Geomatics Techniques for Historical Buildings

Documentation and Restoration in Northern Jordan

Dr .Rebhi Damseh
Al-Balqa Applied University (BAU)

Project:
MEDiterranean QUadruple helix Approach to Digitalisation
"MED-QUAD"

Contents

1. Abstract

Historical conservation and restoration is an important issue for heritage structures, this research aims to develop heritage building information model (HBIM) for (**Klaib Basha Saraya)** in northern Jordan. In Jordanian Heritage Management, such models are still regarded a long way from becoming a well-established and widely used technique. Using terrestrial laser scanning technologies, the project will bridge the gap between historical documentation and historical building information modeling. HBIM was created with parametric pieces to reflect the study area's structural, functional, architectural, and historical aspects. The model also incorporates 3D geometry as well as non-geometric data like materials, appearance, and condition. This model also incorporates historical and architectural aspects, as well as style and age. It is recommended that a numerical reconstruction model of the citadel be created in order to check for any potential structural instability. In addition, it is suggested that a documentation effort be started to encompass Jordan's other significant historical and cultural sites.

2. Introduction

This paper will emphasize the importance of the documentation of architectural heritage as a product of the experience of intellectual creativity of human societies across different civilizational eras, Its role, and capabilities to achieve personality and civilized identity in the city of the twenty-first century. because of its national, historical and artistic value and the positive outcome it constitutes, effects on sustainable development plans in contemporary urban community’s Historic preservation treats historic buildings in one of four ways: preservation, restoration, rehabilitation, or reconstruction. No matter which treatment we ultimately choose, we must first

documentation assess the building historic structure to understanding how buildings were constructed, used, and maintained.

restoring existing buildings nowadays and especially heritage buildings is increasingly the subject of research. So, the need to renovate and document cultural heritage has become more important than the construction of new buildings. With technological progress, new technologies and programs allow for a change in the construction industry by helping Heritage Building Information Modeling (HBIM) to transform buildings into structures capable of providing information regarding the building throughout its life cycle, and facilitating the sharing of information between engineers, professionals and specialists, with the consequent provision of in time and cost. This thesis aims to present a key to changing the way the construction industry is perceived, using a case study to document for (Klaib Basha Saraya) using Heritage Building Information Modeling (HBIM) methodology. The methodology used to obtain the 3D model will be described, starting from topographic and photographic survey data and from searching archival documents in 3D modeling of historical building by Terrestrial laser scanning (TLS) applications.

2.1 Terrestrial laser scanning (TLS)

Terrestrial laser scanning (TLS) applications has been promptly growing in different fields since decays. Nowadays, the three-dimensional (3D) technologies are used widely in many different applications around the world; it is commonly used in roads maintenance and management, urban planning and modeling, industrial surveying and heritage conservation (Guan et al, 2016). Commonly, the output of such systems is so-called point cloud which a huge set of data represents the scanned points of the object

carrying different information such as coordinates, backscatter intensity and color of the scanned object (Rosell- Polo et al., 2019). Working with point clouds provides many processing options such as classification of the objects in different classes, creation of cross sections and profiles, making measurements and extraction of specific objects (Kwoczyńska et al., 2016). Laser scanning is an innovative technique for rich accurate data collection and digital visualization used to capture forms in faster and greater details (Greenop and Landorf, 2017). Terrestrial laser scanning (TLS) to visualization and processing of a point cloud allows cross-sectioning, parts isolation, parts measuring and visualization for all sides to all parts which is perfect for best documentation. Terrestrial laser scans is very practical in the documentation of very large objects such as a huge church (Kwoczyńska et al., 2016), or very small objects such as jewelers in a very short time. The use of the TLS is expensive for small scale and very detailed documentation but it is the best solution.

Accurate surveying and modeling for documentation of very detailed objects is done using laser scanning technique which is extremely fast to provide all the details using the needed intervals to complete the job. It is used to in particularly for historical and precious objects documentation as accurate as it needs. It can provide the details with high accuracy in three dimensional forms (x,y,z coordinates). Then using the proper software, the surveyed point cloud will be modeled and the close to reality form will be built for exact and accurate documentation of the objects. Moreover, it allows real color documentation and the gray color scale (Altuntas et al, 2007). Terrestrial photogrammetry and traditional recording methods for heritage documentation are not appropriate for some objects but Laser scanning is more appropriate for 3D surveying and provides large amounts of points in a short time (Gruen and Akca, 2005).

Nowadays, laser scanning is extensively used in 3D modeling of historical buildings, but managing historic buildings is mainly faced with complex decision-making process due to limited or unavailability of reliable information (Ali and Ismail, 2019).

Managers will be able to have faster and efficient process when it comes to making crucial decisions in managing problems. BIM approach, which emphasizes on the digitization of information, is believed to have many unexplored potentials in the area of heritage building management. Conservation of historical building is an important, hard and expensive process which employs state of the art technologies and consists of two different parts; documentation, and refurbishing (Cheng et al, 2015).

Tourism industry is very important and creates a major income for the economy of some countries. History and culture need to join the digital world for conservation, animation, reality augmentation, etc. For digital documentation and virtual reality 3D laser scanners are used and point clouds are created. Meanwhile, historic building refurbishing engineering with heritage conservation is the real need and future challenge. Historical sites reconstructing is easy but to restore real cultural heritage is the future. 3D digital cultural heritage models are widespread and used to accurate and efficient documentation of structures remotely, which was impossible using the old surveying methods, in addition to excellent digital information systems capabilities for presentations, analysis and archiving of all information related to these structures. The diverse data include historic texts, architectural information, archaeological figures, in addition to administrative data and past drawings, sketches, photos etc. The data include current situation to facilitate collaborative design and facility management. The metadata information model will allow the use of the Building information modeling (BIM) which is a planning, design, construction, operation, and maintenance process

for the life of a building (Cheng et al, 2015). The BIM will generate parametric model to convert the surface of constructed facilities to the desired model. Then BIM system combines these parametric databases to facilitate collaborative design and management.

2.2 Historic Building information modeling (HBIM)

'HBIM' (as Historic Building Information Modelling) was first mentioned in 2009 and defined as "a novel solution whereby interactive parametric objects representing architectural elements are constructed from historic data, these elements (including detail behind the scan surface) are accurately mapped onto a point cloud or image-based survey" (Murphy et al., 2009). The term has since been broadened to include the heritage environment generally, recognising a more complex set of historic and aesthetic values and the involvement of multiple stakeholders and disciplines.

HBIM appears to have the same potential as implementing BIM for the entire building lifecycle. . As the distinct nature of heritage buildings as cultural and community resources raises the question about what are the useful, relevant and important data for the building, which must be documented and evaluated for any future plans . And achieve integration between different disciplines of architects, engineers, surveyors, archaeologists and conservators (Godinho et al., 2020).

Applying HBIM to heritage buildings seems to be an opportunity to mobilise a proactive approach to management and conservation of the construction and its community value. HBIM can provide a set of information useful for condition monitoring, preventive maintenance, repair and restoration, but also for the management of visitors and related security and safety planning (Pocobelli et al., 2018). After defining the rules to be checked, the method for generating functions capable of handling the cultural data within a HBIM file is investigated, with a subsequent charter

of the Heritage Building. The analysis for (Klaib Basha Saraya) illustrates the critical points and the caution needed to conserve an efficient IFC export for structural code review. Using flowcharts, special emphasis is given to the investigation of the sequence of operations to obtain the information in a more efficient way for different applications of the HBIM.

The paper investigates to build a model of documentation of the heritage site by "Building information modeling". Furthermore, this study will collect and classify data from the cultural heritage site of (Klaib Basha Saraya) .Hencemay serve as a model to store, provide animate graphic and digital information of the cultural heritage .The BIM environment will fill the documentation gaps for the present and future. Overall this proposed plan will create a digital database documented with architectural plans and 3d model to provide animate graphic and digital information of palace can be adopted, as the concept of a repository, to provide a baseline to which more detailed information can be added in the future for any treatment with this historic building. and referred to for any future projects in preservation, restoration, maintenance, etc.

3. Historical Overview of Study area

The lineage of the Jordanian hero, Kulaib bin Yusuf bin Sharida bin Raba', is descended from the Hammad clan, which used to live in Wadi bin Hammad in Karak, in southern Jordan, and then moved north, like many Jordanian clans that moved in search of security and to escape oppression and injustice in light of the lack of a state during the period The Ottoman occupation, which was ruling the region by proxy, and things settled in the town of "Tebneh", which was inhabited by several other clans, a town in the "Al-Koura" district in the Irbid governorate in northern Jordan. Studies

conducted by researchers from the University of Toronto in Canada have proven that the oldest signs of human settlement The town dates back to the Stone Age, and the Koura Brigade is characterized by a distinct geographical nature, as it is surrounded by mountains and surrounded by valleys and intertwined forests, which made the attempt to control it from external forces a form of impossible.

The features of the leadership personality emerged on Sheikh Kulaib since his youth, as his guest house (Klaib Basha Saraya) filled him with guests and those who sought refuge with him. He forms alliances with the surrounding powers, to strengthen the rule and provide security that was lost at that time in the neighboring regions, and he succeeded in protecting the interests of the Koura and its people, who formed the backbone for the continuation of his sheikhdom and leadership and extended it beyond the borders of his region. figure 1 . show Klaib Basha House (Saraya)

Figure 1 Klaib Basha House (Saraya)

(Klaib Basha Saraya)

Kulaib re-used the guesthouse of his father and his ancestors (Al-Alali), which he turned into a prestige self-governing institution. The tyrant who was committed to his opinion, but decisions were taken with advice, which made the government firm and coherent in the face of all external attempts to destabilize it.

Thus, his guest house became equal to the strength and action of the Saraya, but rather surpassed it in all that it does and is distinguished by the institution of civil and legitimate government. It was also (Klaib Basha Saraya) gathered people of knowledge, literature and poets and served as an education center in the mosque that was built by Sheikh Klaib and attached to Saraya to be a beacon of knowledge and knowledge. Figure 2.. show An old picture of the foundation stone in Al-Saraya (Al-Alali) showing the date of construction

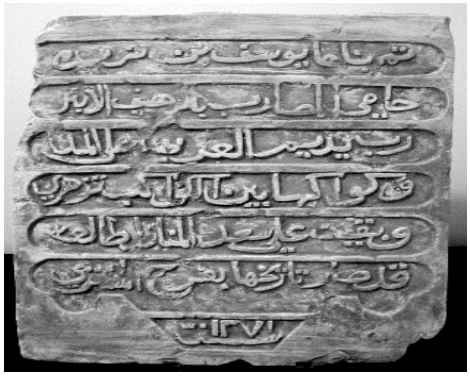

Figure 2.. show An old picture of the foundation stone in Al-Saraya (Al-Alali) sh owing the date of construction

4. Literature review

The visualization of the objects is very close to reality that it starts to be used for different applications. For Archeological documentation the technology provides the optimal suitable solution for its accuracy, ability for details and fast processing

without disturbing the objects. In turkey it is used in Konya Museum for tomb documentation (Altuntas et al, 2007).

Managing historic buildings is a complex decision-making process due to limited reliable information. The potentials of the (BIM) as a decision support system for cultural heritage management is proved to be of a great value (Ali and Ismail, 2019). The authors for their study on Istana Balai Besar Kota Bharu, focused on the changes of the historical building's layout to demonstrate the ontology. They used a drawing which was measured in (1976) and the latest TLS activity on the physical building to create a model in BIM environment, to track the information on the changes within a historical building to help in its documentation, preservation and management. They found that utilizing the existing data with the late TLS data (for 3D modeling) and the BIM, the managers will be able to store important information, retrieve and analyze efficiently with more productivity. The BIM is created to manage the construction industry but the finding made it very useful to support the cultural heritage management (Ali and Ismail, 2019).

Building Information Modeling (BIM) is a method of digitally documenting structures. Given the complexity of modern structures, laser scanning allows for quick and accurate building mapping. Building high-density scans will aid in the detection of the tiniest structural flaws as well as the building's serviceability, for proved efficiency it was used in documenting the construction process of a six stories building and proved its efficiency. Additionally, they used Potree an open-source WebGL based point cloud renderer (for point cloud data visualization) to render point clouds and visualize in a portable web application, which provides accurate measurements on the 3D model of the library.

Employing BIM for new construction is an easy task; however, applying BIM to existing constructions is more difficult but particularly suitable for heritage buildings (Baik, 2019). The heritage buildings have unique façades and architectural vocabulary which require advanced tools to understand their design. Digital representations will provide a complete image of any aspect of the project and accurate details with easy access and tools that can extract information professionally and explain the essence of heritage. BIM has emerged as an efficient solution for architectural heritage (Baik, 2019). Existing BIM is having the ability to operate within a digital database of any 3-D laser scanning and transforming it into point-cloud as digital data.

5. Methodology

The scan-to-BIM process involves three tasks (Tang et al, 2010): modelling the geometry of components, assigning an object category and material properties to a component, and establishing of relationships between components. In this study the used methodology to achieve the aims consists of the following parts:

1. Setting out the scanning plan: In this part the site is visually inspected and checked to determine the best locations of the scanning stations which provides full coverage of the site. The used laser scanner in this research has a 340 m range which affords wide range of scanning and reduces the number of scanning stations.

2. Data Acquisition: During this step the laser scanner transmitted one million laser pulses per second to form a point cloud of the site of 1.1 cm spacing. This dense point cloud enables the software to extract very accurate objects and measurements.

3. Point cloud alignment: The acquired point clouds from all stations were registered, a general point cloud was used as a reference station for the other stations to form a 3D model of the site as shown on Figure 3.

Figure 3

4. Optimization of 3D modeling (BIM): In this stage all structural and architectural members such as slabs, walls windows and doors have been built.

5. Advanced 3D modeling for design purposes using Total station: in this stage, total station linked with a reference point was used to measure the dimensions of the structural elements of the citadel.

6. Comparison between methods from precision and economical point of view.

6. Results 3D HBIM model

The final results are a 3D HBIM model and a 3D perspective section , then enriched with information , As shown in the pictures below in the figure 4\ 5\ 6\ 7:

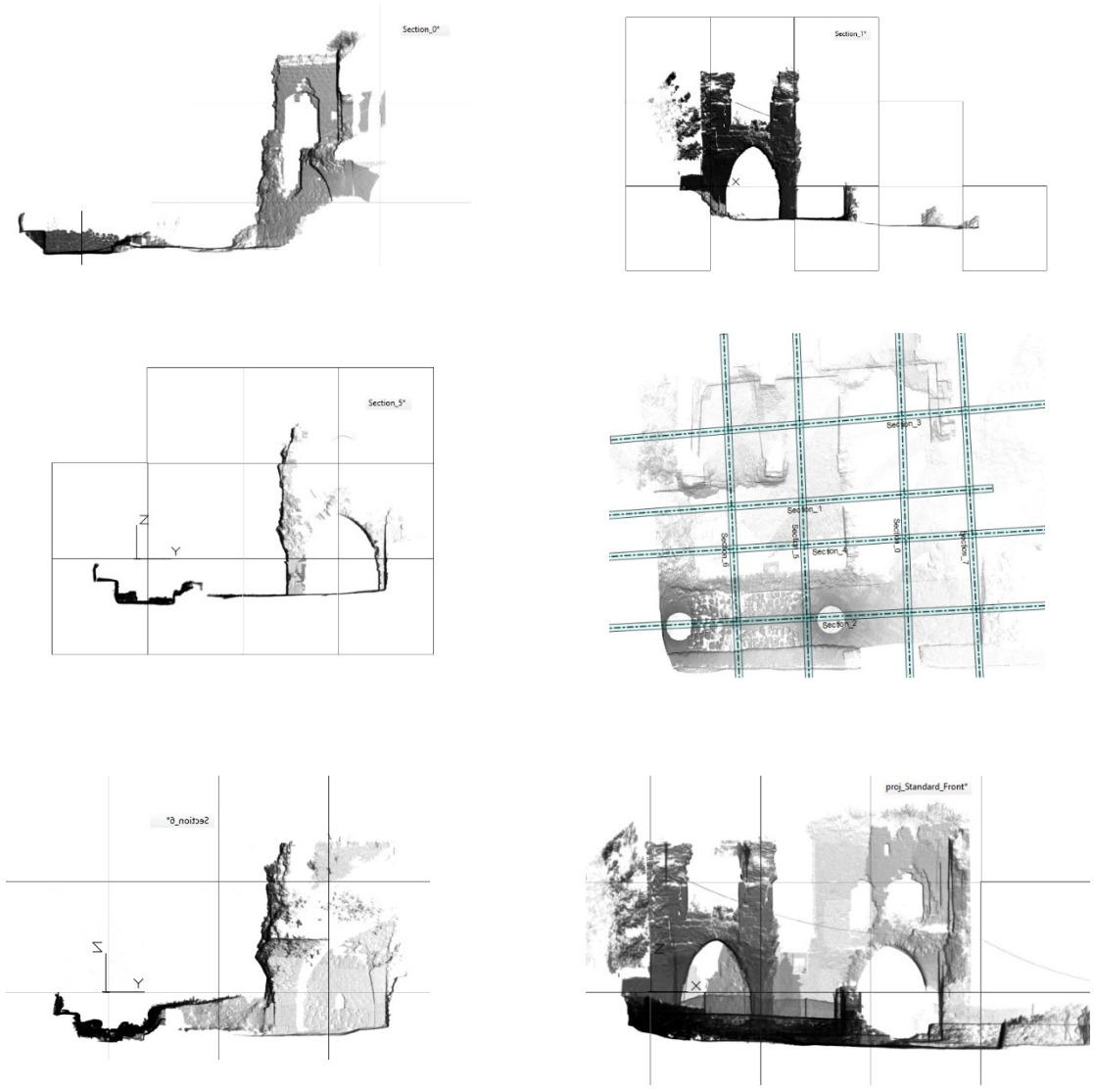

Figure 4

present a cross-sectional view of a three-dimensional drawing

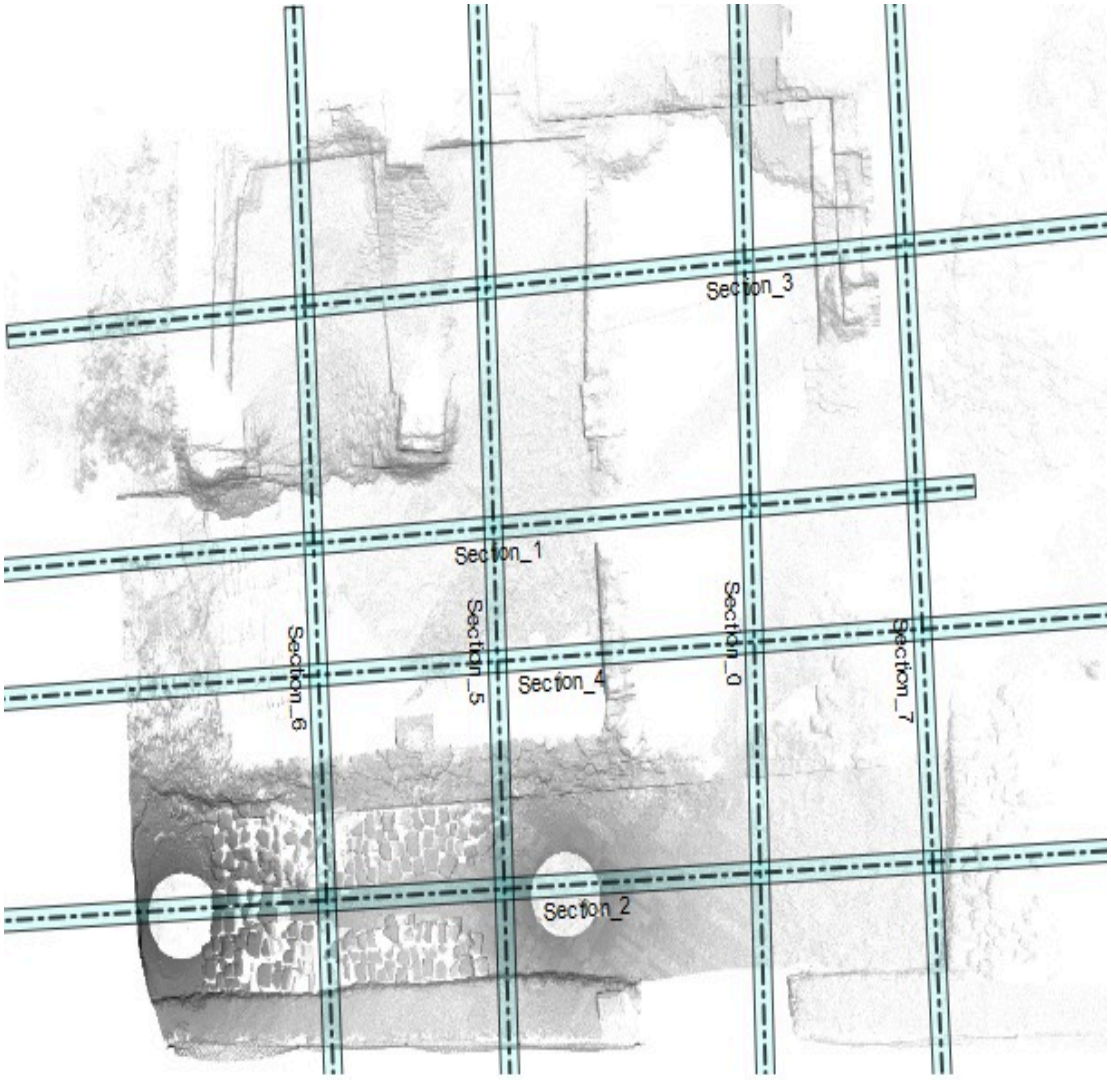

Figure 5 2D plans

Figure 6 show 3d Perspective of interior spaces

Figure 7

7. Conclusions and Recommendations

This research work shows high potential of new technologies such as laser scanners in order to document and quantify measurements of historical buildings. The work investigated this documentation using new techniques that are practical, precise, accurate and safe. It was possible to develop the HBIM process for the entire design of the work as this have taken a short time and less resources compared with traditional methods. The usage of BIM, on the other hand, provides not only for the organization of information that may be relevant to each situation, but also for the addition and modification of such information. The user may engage with the form and build a more dynamic process as a result.

It is highly recommended to have numerical reconstruction model of the citadel in order to check any possible instability in the structure. In addition to that, it is recommended to start a documentation program to include the other important historical and cultural places in Jordan using this technique and other techniques such as mobile mapping and drones.

7. References

Khalouf Ma. Lwis, (1975) Jordan, History, civilization and Archaeology, Arabic version, Amman, Jordan p. 123.

Rosell-Polo, J., Gregorio, E., Llorens, J. (2019) "Special Issue on "Terrestrial Laser Scanning": Editors' Notes" , Sensors,19, 4569.

Kwoczyńska, B., Piech, I., Śledź, J., Litwin, U., Obirek, P. (2016) "The Use of Terrestrial Laser Scanning in Surveying Historic Buildings". Baltic Geodetic Congress (Geomatics)
Gdansk University of Technology, 2-4 June 2016, Poland.

Guan, H., Li, J., Cao, S., Yu, Y. (2016) "Use of mobile LiDAR in road information inventory: a review" International Journal of Image and Data Fusion, 7(3), 219-242.

Ali, M., Ismail, K. (2019) "BIM Backed Decision Support System in the Management of Heritage Building". International Journal of Built Environment and Sustainability. 6(2), 63-71.

Kelly Greenop, K. and Landorf, C. (2017) "digital cultural heritage: FUTURE VISIONS" Papers presented at the digital cultural heritage: FUTURE VISIONS London Symposium13–15 November 2017 in London, United Kingdom
https://www.digitalculturalheritagefutures.com/london-symposium-november-2017

Cheng, H., Yang, W., Yen, Y. (2015) "BIM applied in historical building documentation and refurbishing", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-5/W7, 25th International CIPA Symposium 2015, 31 August – 04 September 2015, Taipei, Taiwan.

Altuntas, C., Yildiz, F., Karabork, H., Yakar, M., Karasaka L. (2007) "Surveying and Documentation of Detailed Historical Heritage by Laser Scanning", XXI International CIPA Symposium, 01-06 October 2007, Athens, Greece.

Gruen, A., and Akça, D. (2005) "Least Sequares 3D Surface Matching", ISPRS 2005 Annual Conference, Baltimore, Maryland, March 7-11.

Tang, P.; Huber, D.; Akinci, B.; Lipman, R.; Lytle, A. Automatic reconstruction of as-built building information models from laser-scanned point clouds: A review of related techniques. Automat. Constr. 2010, 19, 829–843.

Baik, A. From point cloud to existing BIM for modelling and simulation purposes (2019) ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences [online]. 2019, XLII-5/W2, 15–19. ISSN 2194-9034. DOI:10.5194/isprs-archives-XLII-5-W2-15-2019