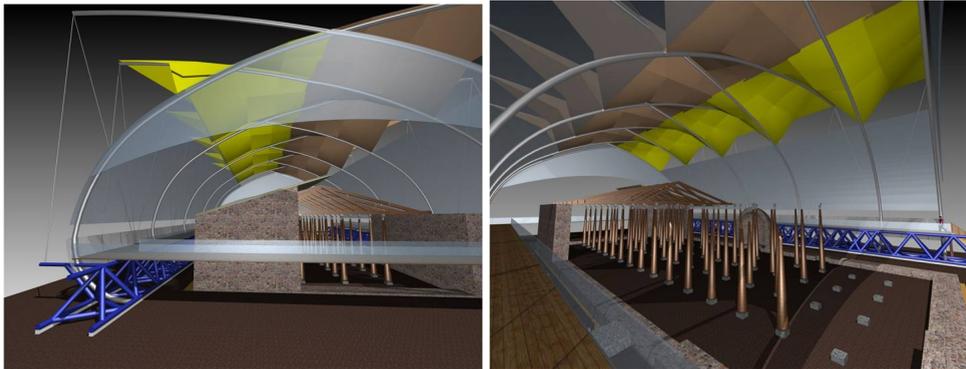
**- A DECISIVE REMNANTS' ENSEMBLE: FINDING OF THE MOSQUE**

The excavation of the ancient Agsu Mosque – the one we suppose to be the main central one, connected with religious ceremonies practiced by the rulers – marked a decisive enhancement for the reconstruction of Agsu main features' layout: during the Spring 2011, the building was individuated by on purpose aimed excavations, that revealed a wide area surrounded by enclosure walls, furnished with access way from the main street to an entrance atrium, hygienic services with clean water supply and sewerage system.



*Image 9&10 – Views of the digital model of the Agsu Mosque, protected by a provisional structure against the damages due to the rain season.*

The Mosque prayer area is a wide rectangular building of which very thick enclosing walls made by clay and straw bricks have been excavated, together with the very regularly disposed base stones of 56 columns have been found. The Mirhab structure has been individuated through the ruined remnants, perfectly recognizable because of the presences of the couple of crowning arches made by burnt bricks and lime mortar – the one structure built by solid and permanent materials among the whole ensemble of up-to now excavated structures belonging to such an important building. Examples of the cone-shaped stone capitals of the columns have been found; the slender shape and limited dimension of which tells about a light roofing structure, in which wide and high wood truss-beams had to configure the interior space of the praying area.



*Image 11&12 – Views of the digital model of the Agsu Mosque tentative reconstruction on the base of the finding analysis. A permanent protection system is added to rescue the site, allowing visits.*

A huge quantity of the burnt clay roofing tiles have been found, broken unto a myriad of fragments from which some entire examples were extracted and assembled to configure the real consistency of the tiles waterproofing, allowing the evaluation of the whole amount of loads to be supported by truss-beams supporting structure. The analysis of the tiles describe the great attention of the architects and tile-makers for the quality of the manufactured elements, that are very thin and light in comparison with the normal size of Italian similar elements, our Italian “*coppi*” - covering tiles. The 3D preliminary architectural models for the reconstruction of the Mosque, based upon the tentative and provisional commonly shared interpretation of the findings issued by MIRAS archaeologists and BEST architects, describe the main features of the building and forward the representation of the special atmosphere that had to permeate this worship place.

#### **- THE EXCAVATED FINDINGS’ PROTECTION: INTEGRATED DESIGN OCCASION**

Advanced architectural and engineering modeling techniques are applied to configure the archaeological remnants, the ideal – by now – or preliminary reconstruction of the buildings, by using 3D, Object Oriented, Parametrical modeling software tools, populating the IFC Standard-based elaboration environment enabling the interoperability practice among the phases of the design development, enhancing from the preliminary to the executive and shop-design stages.

This sophisticated software apparatus is adopted in order to allow the very ‘sensitive and exact’ representation of the original archaeological materials fruit of the excavation campaigns, associating the assumption of correctly assessed building materials and techniques data with the ability of configuring the linguistic and spatial suggestion that the original buildings were offering to the population of their users, including the light and shadow atmospheres, the climatic variations control for the comfort of the inhabitants.

#### **- FRAGMENTS OF MATTER DESCRIBING BUILDING TECHNIQUES**

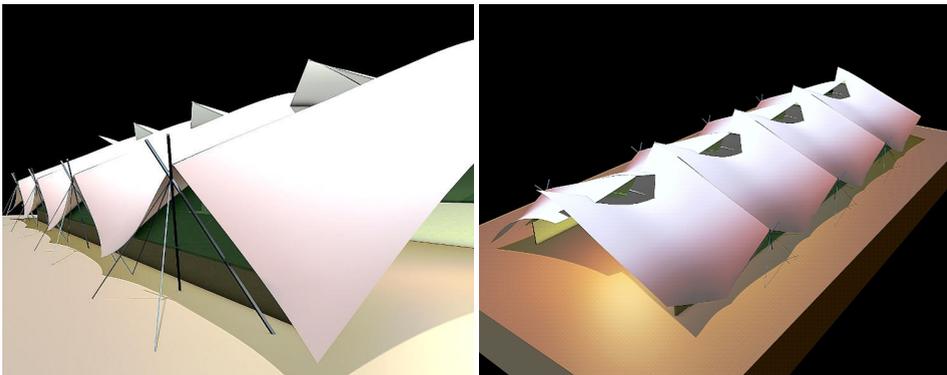
The construction techniques of the buildings - as revealed up today by archaeological excavations led by MIRAS - are directly influenced by the limitations imposed by the compelling construction accomplishment program and by the nature of the locally available resources of construction materials, in the flat alluvial plan along the Agsu river. Large layers of gravel with rounded pebbles of every dimension made of hard limestone, fruit of the glaciers’ erosion from the sides of Caucasian mountains. Among the gravel, middle-size stones are abundant; in spite of their rounded and globular shape, their use for the construction of buildings’ foundations is allowed by simply splitting them into two or four parts by sledge-hammer strokes, so that nearly plane surfaces can be composed with crude clay into thick foundations, the peripheral sides of which show a nearly regular texture. The thickness of foundation walls is the consequence of the evaluation of ability of the applied

building technique as the load-bearing structure supporting the crude clay and straw bricks elevation walls, on which wooden horizontal structures are laid to build flooring and roofing parts of works.

- **AUGMENTED REALITY' TECHNIQUES**

Profiting both of the digital 3D models elaborated for the Agsu terrain from topographical, terrestrial, aerial and satellite surveys, and of the main buildings' digital models the layout and architectural features of which the archaeologists' excavations have already revealed, a simulation of the ancient Agsu city will be elaborated; the virtual reality environment into which the digital model will be implemented will allow visual exploration and other interactions, in order to explore the alternative possibilities for architectural reconstruction, for conservation actions modeling, comparing alternative of techniques to be applied, for the preservation policy to be implemented in order to allow visitors access, etc.

An advanced software environment will be implemented to support the issuing of a number of alternative and concurrent reconstruction hypothesis for the whole Agsu city ensemble and its surrounding territory, by means of digital simulation of its urban texture, the hierarchy of streets and little squares infrastructures with their technical installations as water supply pipes and sewerage systems, the location and architectural features of the urban landscape configures by main public and civil representative buildings, of the main public services as markets, completed by the filling-up texture of more modest residential and service buildings as artisans' and merchants' shops, etc. The progressive upgrading of the urban model will be the fruit of the updated data and reconstruction issues supplied by archaeologists' exploration of the Agsu site by new excavation campaigns; the virtual reconstruction. The ability of the digital model of Agsu to receive and implement the upgrading of the newly added data sets in the ensemble of its information system, the consequent ability to re-formulate the network of spatial and physical relationships describing the complexity of the city, depends on the potentialities of the virtual representation software environment. The *Augmented Reality* techniques applied to the urban digital model will allow, by a dedicated encoding technique, the direct association of any kind of data stored in the information system that the model's author or users may want to represent in close connections with the objects or sets of objects composing the digital model itself: for instance thermal data fruit of the simulation of seasonal behavior of buildings under the seasonal solar irradiation regime, or the performance data connected to specific building materials or parts of work.



*Image 13&14 – Views of the digital model of the Agsu existing Museum building, protected from solar irradiation by a tensile added structure and textile filtering membrane.*

(Credits: Digital 3D object Oriented parametric models elaborated by **ProTeA - Progettazione Tecnologica Assistita** Research Unit. Authors of the pictures included in this paper: Ezio Arlati, Luigi Scrinzi, Fariz Khalilli, the Agsu Excavation Mission members).