

## The CHRIMA project:

### Investigating the rupestrian architecture in the Mediterranean area

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**Abstract:** The architectures carved into stone, realized in a subtractive process starting from the natural environment are a typical human realization of the early times of our civilization. This rich, suggestive patrimony spreads all around the Mediterranean area and it is mainly made of human built caves, sometimes easily mistaken for natural phenomena, sometimes showing a clear architectural aspect in their façade or in the overall shape. These spaces were used in time as churches, cemeteries, depots, recoveries, houses and their remains show the remembering of a past based on hard living conditions but also of faith and relationship with nature. All these creations have common features, the clear persistence of solutions linked to material needs, but at the same time they show specific and local solutions according to the kind of stone, to the behaviors and to the climate of the area. The whole world of these settlements creates a sort of continuity in time and space, extending its presence in a common ancient language around the Mediterranean area starting from the prehistoric age to our days. The intention to document, survey, read, understand and divulgate the rupestrian architecture in the Mediterranean area is at the base of the CHRIMA project (Cultural Rupestrian Heritage In The Circum-Mediterranean Area). Starting from the works and researches from five University partners and three non-academic partners, based on the support of the “Cultural Program” from the European Community and the efforts of a large group of scholars, the project started in October 2010 and closed its first phase in June 2012, developing an huge digital and traditional documentation about various aspects of this particular patrimony. The paper proposed here want to present the CHRIMA project in the results achieved in two years of intense research activity and the contribution it can offer.

**Keywords:** CHIRMA, rupestrian, Mediterranean, archive, architecture

### Introduction

The rupestrian architectures are fragile, they can get lost for natural events or for the human action, a large number of cases has shown how easy is to damage with no chance for recovering a rupestrian object. In certain part of the world, the rupestrian area are so extended and rich of elements that it is almost impossible to hypothesize a complete protection of the whole patrimony. The strategy to survey, catalogue and investigate over this architectures is an important step to take in front of this situation, while it is the right base for understanding further actions or at least to preserve a detailed image of what is in risk.

Cultural Rupestrian Heritage In The Circum-Mediterranean Area. Multimedia for its diffusion and knowledge

Core of the project is communication<sup>1</sup>. Communication in its two meanings of "community": in its ancient and fundamental of the "pool" things and "join together" to events, meaning that calls on community social structures; in its metaphor of "making common" ideas and thoughts that do not have the community as center, but individuals as interlocutors individually thought.

To attract consensus and interest, engage new generations (not only in the sense of young people) need to communicate and communicate with the image that focuses a plurality of interests, the same features that characterize a "culture", not only the past, but that current in continuous training. To Inform - to Persuade - to Suggest - to Emotion - to Interact are the basic principles to bring to completion the project we have just proposed. To meet the prerequisites website <http://www.rupestrianmed.eu> will support both the spread of individual initiatives, and the activity of individual researchers who will share the knowledge.

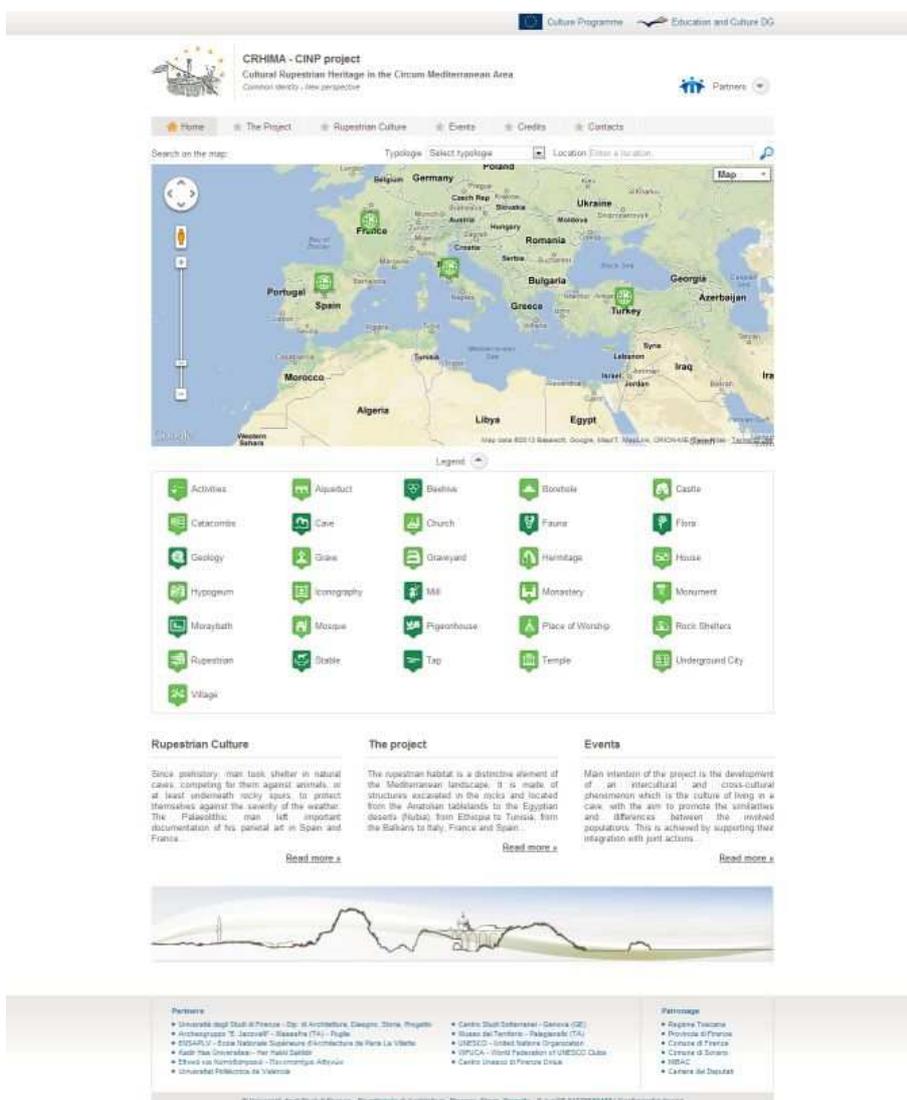


Fig. 1 – The homepage of the CHRIMA website, as updated in the September 2012

<sup>1</sup> For more information about the CHRIMA research project please consult the web page <http://www.rupestrianmed.eu/>, project coordinator: prof. Carmela Crescenzi.

The site, created for a global spread of cultures and rupestrian to promulgate and connect the various initiatives of the network and other media, has a grassroots organization in development and likely to vary according to the demands of the various disciplines that contribute to creating new entries and completeness of existing ones. The project was born and will grow up with the contribution of all participants different voices, with different and varied knowledge, from interaction of multiple disciplines. The heterogeneity expressed by project will use the media in its dual interpretation of a physical instrument and physical - mechanical instrument -. Immediacy the media, old and new (books ... television, internet), are the means of communications, but they are actually distribution instruments (media), then the transmission or communication instrument (medium) is the "message "with its expressive and representative ways with relational skills of human cognitive and perceptual processes.

For example singular and unique in their expression patterns are depicted on rock-paintings are the media of the distant past of which we do not have unique interpretation codes (of comprehension).

Keeping in mind that one of the research goals is the diffusion of "rupestrian culture", so communicate it, you need to ask to whom and for whom the work is done. Having to reach more users with different interests and levels of preparation and dialogue, tools and models necessary for use are diverse, understanding and relationships. The cultural media that wants to tell are handwork or graphical, iconic and aniconic sign, a story to reveal written in architecture by subtraction and parallel to the history subdial. The story of a cross culture that takes place over time without interruption, through the civilizations, peoples and their territories. To meet the needs of the project it was built a web site ([www.rupestrianmed.eu](http://www.rupestrianmed.eu)), offering a relational database, with iconic and textual interface that makes use of different media according to the needs and skills of the researchers who contribute to the enrichment of the database. This presents a wealth of arguments that relate the phenomenon of living in a cave. It is not intended to restrictive and exclusive scope architectural elements and artistic expressions, but is related to the characteristics (biotic, abiotic and limiting) reference (bearing related) rocky habitat. The dossiers of individual artifacts and monuments have a textual description and references. They are associated with icons that indicate the acquisition of the documentation of the plan, paintings, drawings, photographs, graffiti, inscriptions, restoration, multimedia processing and text-depth.

The heterogeneity of the public who want to involve (scholars and students of different levels), requires different tools for the graphic and multimedia description, both to understand the continuity of living in a cave, both for the representation of the architecture and the environment. The representation, in all its modalities, is one of the most useful tools for the documentation of monuments already ruined by the passing of time and that are destined to destroy.

The acceleration of degradation is clear: in the environments of the monastery of Hallaç (Ortahisar – Cappadocia), in a few years, there has been a loss of quality of the drawings and the integrity of the rock appears more compromised. In 2007 the village of Zelve was accessible, while in 2010 was closed to the public and now is only passable in the valley. Failing to safeguard and restore the abundance of cave sites,

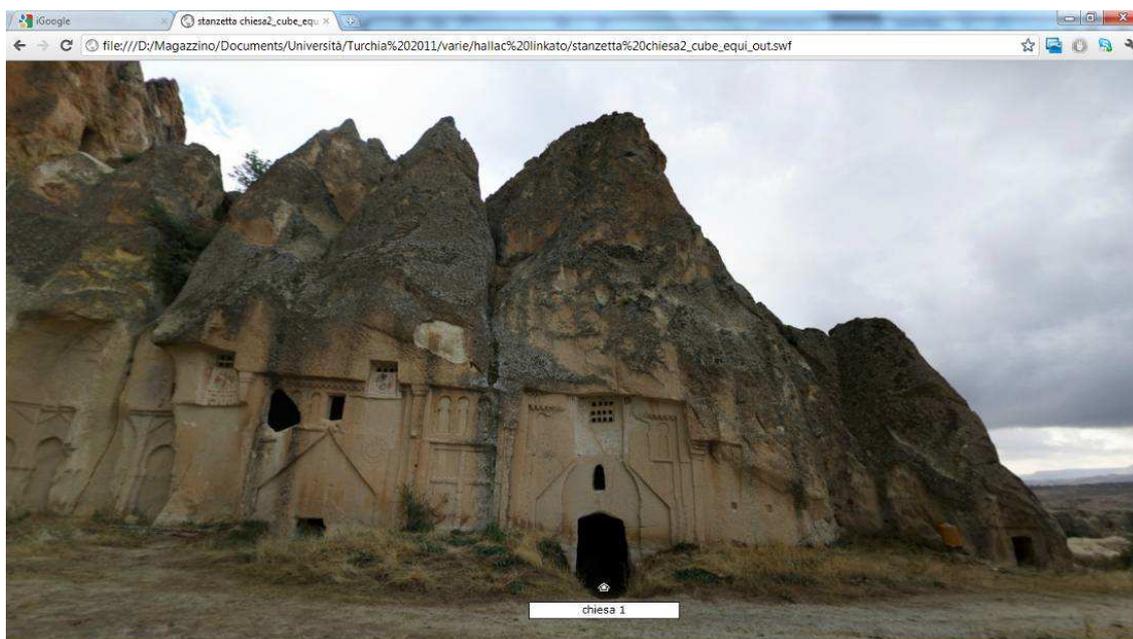


Fig. 2 – Panoramic interactive view of the Hallaç site, Ortahisar (C. Giustiniani).

any form of documentation, even if only photographic or aimed at a simple survey, it would be desirable in order not to lose the memory of the legacy left to us over the centuries. To document in a quick, affordable, and effective way these monuments the choice of photographic survey seems the most interesting solution, the use of a simple common tool like a digital photographic camera allows to avoid the moving of complex and expensive tools like a laser scanner, moreover this is a renounce to the level of accuracy of the overall result and to its versatility, but the high level of detail and the high multimedia vocation it is possible to obtain from a panoramic interactive view, allow to read minimal details and at the same time allows to produce easy to use and to interpreter visualizations.

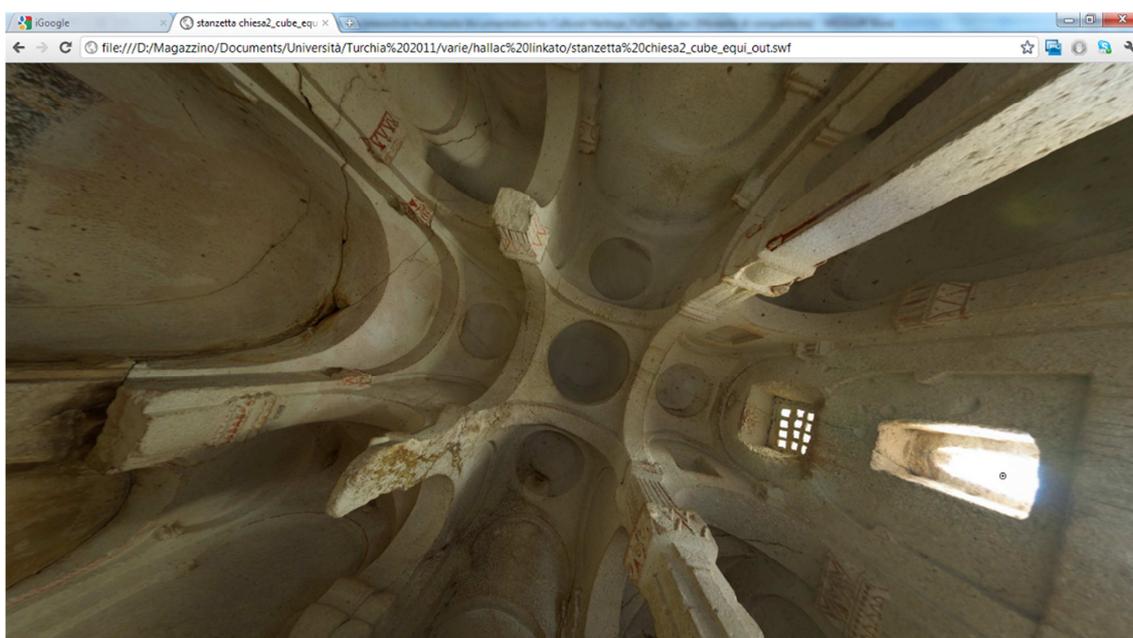


Fig. 3 – Panoramic interactive view of the Hallaç site, Ortahisar (C. Giustiniani).

Some software, exploiting the ownership projective of the photo, can recreate three-dimensional reality with a good visual surrender, allowing to appreciate quality environmental and single elements with sure effect and involvement. In this way it is possible to create full panoramic view, not easy to reproduce on paper, but really effective in the task to communicate the sense of a place using digital multimedia tools. The possibility to create "light weight" visualizations allow to bring this product directly on the Internet for sharing making them easy to find and to navigate. The Internet based approach of many personal devices allows the direct use of this kind of images directly on a netbook, a tablet or a mobile telephone.

### **Digital survey, main tools**

In the past ten years the number of solutions for digital survey is raised continuously, increasing the panorama of possible strategy in facing documentation and research opportunity. At the same time the digital survey tools have increased their performance characteristics and their reliability, renovating the overall approach to architectural and landscape survey. In this text it will be presented a short examination of this panorama, trying to spot over the main tools usable in a rupestrian architecture digital survey, underlining from a practical point of view the main benefits and issues of each technologies and trying to define a common methodology with a clear reference to the rupestrian subject.

### **Photogrammetrical survey**

The first phase of the digital photogrammetrical survey was mainly "traditional", with high quality results and an huge amount of case studies. Still today it can be considered interesting even if mainly 2D, it can be useful for large uniform fronts, which are not a common situation while working on rupestrian architectures. At the same time, the high time consuming procedures, required in the most of the time, can make it reasonable only in very specific conditions and with the right kind of subject. On the other hand, the following photogrammetrical three dimensional tools (those it is possible to call "digital classic"), like Photomodeler or Autodesk Imagemodeler made the difference between the previous approach and a new, more direct, set of procedure aimed to produce accurate results out of simplest photographic equipments and more "easy to use" strategies. The main strength of this first tools was the fact to allow a good level of interaction in the refining of the process, giving the opportunity to control a lot of features over the final result. The overall process was based on high quality but time consuming most of the time, requiring a lot of editing over the project to obtain nice looking and accurate models while an experienced user was at the basis of any streamlined results. Software like Photomodeler have a meaningful number of case studies about archaeology and rupestrian subject, but the quite complex process seems to make the more recent "digital automatic" tools as a valid and preferable alternative. The latest generation of this kind of software, like Agisoft Photoscan or Arctron Aspect3D, or the packages based on the freeware Bundler system, allow an almost automatic workflow with various options, some of them are "black boxed" (in the meaning it is impossible to set extended features), but they support very well both terrestrial and aerial shots, adding compliance with the use of multiple cameras and giving to drone/balloon shooting a great chance to become even more useful in the overall survey work. If the process operated by the user is greatly reduced, these solutions need meaningful hardware resources and a lot of time for computing. Thus this first series of

completely automated software are capable to offer good quality results for survey and multimedia, starting from common shots taken from any kind of digital camera.

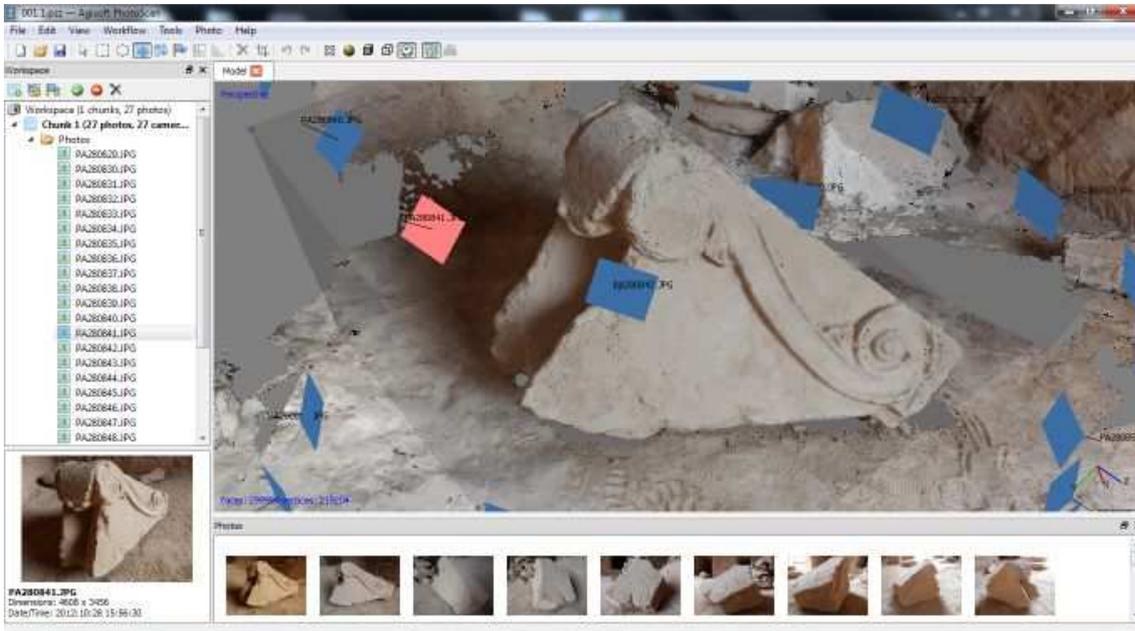


Fig. 4 – Photo modeling of a capitol ruin, using Agisoft Photoscan, Tombs of the Kings, Paphos, Cyprus (G. Verdiani).

A very interesting enhancement of these software is represented by the recent "online automatic" systems like Microsoft Photosynth or Autodesk 123D Catch. Using these tools it is possible to benefit from an automatic workflow with remote computing with very accurate results which are highly suitable for multimedia applications. The use of remote computing, in this case, comes out as a very interesting feature, allowing the production of great quality models, with full texturing, in a very short time in front of the time required for local machine calculation. The only odd features should be about the ownership of the project, while the access to this service using an online sharing system with not so clear contract with the provider of the software can create some doubts about who is the real owner of the models. Thus, the advantages of the online remote computing and of a very advanced freeware software, can be considered as worth the risk with some issues about ownership.

Considering the group of tools aimed to produce three dimensional texturized models out of pictures in a complete automatized way, there are some general characteristics to keep clearly in mind, obviously, being general, these characteristics are common to almost any kind of digital survey, not only those having a rupestrian architecture as a subject. First of all it must be known that the main factor to influence the accuracy is the size of the pixel. Well taken, deep shadows free shots are needed. Clear, easily recognizable features in each shot are fundamental to obtain a correct result. A very good or -even better- a full depth of field in the image can give excellent results, while the use of calibrated cameras can give a furthermore help, so it is always worth the effort trying to calibrate the camera before starting to use intensely this kind of tools (if the software offer this function).

Going to analyze some specific suggestions connected to the survey of rupestrian subjects, it is possible to divide them between the shooting in the outside and in the inside. For the outside it is important to consider:

take shots in the shortest time (to avoid any changes in the weather and/or in the shadows), prefer cloudy weather (to have very homogeneous lighting), try to take zoomed pictures also on the parts you want to have with a better level of details (but there will be the need to have certain common features between this shots and the others), when possible try to take "stereo" shots, some software, like Agisoft Photoscan can benefit from this shooting method. Avoid panoramic shots and prefer sliding positions during the shooting.

For the inside it is important to consider: pay attention to shadows, try to choose a moment of the day when there are no strong light stamps inside the caves/rooms. Always use a tripod to support the camera during long time exposure (quite common during internal shots). Try to have an almost "all in focus" shot (this will require to stop-down the lens reducing the light passing by and augmenting the exposure time, so the tripod will be even more a need). Add targets when needed (some targets will allow a more easy and quick correlation between shots. Don't forgive to take a series of shots toward the floor (this will enhance its rendition). Avoid single panoramic position and prefer to shot from the perimeter to the center of each room. Try to have a good (1/4) image overlapping between pictures. Try to use well known lenses, this means that very new and recently distributed cameras and lens can give some more trouble in being implemented inside these software, while a little bit older camera and lens will be fully supported in the most of times.

### **Laser scanner survey**

The laser scanner units has seen a great evolution in the past ten years, their main vantages are: they offer a fast survey of very complex elements, allowing a complete coverage of the subject in a very short time. At the same time they allow a high accuracy of the gathered data which will be easily compliant to the overall workflow in the survey plan. At the same time this kind of tools may be afflicted by some troubles: first of all the laser scanner survey will be always in need of right choices and this can be supported only by well-prepared operators. At the same time the weight of the instrument and its battery autonomy will constitute a meaningful point in the managing of the survey mission. Working on rupestrian architecture, very often the operator will be in the need to climb, crawl, and access not comfortable spaces, often totally lacking in power supplies, so the use of long term batteries and low weight tools can revel as a right choice to avoid slowing down the overall survey mission.

There are two main well known measuring technologies in laser scanner measurement: the Time of Flight and Phase Shift. Both are quite well diffused and now a day they both offer good quality and excellent results from the close distance to very far targets.

The very first laser scanners had a fixed angle for their measuring field, but now all the scanners offer partial or full panoramic measurement field. This first machines, like the now discontinued Leica HDS 2500, can be considered interesting for teaching and tutorials (if still working fine) but really not suitable for serious survey on a rupestrian architecture, except being interesting for medium long range scanning (like the external parts of a ravine). Their super heavy weighted structure, the longtime operations, the fact that this tool is not suitable for internal parts of a cave and the need of a huge topographical work to produce a good result in the alignment of all the scans create the condition not to consider them as a possible tool in any rupestrian survey intervention.

Obviously the things change with a panoramic laser scanner based on the same Time of Flight measurement procedure. Three main samples: first of all the Leica Geosystem HDS 3000/Scanstation will

have on its side the positive factors of good accuracy, reliable construction, long range measurement, while in the odd features it is possible to enumerate: the heavy weight, the fact that the dome is scanned in 2 parts, and an overall quite slow performance when the scan is done with a high density of points. Second, the most meaningful evolution between the Time of Flight solutions: the Leica Geosystem Scanstation C10 capable to offer good accuracy, reliable functions, long range measurement, compact body and very complete system with the possibility to add GPS positioning system and other accessories to the basic measurement unit.

The C10 probably represent the Time of Flight at its limit, but at the same time it can be not so compact when needed. Third, but not the last the Riegler LMS-Z420 (and similar models) represent a modular and versatile machine, reliable, capable of a very long measurement range, at the same time it's not completely panoramic field of measurement, the large and quite heavy body, and the accuracy not always at the best in front of the other models reduce its effectiveness in an inside survey, while the just mentioned "long range" allows to get scanned parts at a landscape level.

Operating on a rupestrian architecture there is no doubt how a Phase shift laser scanner like the Cam2 Faro Focus or the Z+F 5010 can be able to offer a superior performance in this context according to its very fast measurement process, it's a very compact modular system, very Light Weight and its possibility to work great in small to large inner spaces. There are few features to check when using this kind of tools, like the results obtained on the long distance which can result not so good, complete and trustable as those gathered from a Time of Flight system. And last but not least, because of the ease of use and fast operations it is even more important to plan the survey campaign to avoid the over measurement of the subject.

### **Topographical and GPS survey**

Targets are fundamental for any serious Laser Scanner survey, and the best way to create their network is a topographical network, this is to be considered as a fundamental part to support a correct Laser Scanner survey. The target network will also allow a better timeline in Laser Scanner survey and will be a fundamental element to reassemble this kind of survey in time.

One practical note: targets are quite expensive, but it's not that difficult to produce them, so it is always possible to face even a large network with an appropriate number of targets.

Using a target network in Laser Scanner survey will bring the following benefits: reduced overlapping in scans; isolated elements can be aligned; reduced post processing time; more solid overall result.

The use of an integrated GPS survey can help to geo-referencing the scans, so it can be a great help when it is fully integrated in the Laser Scanner unit or in the total station. In this way, separate scans like those it may happen to take from the opposite sides of a valley, can be aligned in the same reference system with a meaningful reduction in the need for complex topographical network. At the same time the use of portable GPS units can be an efficient support to all the survey operation, creating tracks of all the operator movements around the survey area and allowing to place some waypoints on isolated elements for further reference.

### **Suggested solution for a complete rupestrian digital survey**

Rupestrian architecture is deeply linked to the natural environment, so a robust network based on a topographical and/or GPS survey should be the basis for any further survey, overall it is possible to plan an

integrated survey according to the following division of areas: For the landscape a time of flight scanning (with a specific preference for the time of flight scanning where the best choice on market seems to be the Riegl long range models) or 3D Photogrammetry using a drone or a balloon camera can produce a high quality result with a well-planned survey campaign. Both the choices can be enhanced if integrated by a GPS unit, creating the conditions for being the base of the overall geo-referenced alignment.

The surrounding environment of the rupestrian architecture can be documented using the same tool used for the inside scanning, trying to have a common reference system of targets between the inside and the outside and linking it to the landscape survey.

For these two steps there is no doubt as a phase shift scanner can be the best choice and according to the needs about weight, autonomy, size and need for quickly modifying the setting of the scans while working, the use of a Cam2 Faro Focus is for sure the best choice on market while working.

The extremely compact design of this scanner largely helps all the operation on rupestrian subject especially in the interiors and in the surrounding area where the need for articulated maneuvers (like crawling in a tunnel, using ladders or ropes to access some room) is more than frequent.

To complete the survey, when needed, it may be worth the effort to take some specific survey of architectural and artistically realized details from the inside, if high quality traces are remained in the carved spaces, it will be really the case to take high quality survey of them, for this task 3D photogrammetry or high accuracy scanner can be the best choice, their link to the overall survey can be easily resolved using geometrical features.

To complete and to coordinate the whole work a correct Topographical Network and/or GPS Network.

### **Photographic survey, from the panorama to the details**

As an important operation conducted in parallel with the metric survey it is always fundamental to produce a complete and detailed photographic campaign.

The common digital photography is the best efficient way to complete this task, but in a complex situation like the one of the rupestrian settlements a complete set of tools is always needed.

A good quality digital SLR seems to be the best choice, but it might be equipped with a complete set of lens, from a meaningful wide-angle to a near telephoto (or even a real telephoto lens, useful to spot over landscape emerging elements), a good "macro" lens can be useful to get detailed shots of a fresco and of the stone surface. A solid tripod is always needed especially when shooting in interiors.

A set of low weighted lights can be useful to balance the natural light in a cave, but a single flash will rarely be a successful choice, so better to have at least two triggered flashes to allow a full and homogeneous light coverage. The photographic survey can be the occasion to produce meaningful multimedia product, like some panoramic shots.

The technical needed for this kind of shooting is a little complex and to achieve a professional result a specific -panoramic- tripod head is always required (there are various solution on the market, from classic fully manual tools to completely automatized), this type of heads can be setup according to the camera and lens in use allowing to preserve a correct position in every shot with further benefits during the panorama reconstruction. This kind of shot can be highly spectacular, but to have a good quality in the final result a

certain skill and a long time shooting (with multiple exposures and long time exposures in the inside) is required.



Fig. 5 – Fisheye view of the “Mago Griguro” cave in Massafra (TA), Italy.

## Conclusions

The digital survey of rupestrian settlements must be faced in a complete multi-purpose way. The base to operate it correctly is a clear planning before the beginning of the survey.

The choice about the tools to use and a well prepared group of operators is essential to guarantee a well working result. The right choices in aims and final use of the survey are quite important but can be planned even in a second time if the resulting survey is really versatile and complete. The post processing of the data is always a meaningful part of the whole workflow, taking a large part of the overall time needed for completing the survey from the measurement to the final drawing and multimedia product.

Even if this article has not enough space to produce a general analysis of the subject it is possible to identify in a gradual post processing (producing various steps from the pointclouds to the surface modeling and texturing for multimedia purposes) one of the best way to fully use the data coming from the digital survey<sup>2</sup>. According to our past experience the best way to approach a monument is to face it with correct tools, the large use of digital survey and of advanced digital photography today represent a double effective tool to document and disseminate a large set of information about a place.

<sup>2</sup> G. Verdiani, Il ritorno all'immagine, nuove procedure image based per il Cultural Heritage, Lulu.com, 2011

Thus, panoramic photography and digital metric survey are not similar at all, nor in the procedures, nor in the kind of result, they are absolutely different, but both, if used with intelligent will can bring to the production of precious and easy to use multimedia products.

This kind approach will produce in time two great versatile results: first of all the dissemination using multimedia web based systems of the images of the rupestrian settlements, making even more interesting, complete and desirable the direct visit to these places not only as simple tourists.

The second and important result will be the one to contribute to the overall documentation of these important and impressive monument, preserving a rich and detailed image of the realty as it was at the moment of the survey. This will be not a melancholic issue, it's a point of strength to allow preservation and possibility of intervention if any destructive evolution will come in time.

So with this articulated approach it is believed that a complete survey of this fragile and in risk of loss monuments can be correctly documented to keep at least a detailed memory of this impressive part of the human history.

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