The city plan as an information system The example of the Middle Islamic city of Qalhât (Oman)

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Abstract: The approach used for the making of elevations at the archaeological site of Qalhât (Oman) with the help of a DGPS and aerial photos demonstrates the efficiency of the methods and also how the archaeologist should use resulting plans as an information system. The results produce a system which takes into account the heterogeneity and the gaps of information which are inherent in archaeological data. In addition the qualification of the information obtained in the field produces a reliability map. While the geomatic tools offer flexibility for the composition of the cartography, they also offer the possibility of intuitive perspectives: they allow to capture archaeological reality of the town with the prospect of dissemination to a wider public, as well as a scientific approach.

Keywords: information system, archaeological survey, update, reliability, Qalhât.

Introduction

For ten years French archaeology has been developing the use of GIS tools, but they remain marginal. Archaeologists are familiar with data sets (Joliveau, 2005), being obliged to save information that tends to disappear because of human activities or are destroyed by investigations themselves (excavations). Thus archaeologists have always been producers of maps and plans. There are several possible reasons for the reluctance to use GIS tools. Procedures for obtaining plans or maps have already been in existence for a long time, and were giving satisfaction. Moreover, common logic itself leads to produce detailed inventory maps, more than thematic maps. Thus automatic mapping capabilities of GIS have not been motivating their adoption. Similarly, ways of spatial analysis initiated by geographers, taken over by English and American archaeologists in the 1970s (Clarke, 1977, Hodder *et al*., 1976) had only few echoes in France. Although there have been notable exceptions (Van der Leeuw *et al.*, 2003), the potential of GIS for that purpose has not been fully understood.

This statement must be moderated: since the early 2000s, the community of French archaeologists using GIS has been expanding. This movement was accompanied by the creation of exchange networks, like the ISA network (Spatial Information and Archaeology, http://isa.univ-tours.fr/), which helped archaeologists to meet and share experiences (Barge *et al.*, 2004, Rodier , 2011).

On the site of Qalhât, our work was influenced by particular conditions, which led us to develop new methods.

Qalhât is one of the most famous cities of the Middle Islamic Period, located at the tip of the Arabian Peninsula in the Sultanate of Oman (Fig. 1).

Fig. 1 – General view of the site of Qalhât

This strategic and unavoidable place of commerce of the Hormuz kingdom during the XIII° to XVth centuries, was destroyed a first time by an earthquake in the XV° century, and a second time by the Portuguese in the beginning of the XVI° century (Rougeulle, 2010). To study and develop this part of their national heritage the Omani authorities decided in 2008 to entrust Axelle Rougeulle, from the French CNRS (UMR 8167) for the first exploration of the town.

Extending over a surface of 35 hectares, the site is located at the foot of high mountains, in front of the Indian Ocean. In addition to these natural protections, it is surrounded by large fortifications, protecting the city and its port. A. Rougeulle opened several excavation fields, which brought answers to questions of chronology, material culture and trade networks. The building of a GIS was also one of the main objects of the project but the large size of the site and the difficulties of ruins interpretation forbid to use traditional methods of mapping for studying the urbanism network of Qalhât.

To map the city including topographic data and a drawing of each building, we used a composite method based on the use of aerial photographs and Differential GPS. Especially, the map was considered mainly as an Information System, structured in a GIS. The main principle was to gather raw data in the field, and from them to construct a model able to evolve according to the advances of research. Conceived in that way, the information system not only allows to generate several types of cartographic representations of the site, but also enables evaluation of the reliability of raw data and provide transparent interpretations.

Acquisition methods

A Differential GPS was used to determine the layout of visible structures. This was easy in sectors of low concentration. However, in the central quarters of the city, remains were too entangled, and looked just like huge humps of stones (Fig. 2). But often, what seems incomprehensible seen on the ground appears more clearly seen from the sky.

Fig. 2 – Left: View from ground level of the city center. Right, aerial photography showing two kinds of building's organisation: on the left, with loose planning, on the right, densely built (city center).

For this reason a camera carried aloft by a kite was used, operating by remote control to take aerial pictures (Sanz, Barge, 2005). Markers were set on the ground, easily visible on pictures, for enabling geo-referencing. Through photo-interpretation, we were able to outline visible buildings, although sometimes only roughly. In a second time we verified these determinations on the ground. In many cases, elements that were not linked on the ground appeared to be parts of similar structures when mapping with GPS (Fig. 3).

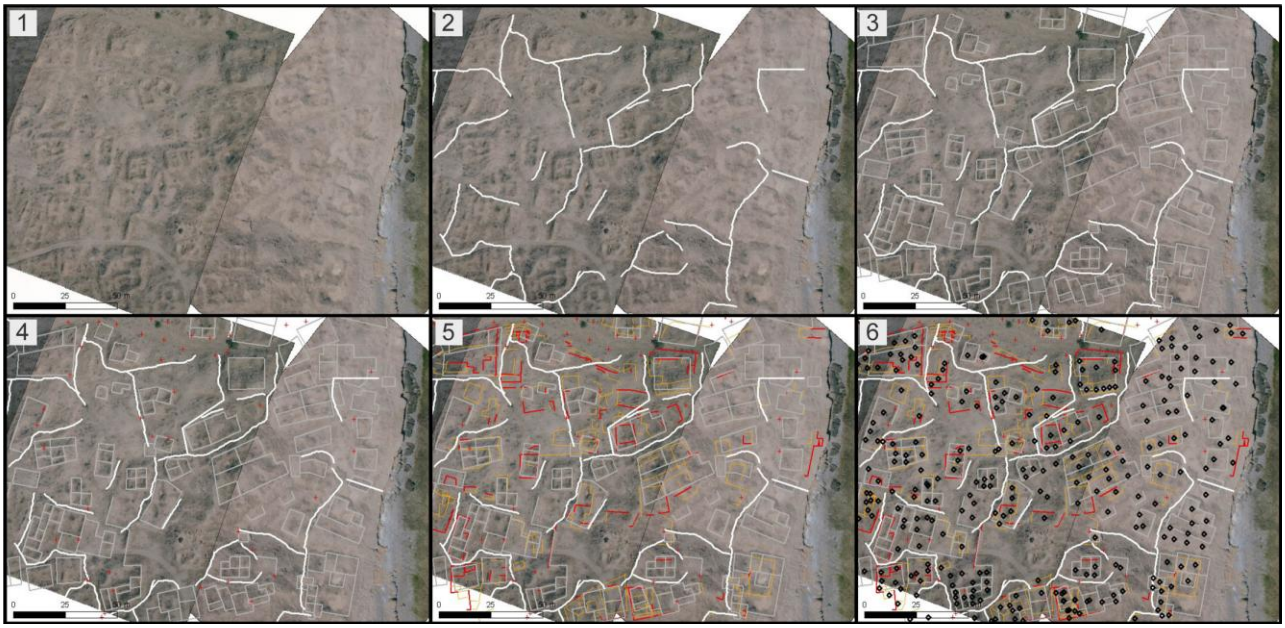

Fig. 3 – Work on city center step by step: first, aerial kite view, geo-referenced. 2, with DGPS, street recording. 3, the visible structures on the picture are digitalized. 4 and 5: back on field, control points, validation or correction of each structure's map. 6: taking points "id_space" in each space delineated.

This composite method enabled the city map to be completed step by step. In comparison with the use of a tachometer, that is traditionally employed, aerial photographs allow to progress from general network analysis to particular spacing identification. Then GPS allows a geographic representation of these interpreted remains. It has the advantage of being coupled with a field notebook where a description of each element can be recorded (for example the width of a wall and the size of its stones, Fig. 4). Indications that add to the reliability of the element and that can be mapped.

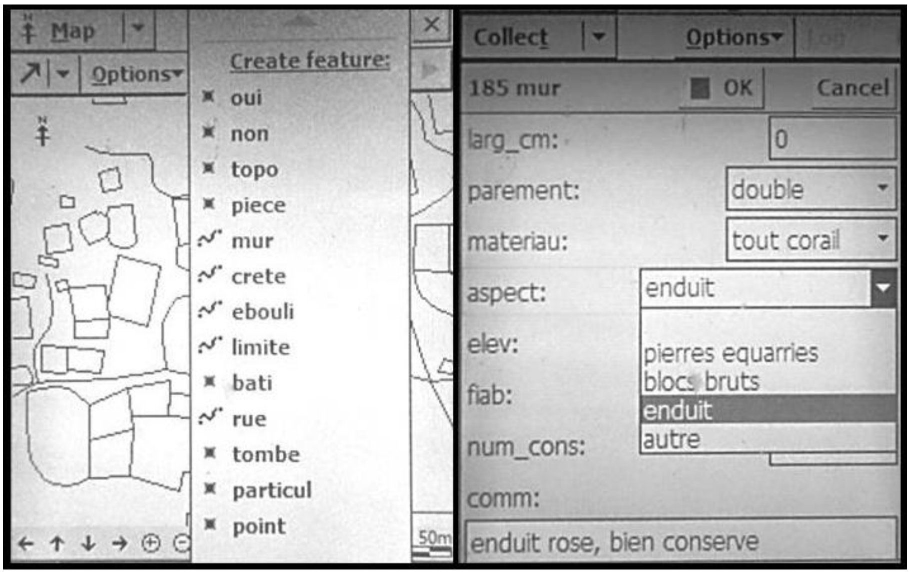

Fig. 4 – Field notebook on the Trimble DGPS: each entity is described inside a data dictionary before designated.

The use of a field notebook allows the map to be instantaneously drawn in the field following the process of seeing and describing structures, a valuable aid that cancels the necessity of a preliminary sketch. Moreover, traditional method of archaeological mapping saw the plan as a drawing. There was a single reading of the terrain, given as exact, and this reading was frozen in the result. Here instead, we generate a raw data set from which it is possible to create several interpretative maps leading to in a living information system.

Data structuration

On the field, with the GPS, walls and edges were recorded to enable delineation of buildings. Edges are suggested by indications such as a break in the slope or a change in the texture of the soil. These traces are not necessarily joined. A point “id_space” taken in the centre of the outlined space enables recording of the type of space and its height in relation with the whole building.
Besides, traces seen in the aerial photos, once validated, are assigned to a feature class, called “bld_pict”. Again, a point “id_space”in the center of each outlined space will be taken to record information about it.

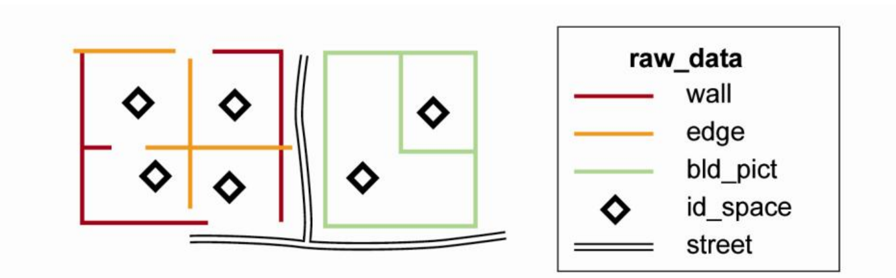

Fig. 5 – Data structuration: a first DDB contains exclusively the raw datas

All these elements are assigned to a feature dataset called “raw data” (Fig. 5). These are crude field data, which will not be modified. They will be used to feed other feature classes called “spaces” which belong to a feature dataset called “model”: the latter can evolve. It will enable the outline of polygons that are integrated with their attribute data of the identifier “id_space” (Fig. 6).

Several contiguous spaces form a building to which a number is assigned. Terraces are particular spaces that may be situated within a building (they are private) or outside a building, (where they are public). These terraces play a large part in city spaces; they often were built to adapt to natural relief. The adjoining of these polygons is perfectly respected in a topology (streets for example which are connected in a network).

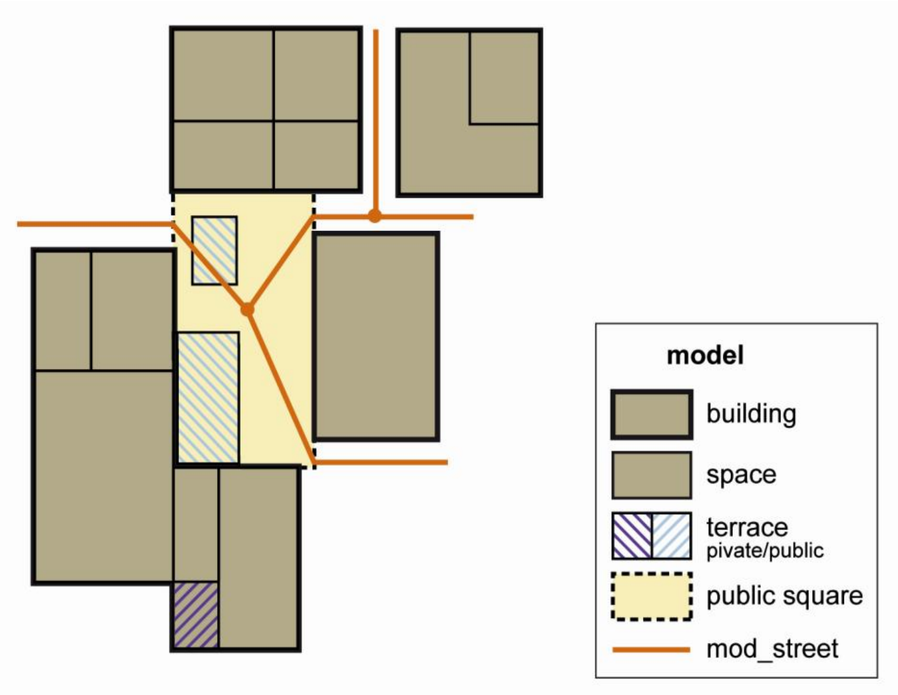

Fig. 6 – Data structuration: the second DDB outcome from de field datas is an interpretation

Map and its reliability

The information system structured in this way enables production of a city map, first according to the canons of archaeological plan. But the functionalities of symbol tools also enable production of other representations: the type of spaces identified in the field, or the functions determined by the archaeologist (Fig. 8).

The information system also allows for an estimation of the reliability of the plan. We have seen that some areas are simple and clear, whereas others are complex and hardly read. We have also used different feature classes, which reflect a reality that is well known, that is sometimes only probable, or that is even sometimes only “possible”.

There are two types of lines picked up with the GPS to define the buildings: walls and edges, the latter being less reliable.

There are also edges drawn on the basis of aerial photos, verified on the ground. For these, three levels of validity could be distinguished. In level 3, the geo-referencing of the photos is satisfactory and the traces are coherent with observation on the ground, giving a comparable reliability to that of “walls”. In level 2, traces visible on aerial views are less easy to be read on the field. The level of reliability matches that of “edges”. In level 1, traces could not be clearly verified, mainly because of the difficulty of reading the vestiges on the ground.

Thus from the point of view of reliability, a correspondence between the two types of lines (“walls” and “edges”) can be established, with 3 levels of reliability (3, 2 and 1).

A regular grid measuring 20 m per cell is then applied to the map. In each square, the accumulated length of the three types of traces is calculated, and the percentage of each type in each square is established. This enables sorting of the squares:

Those in which level 1 traces are predominant,

Those in which level 2 traces are predominant,

Those in which level 3 traces are predominant,

Those that contain only level 3 traces.

In this way a scale of increasing reliability based on 4 levels can be obtained and mapped (Fig. 7).

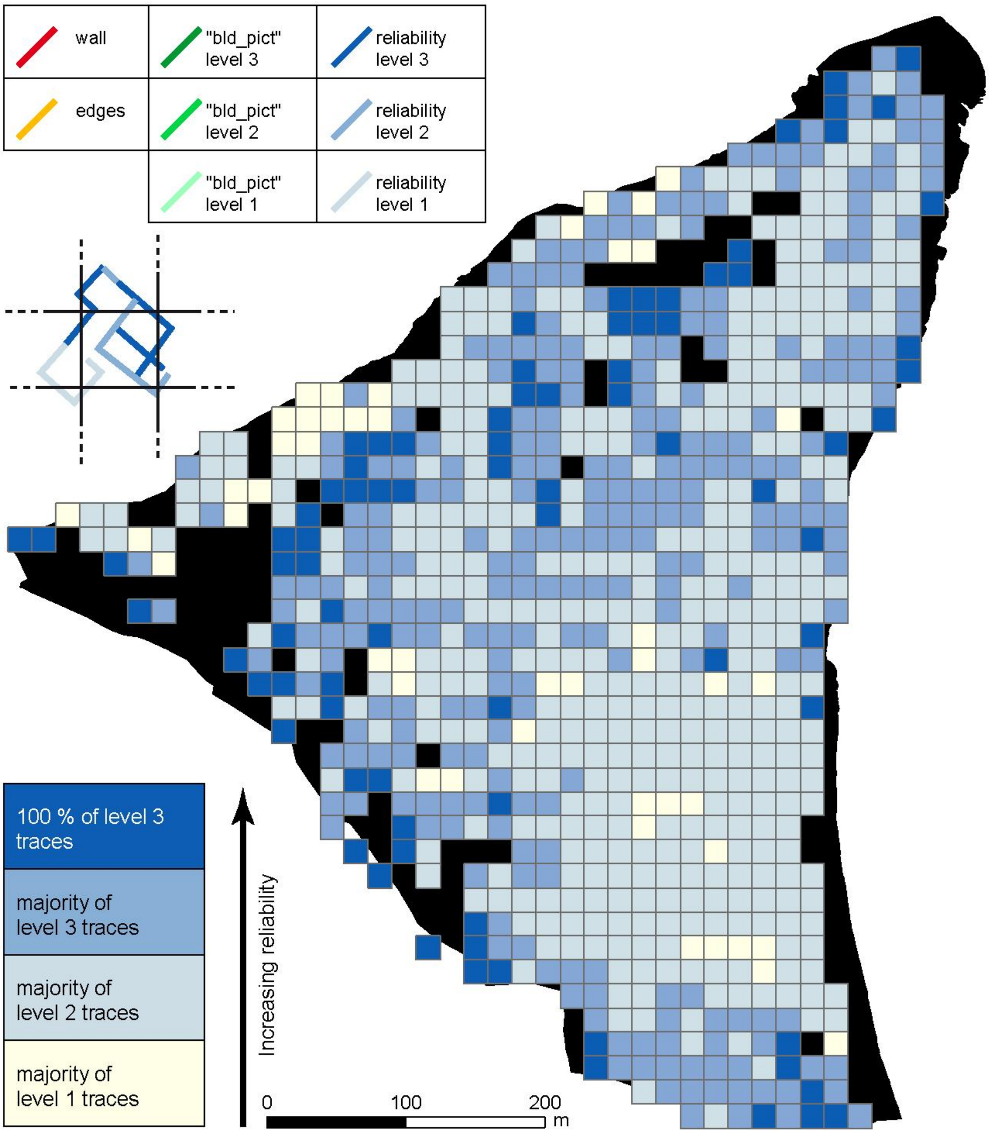

Fig. 7 – Reliability of the raw datas

The result corresponds well to the complexity of the terrain in that it can be understood intuitively.

This map enables the archaeologist to know the level of reliability he can attribute to the plan according to the sector being investigated.

Information system and its uses

The information system can also be used in other ways: without being a GIS specialist, the archaeologist can undertake an exploratory approach to the data by activating the display functions.

In this way, it is possible to develop the plan (Fig. 8).

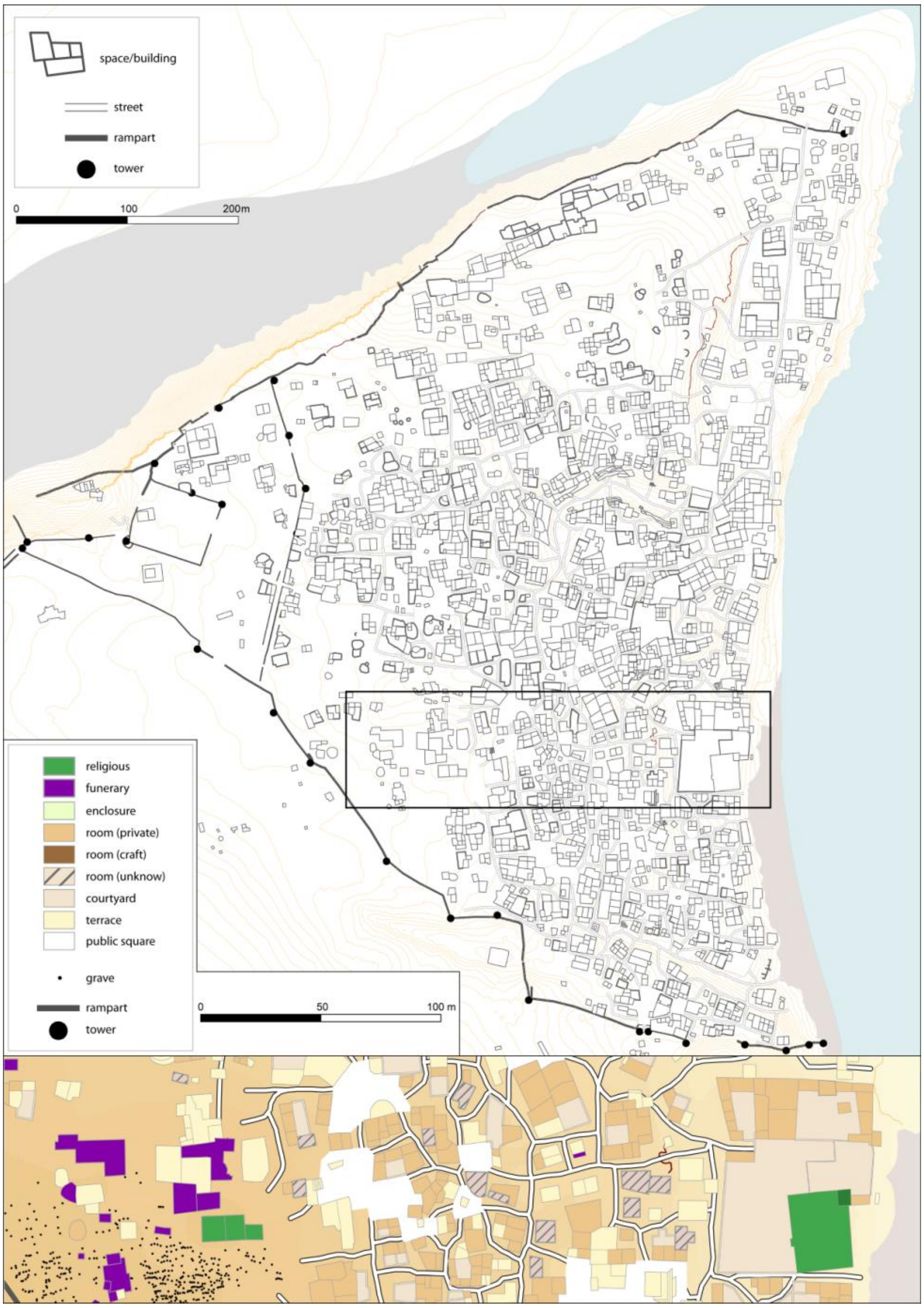

Fig. 8 – Map of the medieval city of Qalhât. Different possibilities of representations

In fact, the structures depicted on the plan are open to interpretation. They apply during the choice of the different traces of the layout, such as their continuation, to constitute the spaces of the model. It is always possible to superimpose the traces of the depicted layout and the model, and then to modify the latter according to a new interpretation considered to be more pertinent.

Interpretation also applies in the field. In this case, there is no longer recourse to the elements that led to the choices made; however, the attribute data recorded on the ground can be displayed when the recorded traces are doubtful (Fig. 9). In the same way, it is possible to modify or refine the plan, based on work carried out on a finer scale - excavation plans or plans of the buildings studied.

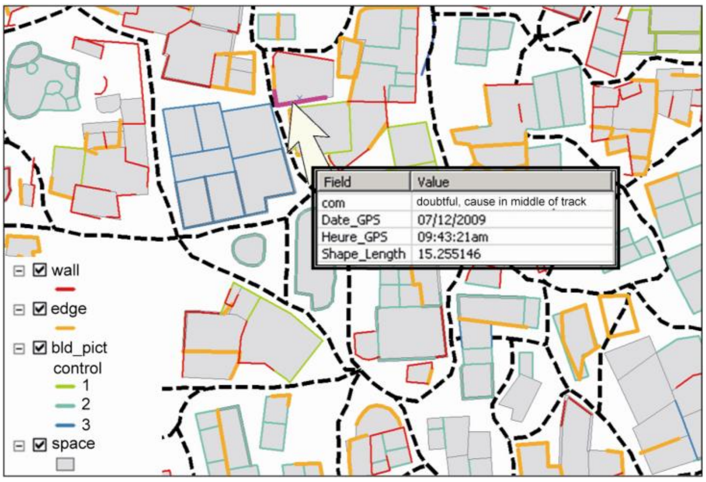

Fig. 9 – Building the model, it’s possible to go back to the survey conditions

The information system also enables proposition of 3D representations of the site. As we have roughly recorded on the ground, the relative height of each outlined space - 0 for the open spaces, 1 for the spaces whose cover of collapsed debris indicate a closed structure, 2 when the collapsed debris reaches a height indicating the existence of several storeys –, this height can be expressed by extruding volumes based on polygons. Images of the site can thus be obtained, quite rough graphically, but enough for a not specialist to have an idea of the medieval city (Fig. 10, Fig. 11). Indeed, it is not easy for a visitor to see any representation based on a field of ruins. Those views propose a representation that agrees with the information system, and thus with the state of the research (Fig. 12).

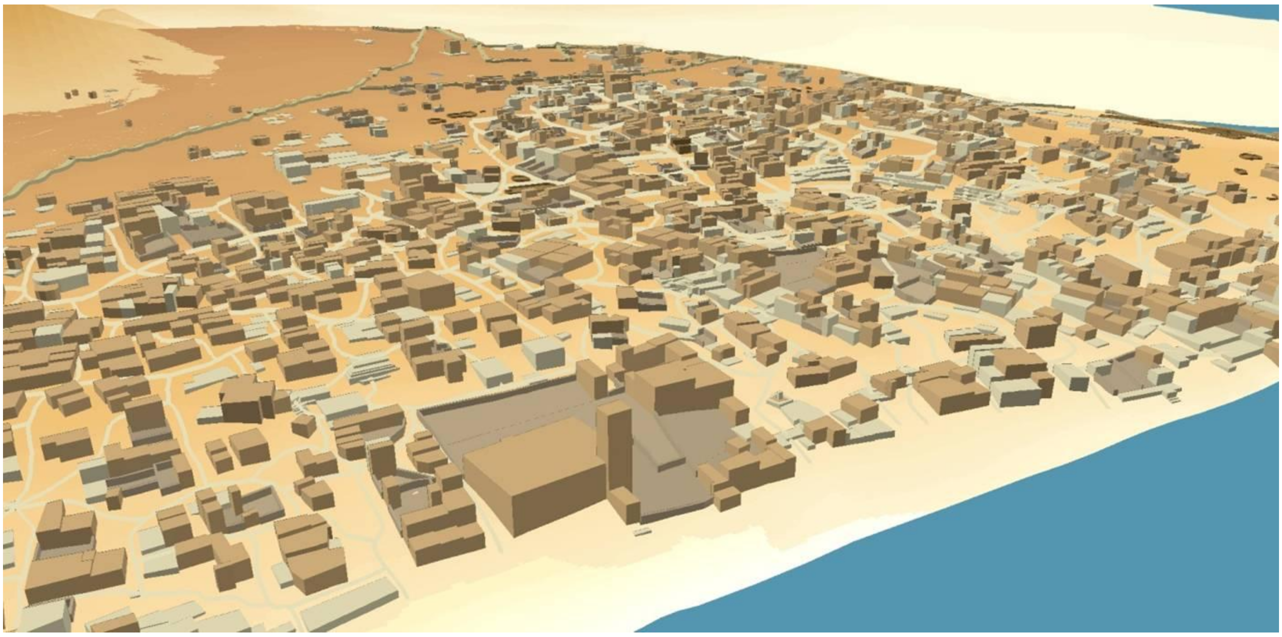

Fig. 10 – Percepective views are easy to produce with the GIS tools.

But these 3D representations go beyond being just useful for communication with the public. They can be used to back up scientific discussion, or even to stimulate constructive criticism; this enables understanding of the archaeological realities from an angle that is closer to intuitive perception. The hypothesis is that the 3D representations are perceived more rapidly and that they illustrate more concretely the urban plan reconstructed by the field work; thus they enable scientific discussion to be supported by evidence that is more easily perceptible, even dynamic, whereas the reading of a plan, even for an archaeologist, remains a technical approach and involves an abstract perception of the city.

Fig. 11 – Two sights from Qalhât: with kite aerial photography, and perspective view from GIS model. This type of layout is very meaningful for large public

In this scientific framework, as many views as models may be proposed, scenarios may be built and hypotheses put forward.
It's the same way for the updates of the data according to the advance of the knowledge of the site. So, it is easy to integrate the new plans of excavations which sometimes modify determinedly the aspect of buildings such as they had been perceived the first time. These data are added in the raw data of ground, and allow the elaboration of new models. Thus the transparency of the elaboration of the new plan from the raw data is always preserved.

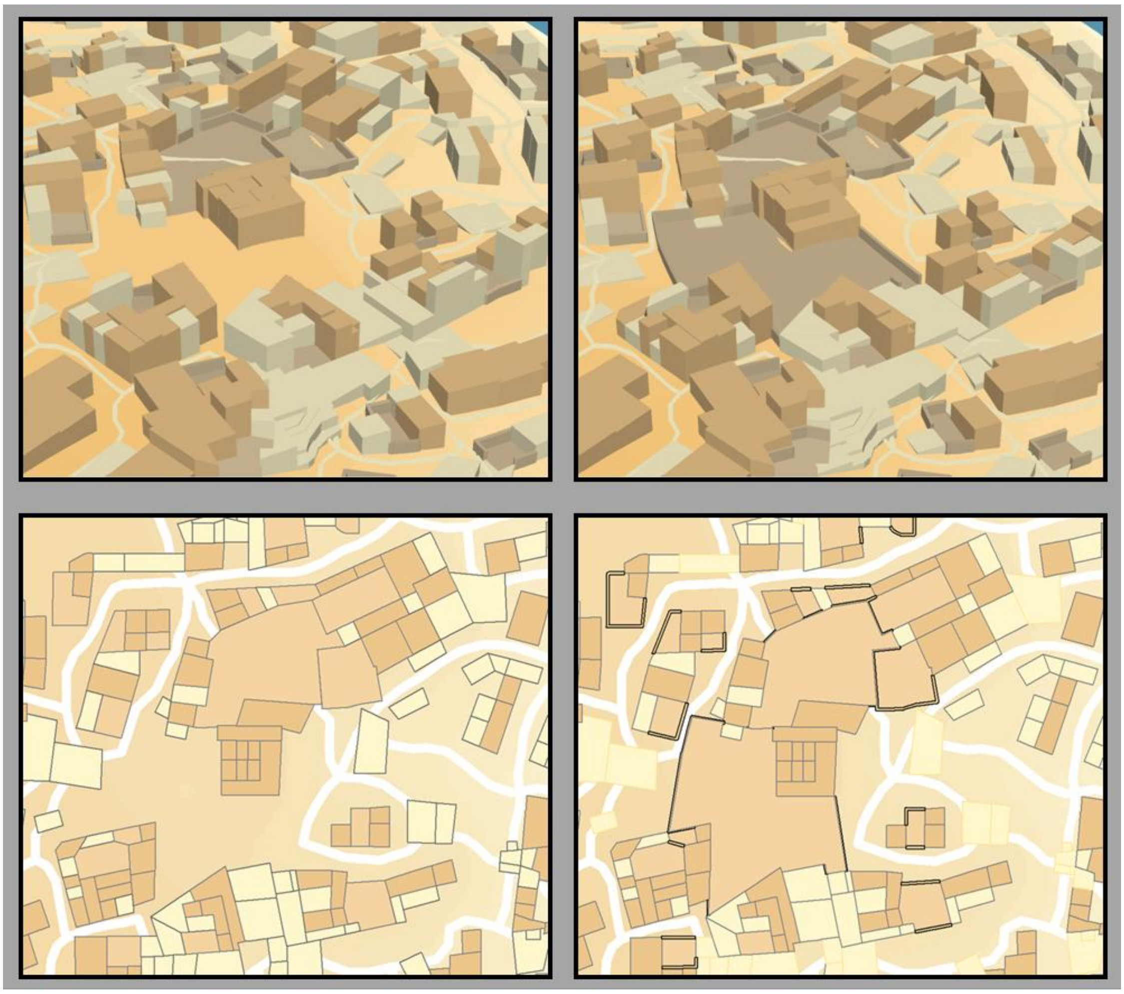

Fig. 12 – With excavations, the knowledge of the site refines: a new model is easily generated

Conclusion:

The survey method followed in Qalhât presents several significant advantages for archaeology.

The first of these advantages is the implementation of smaller time frames, thus reducing the cost of prospections. For instance, here, five weeks were enough to cover the site and its surroundings (about 60 ha). Moreover, apart from the Differential GPS, it requires a very inexpensive hardware for its implementation.

The second is to offer a new approach to the survey methods traditionally used in archaeology, at almost any scale. The whole point is to design from the outset the plan as an Information System structured in a GIS. Thus, several city map can actually be built, but this approach leads to a living tool that opens up to other types of uses. According to us, the interpretation of raw data transparent, unlike the implicit production plans, constitutes a great advance scientifically speaking. Finally, the updating and refining knowledge can always be included in the database and are, for archaeologists, a valuable support for reflection and sharing the progress of their work.

The potential use of this information system can be evaluated in the long term. Indeed, besides being a tool to the archaeologist, it has a place in the development of the site: this is a complete map database, useful for example in terms of tourism development plan of the site, in direct connection with the Omani authorities. It can also be used to produce images for explanatory scientific popularization: thematic plans, views and even videos bridleways.

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