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Space technology meets policy: An overview of Earth Observation sensors for monitoring of cultural landscapes within policy framework for Cultural Heritage

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ABSTRACT

A wide range of satellite sensors that provide potentially useful imagery for digital documentation, mapping and monitoring of archaeological sites and cultural landscapes. Although some satellites have stopped acquiring new data, their archived satellite imagery can still be accessed, downloaded and exploited for monitoring of changes and therefore useful for research domain of archaeology and cultural landscapes. The aim of this paper is 1) to make an overview of past and current satellite earth observation optical sensors useful for land monitoring, with focus on cultural landscapes and 2) to illustrate a policy framework that goes beyond recommendations, suggesting the need of valuable information possibly provided by the in satellite imagery. Paper will put focus on Copernicus programme as the most recent mission that provides imagery on the global scale and free of charge. Paper, furthermore, highlights the need for a more structured consideration of the contribution that space technologies services and products can offer to the non-space sectors. The actions for implementation of strategies regarding the currently renewed attention towards cultural heritage protection and management, could soon benefit from the technological achievements of satellite technologies in terms of dedicated operational services and applications, tailored to the needs of end-users such as archaeologists, landscape professionals, public administration, researchers and students.

1. Introduction

The first legal international instrument that recognises Cultural Landscapes, World Heritage Convention (UNESCO, 1972), defines them as a “combined works of nature and of man”. The document emphasises the characteristic of landscape as a container of natural and anthropogenic information deposited in layers over time, and requiring thus exhaustive studies of landscape. Furtherer, the publication “World heritage Landscapes” (ICOMOS-ICSSL, 2009) describes the Cultural landscapes as witnesses of the creative genius, social development and the imaginative and spiritual vitality of humanity, stating that landscapes are “part of our collective identity”. Due to their extensive scale, landscapes are particularly appropriate to be observed, studied, monitored (and possibly managed) using integrated geospatial information. More specifically, numerous applications of satellite remote sensing have already largely contributed to study this category of cultural heritage, illustrating both technological potential as well as practical implications for territorial management. Although some satellites have stopped acquiring new data, their archived satellite imagery can still be

accessed, downloaded and exploited for monitoring of changes and therefore for research in domain of archaeology and cultural landscapes.

This paper aims to make an overview of the earth observation satellite sensors (both past and currently active) useful for monitoring of cultural landscapes. Recently, several research examples have been provided regarding the overview of scientific work (Agapiou and Lysandrou, 2015), contribution of Space agencies (Giardino, 2011) and the guidelines on the past trends and future tendencies of the discipline (Lasaponara and Masini, 2011). However, yet a limited work can be found on the link between (1) the endorsement of earth observation technologies to support archaeology and culture landscape management within policy frameworks and on (2) the concrete possibilities that such technologies can offer. The paper provides an overview of policies and ongoing global initiatives that already see engagement of satellite Remote Sensing for purposes of heritage management with a special focus on a situation in Europe (section 2), while section 3 illustrates earth observation sensors suitable for archaeological prospection and landscape monitoring in terms of

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spatial, spectral and temporal resolution. Discussion in section 4 provides food for thought on two main bottlenecks regarding satellite imagery - the data availability and accessibility and the skills required to process such data. Preliminary conclusions and future research recommendations are provided in the section 5.

2. Satellite Remote Sensing meets heritage: an overview of policies and ongoing initiatives

2.1. Some global initiatives

The link between Space technologies and World Heritage Sites seem to officially exist since 2003 UNESCO and European Space Agency (ESA) have launched an “Open Initiative on the Use of Space Technologies to Support the World Heritage Convention”. Further, in 2009 one of the strongest research engines and map providers based on satellite imagery, Google, achieves an agreement with UNESCO on enabling internet users to visit selected World Heritage properties via Google's Street Viewinterface and to browse all other sites on the Google Earth and Google Maps interfaces. In domain of research, a highlight is reach with an International Centre on Space Technologies for Natural and Cultural Heritage being established in Beijing (China) under auspices of UNESCO in 2011. All these initiatives seem to have on one side set the ground for a wide range of novel useful technological applications; and, on the other, they have indirectly expressed the need for geo-location sites and for up to date geospatial information, that would possibly allow a more efficient and sustainable landscape management.

When it comes to risks evaluation, in 2005 World Heritage Centre has performed a survey among the Member States to access the major threats of climate change and their possible impact to natural and cultural heritage. The climate threats raised for Cultural World Heritage sites were: Hurricane, storms (11 sites); Sea-level rise (9 sites); Erosion (both wind and water driven) (8 sites); Flooding (7 sites); Rainfall increase (4 sites); Drought (3 sites); Desertification (2 sites) and Rise in temperature (1 site). Climate change is in fact one of the main factors with a significant impact on changes of cultural heritage and landscapes. A UNESCO report (Colette, 2006), identifies Climate indicators matched to climate change risk and possible impact on heritage. The study further refers to satellite Remote Sensing as one of the valuable tools, useful for development of “professional monitoring strategies”.

More recently, in 2016, the focus in this domain seems to have shifted from consequences on heritage towards the impact of climate change effects on the economic sector that is most commonly linked to heritage – tourism sector. “World Heritage and Tourism in a Changing Climate” reports that in the period of 1979 till 2013 the highest numbers of cases identify as specific factor negatively affecting the outstanding universal value of the property “*Management system/management plan*”. In Europe and North America for example this number accounts for 58% (Markham et al., 2016). It could be argued that in case of emergency the real threat is the hazardous event itself; in case of ordinary administration the threat seems to be a “hazardous attitude” that leads to inadequate maintenance and thus to a risk of an improper management of cultural heritage sites. Hence it seems in order to propose an overview of existing earth observation satellite sensors that could bring high added value of updated information for monitoring of cultural landscapes and archaeo-landscapes when it comes to monitoring of emergency situation provoked by geo-hazards (e.g. floods, fire, soil erosion or even earthquakes). The objective here is to connect the technological “offer” in terms of services and products with policy “demand” i.e. requirements for a more sustainable management of territory and its cultural landscape.

2.2. Current situation in Europe

Policy makers in Europe seem to be already aware of possibilities

that novel technologies can bring to the society and possibly to cultural heritage. Although not referring strictly to satellite remote sensing, European Convention on the Protection of the Archaeological Heritage (Valetta convention) establishes a requirement for “non-destructive methods of investigation” (Council of Europe, 1995), while European Landscape Convention (Florence convention) calls for specific measures aimed at landscape protection, management and planning (Council of Europe, 2000), highlighting that landscape “is not a matter for individual states alone” but “needs to be considered in international policies and programmes”. Such approach, that could be interpreted as request for collaboration between disciplines and among states, can be observed as a “shift of scale” and tendency to observe cultural landscapes as a whole also in terms of territorial management and hence sites' protection and maintenance. The link here can be made with INSPIRE Directive (European Parliament, 2007), the first EU legally binding instrument that has set the ground for sharing and re-use of publicly collected geo-spatial information (including products deriving from the satellite imagery). INSPIRE dedicates a specific theme of Annex I to Protected sites, highlighting thus the importance of availability of geospatial data and interoperability of systems even for the management of cultural and natural heritage. In this context, the most recent communication regarding culture “Towards an EU strategy for international cultural relations” (European Commission, 2016) becomes of high relevance to the field of satellite remote sensing: in this document, European Commission states its strong commitment on collaboration with other countries when it comes to protection of cultural heritage. Copernicus Emergency Management Service, has been identified as one that should majorly support this action, providing satellite imagery of cultural heritage sites at risk in order to evaluate damage and plan possible reconstruction. This effort seem to be the first official example and a direct link between an Earth Observation programme (and hence potential services and products deriving from satellite remote sensing technologies) with the domain of monitoring, protection and risk assessment of heritage sites.

Table 1 provides a non-exhaustive list of EU policy recommendations and indications that touch upon the link between cultural heritage at territorial scale (landscapes and archaeological heritage sites) and geo-spatial information, including possibly remote sensing and thus solutions coming from satellite technologies. The first classification was done in terms of direct and indirect reference made in the text of specific policies to the three identified categories: Geospatial information, Remote sensing and Space technologies. Direct and indirect reference is here intended as use of exact terminology of the three categories in the text. An earlier example of Valetta Convention (1995) does acknowledge the necessity of “non-destructive methods” and “necessity to take note of change”, implying the need of remotely sensed information (indirect reference), but it does not make a clear mention to specific technologies to be employed. On the other hand, INSPIRE Directive, explicitly cites (direct reference) all three categories, but with major focus on geo-spatial boundaries rather than on monitoring of change or risk assessment of the site itself. EU Joint communication (2016) is also a very significant step forward in the domain of satellite remote sensing for archaeology and landscape domains as it expressly recognises the need for an operational service based on satellite imagery, and hence the role of satellite technologies derivatives, when it comes to protection and damage assessment of tangible cultural heritage.

3. Satellite sensors for monitoring of cultural heritage sites and cultural landscapes

3.1. An overview of useful satellite sensors according to period, resolution and data availability

In the literature there are already several examples that have exploited the potentials of earth observation for monitoring of cultural

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