CHAPTER 18

Digitisation, Digitalisation, Digital Transformation: The Maltese Spatial Encounter

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Introduction

The transformation of society is a slow generational process buffeted by a rapid change occurrence that is governed by a push-pull digital factor. The latter has spurned change that pushed the PREFE (Politics, Religion, Economy, Family and Education) societal foundations to embrace Technology. No longer do these domains operate in isolation, each with its own set of rules, dogmas and regulations, having become unobtrusive as technology infiltrated each domain through access to information in an interconnected global network. However, the resultant data-information-knowledge pivots facts emanating from the access to such huge volumes of material may not have rendered facts as a basis on which to build one's theories-assumptions=knowledge upon. This chapter's scope is to aid in the understanding of the need to create baseline datasets, information systems that are related directly to verifiable data cycles upon which researchers can build theories, policies and enable decision-makers to base their work on sound ground.

The process is based on a spatial rendition of the data creation process that is built around the digitisation-digitalisation-digital transformation tripod. As the Digital Transformation of the Real World entails the need to move from analogue to digital to virtual realities, the attempts to recreate that reality into a digital twin is enhanced through multi-domain, multi-disciplinary integration systems (Boggs, 2012). As detailed in the introductory chapter, the past two decades have been dedicated by researchers and policy makers to morph from a purely analogue reality to a part-digital and a quasi-full digital reality. In turn, this process pushes society to employing a bottom-up approach to the concept of digitisation and digitalisation. Through data, information and in turn knowledge, action can now be taken up by policymakers and decision-takers to ensure that all are ready for a new research and analytical operand: an operand that pivots on the Digital Transformation through strategic, operational and tactical activities as the fourth industrial revolution takes hold (Lachvajderova at al (2021); Vrana et al, (2021).

It is best to view such transitions through Jason Bloomberg's (2018) drive to understand the tripod as one move from a digital to a digitalized to a digital transformative domain:

- Digitisation is the process of converting analogue into digital format.
- Digitalisation focuses on the adaptation processes.
- Digital Transformation is the process of acquiring knowledge from the data into information for future action through creative means.

This chapter explores the processes employed to take cognizance of the digitalisation of the spatial domain, presenting the steps undertaken and posits cases upon which the processes were introduced in the Maltese Islands.

The Digital Realm

The digital realm has gone beyond the mere scanning of physical maps into images or pdf formats but is pushing towards the extraction of data, information and subsequently knowledge from features emanating from the vector and raster models that comprise spatial information (Câmara et al, 2001). The digitisation process, whilst still ongoing as legacy map-based documentation is voluminous, has been superseded during the past decade through digitalisation as driven by legislation and change imperatives such as the INSPIRE Directive (European Parliament, 2004) and international integration initiatives that built on successes achieved over the past years in various domains: These include the Environmental Sciences (physical, natural and social), Heritage and Archaeological Disciplines, Development and Spatial Planning, Forensics and Scene Recreation, as well as Transport and Utilities. The list is endless as new domains partake to locational data bridging the gaps between the domains and allowing for cross-thematic analysis. In turn, the resultant aim of this study aims towards research on immersions, sensors, gaming, art, metaverses, education, medicine, societal impacts, ICT, AI-human interactivities as each pushed words social wellbeing.

The challenges faced a decade ago was one where the Data Cycle was suffering from DRIPS (Data – Rich – Information - Poor Syndrome) as data was available in spreadsheets or flat tables and linkages between them were not possible. Data was expensive and creators needed to recoup costs. Cost effectiveness was further complicated by the need to create cost-recovery measures using copyright and access restrictions. Such was eased one the digitalisation aspect gained ground and entities started working on the digital transformation processes to ensure the maximum benefit from the new information constructs available. Cognition is spatial constructs is central to the transformation (Edwards, 1997; Klippel et al, 2012)

The spatial transformative cognitive processes adhered to cover the following:

- **Conceptualisation** of the spatial elements to transform through an attempt to define what is a direct reflection of the original concept of need, a difficult task indeed.
- **Entitation as the process by which one defines the entities about which one seeks to collect data**
- **Quantification** through an understanding of how rich is a rich dataset? Is the transformation required relative or absolute? Will proxy or surrogate data be used that represent the analogue data into a digital form?
- **Validity** that pertains to the peace of mind that data that was collected is a close representation of reality. The importance of ensuring acid-test for datasets of dubious origins cannot be stressed overly as the result is as reliable as the source.
- **Composition** in spatial domains is of paramount importance as it is the process by which multiple individual indicators are combined into a composite model, which serves as the turf ground for spatial information systems.

The Maltese experience in handling the transformation process was governed by a hands-on approach that delivered the 3D CloudIsle (www.cloudisle.org) spatial information used in many domains, the CrimeMalta 2D spatial output (www.crimemalta.com) and the SIntegraM geoportal and various others (Planning Authority, 2012) as developed on the initial project ERDF 156: Developing National Environmental Monitoring and Infrastructure Capability (PPCD, 2014).

Challenges to the transformative process

Challenges to the process revolve around the lacunae in the transformation process as the state has readily available technologies and little on the theoretical approach as well as the operational processing, the process will reduce the Digital Divide and empower students and experts alike to be prepared for innovation. The challenges ahead focus on the thematics that would be taken up by this initiative through theoretical focus and implementation of practical initiatives on the following:

- Real-World Digitisation and Digitalisation;
- Intra and Inter-Domains Interactivities: Terrestrial, Aerial, Bathymetric;
- Digital Design – Visualisation and Visualization;
- Data Cycle: capture, input, cleaning, storage, analysis, output, reporting;
- Technologies: Laser, photogrammetry, robotics, remote capture, AUVs, UAVs, videography, imagery;
- Capture: in-situ, remote, physical, semi-autonomous, autonomous, immersed, sensors;
- Reliability: Verification, validation, error;

- Data Integration;
- Spatial Statistics, analysis and outputs; and
- Dissemination imperatives.

The SIntegraM (European Commission, 2020) and SpatialTrain (European Commission, 2019) initiatives sought to lay the groundwork for this process, which further require impetus on the transformation parameters required from the spatial domains. These include:

- Real-World to Virtualisation and Visualisation Processes;
- Analytics – tools, software, data mining, deep learning, BIG data, open data, impact analysis;
- Legislation, directives, Data Protection, DPIA, financials, auditing, security, National Data Strategies, Smart Specialisation Strategy, RRP and other instruments;
- Reporting;
- Disseminators – IoT, real-time analytics, gaming, metaverses;
- Real-World to Virtuality Interactivity;
- Digital Twins – replication, innovation;
- Immersion; and
- Inter-Domain/Entity/Industry/Academia/Governance/Stakeholder collaboration: specifically, the domains catering for AI, Built Environment, GeoSciences, ICT, Social, Public Sector, Public Service, Industry

Sourcing the Protocols

The imperative of the digital transformation impinges on the need to be aware of the INSPIRE parameters as well as the GDPR requirements to ensure that any data pertaining to individuals is removed to ensure privacy (European Parliament, 2012). This section partakes to the descriptors of such a process that detail the reasons for conducting a DPIA, the nature, scope, context, and purpose of the envisaged processing, the procedures employed, the processing operations, the legal basis for processing, the categories of personal data processed, resultant security of processing, retention, data subject rights, and risk assessment. The process to capture data and ensure protection is difficult in spatial technology processing due to the sheer volumes of data being captured on a routine basis. aerial, terrestrial and bathymetric data is volume and space hungry, requiring additional tools to ensure protection on all levels.

As a case study the chapter describes the process required to capture spatial data for digital transformation using aerial technologies such as UAVs.

- **Reasons for conducting a DPIA**: main reason pertains to a new processing activity for the update of the specific thematic map for the Maltese Islands.
- **Description of the nature, scope, context, and purpose of the envisaged processing**: upgrading the national spatial data infrastructure developed through the SIntegraM project with the scope of enhancing the capacity of geospatial and GIS expertise in Malta. The thematic map processing activity subject of the DPIA involves the capture of a thematic map such as an erosion map, a water stream flow analysis. This update process is in line with the relative legislation and seeks to undertake the functions mentioned in the relative legislative tool empowering the data cycle. It is imperative that the DPIA details that the process will be repeated every nth-year cycle.
- **Procedure for the capture and processing**: To define type (such as aerial imagery), means (capture technologies such as drones), locational parameters (distance, height, range as per applicable legislation).
- **The protective measures**: Definition of what could be captured such as 3D pointclouds or images of persons or vehicles within range of the data capture exercise, the processing methodologies, the scope of the exercise, the responsible parties, the data cycle description inclusive of design, capture, cleaning, analysis, outputs and dissemination. The technologies (hardware and software) employed in the process need to be defined as well as the processing methods employed to reduce the pointcloud and image definition, where clouds are trimmed to ensure protection and where images of persons are blurred.
- **Legal basis for processing**: description of the law within which the exercise is conducted.
- **Categories of personal data processed**: description of persons, property, facial elements, and other items that may be captured are to be detailed.
- **Security of processing**: description of how data is stored (cloud, hard-disks, SD cards). Retention and hardware reuse, restricted access, detail that the data is not made available to third parties. Detail of the tools employed such as those listed in the tools section below and how they are used to reduce pointcloud and image definition. Retention periods require stipulation.
- **Data subjects rights**: detailing of how the spatial data organiser will inform the public of such as exercise. This includes informing residents through advising the respective Local Council of the dates and times of technology operations, advertise the relative entity website and social media of the operation's locality, dates and operating times, publishing through the Government Gazette as well as inform residents in-situ through visible signage close to the area of the technology operation to inform passers by of the processing activity.

- **Risk Assessment**: Detailing of the risks emanating from such an activity inclusive of the threat and subsequent residual risk of infringing data protection rights.

Technologies In hand

Diverse technologies are employed in this exercise which cater of aerial, terrestrial and bathymetric domains as well as subterranean and ground penetrating exercises. Urban and rural open spaces have been captured using UAV (Unmanned Aerial Vehicle) and Laser Scanning technologies (Figure 1), as well as TLS (Terrestrial Laser Scanner). The technologies employed included aerial systems inclusive of DJI Mavic Pro 3 AUV (imagery – Figure 2), DJI INSPIRE (imagery), DJI M200 (imagery, infrared) DJI M600 Pro (imagery, infrared, GPR), and a RiEGL RiCOPTER (LiDAR, imagery, infrared). In terms of legged robotic technology, a Unitree Go1 Ai Pro Robot was acquired for scanning in difficult areas such as tunnels and caves, which aided the earlier Faro Freestyle Handheld scanner and the DJI Osmo.

In terms of terrestrial and mobile technologies, the researchers used a RiEGL VZ400i Terrestrial Laser Scanner (LiDAR, imagery) and a GreenValley LiBackpack50 (LiDAR) as well as the RiEGL Vehicle-based VMX-2HA system (LiDAR, imagery). Access to a bathymetric Gavia AUV (autonomous underwater vehicle and a tethered QYSEA FIFISH V6 Underwater Robot. Software used in the processes included Reality Capture, Zephyr 3D, Agissoft Metashape, Pix4D, Lidar360, RiScanPro and RiProcess. Output software that was used for scene reconstruction and immersion analysis include Unity 3D and the MagicLeap applications, whilst the WebGL outputs were published using LasPublish as published on www.cloudisle.org.

Figure 1: Plane based pointcloud

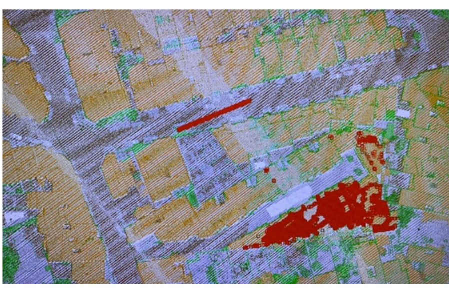


Figure 2: Imagery

Challenges to visualise the results

Policymakers and decision-takers face a challenging duality: their internal visual recollections of what should be and the visualisation they must partake to understand that which is. The discord between flat-photomontaged landscape perception and immersive 3D environments is gradually enabling decisions to be taken within an integrated data-information-knowledge approach. In addition, with a spatial checking process overlaid over a plane-based LiDAR nadir data layer, the latter's nadir lacunae are compensated for by the drone's oblique ability.

In an attempt to create visually realistic scenes for decision taking, a study governing an entire data cycle was attempted to understand the creation of a rolling data capture enterprise for quasi-real-time data capture and outputs. Mapping landscapes through photogrammetry, laser-mapping and GPR were attempted through a conceptual view to creating substantially detailed models that could be modelled in a 3D environment that enables users to explore otherwise unavailable landscapes (Lovett et al, 2015). The porting of such outputs to other domains such as offender studies (Formosa Pace, 2014), offence studies (Formosa, 2007), crime scene generation, inaccessible spaces analysis (Obanawa et al, 2014), erosion studies and heritage outputs during covid-19 closures proved the affectivity of such processes (Bustillo et al, 2015)).

Creating 3D models actually transcribes the final aspect of the data process, with the major activity employing an entire mission planning to fly drones, ground control activities, photogrammetric processes, laser scanning, integration and model exporting. Data capture technologies used include UAVs, AUVs, terrestrial laser scanners, mobile laser scanners, GPR and real-world in-situ human-painted GCP anchor markings. Flight plans were affected through Drone Deploy path mapping averaging 20,000 images per town anchored through 80-100 GCPs as loaded into photogrammetric tools, mainly Agisoft Metashape and more recently Reality Capture. The resultant dense clouds, meshes orthoimagery and DTMs were exported for visualization use (Figure 3).

Laser-scanned areas were also employed through Riegl's Vzi400 and the Mobile laser scanner particularly during the covid-19 enforced empty streets that enables street-level drive-through scanning. Riscanpro and Riprocess enabled the generation of pointclouds and simple meshes for further visualization outputs. Data visualization in immersive environments was enabled through the resultant rendering of the 3D models generated in Unity 3D for the 7-panel CAVE (Computer Automated Virtual Environment) (Li, 2020) (Figure 4), Oculus Rift and Magic Leap (Manjrekar et al, 2014; Yoon et al, 2015). The exporting of same models to an interactive executable (.exe) application has enhanced the outputs to enable users to revisit the scene from a desktop of mobile device.

Figure 3: The image to Information process: LiDAR-DSM-Vector-3D

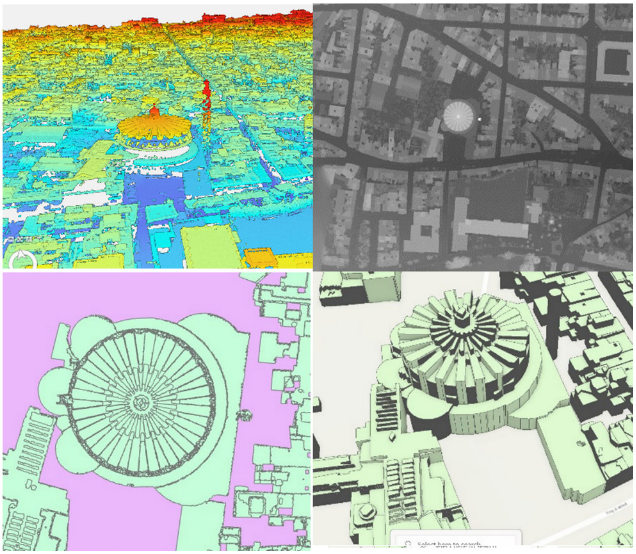
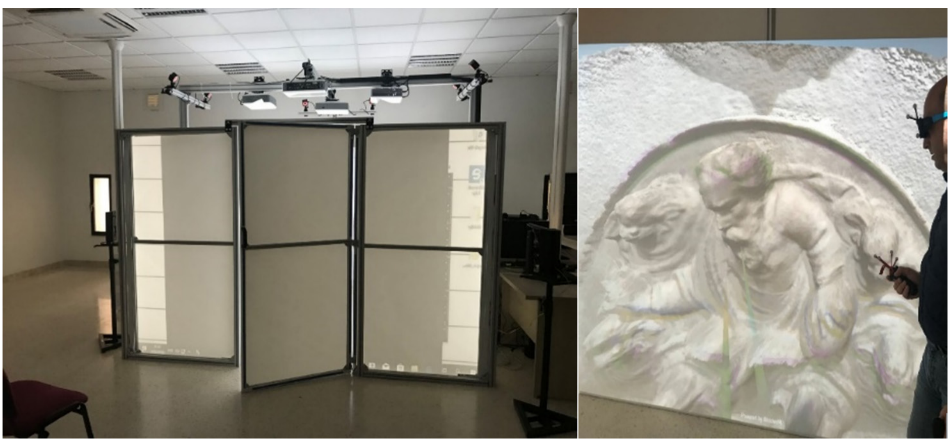


Figure 4: Reaching an immersive level through a CAVE environment



Dissemination

The use of Immersive technologies in understanding past-present and potential landscapes was crucial in understanding how best to preserve a medieval city (Figure 5), to study the changing townscapes in ribbon development in a second island, and to understand how erosion was instrumental in the deterioration of coastal zones and its impact on tourism, calculating quarry rehabilitation volumes as well as monitoring a major sinkhole in a world heritage site. In addition, the same methodology was employed for the creation of sub-cliff dangerous caving-in phenomenon that allowed interveners to view the extent of the dangerous structures in a safe and immersive lab environment (Figure 6).

Taking the technology to the next step through the visualisation of the areas under study is achieved through the rendering of 3D geolocated immersive environments that can be used by landscape designers, architects and decision takers once again on site through the visualisation of the was-is and will be based on their lon-lat coordinates.

Figure 5: 3D medieval city generation for eventual immersion studies

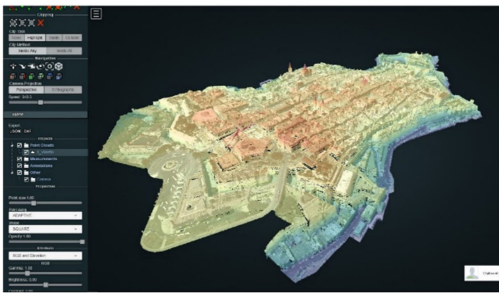
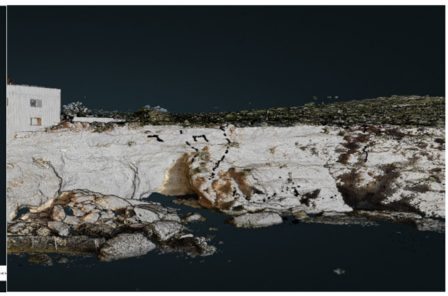


Figure 6: Cliff-side dangerousness studies



Source: www.cloudisle.org

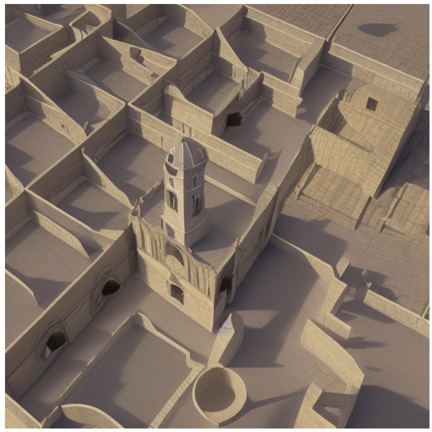
The Next steps to aid Visualisation: AI and AI image generators

Visualisation and its employment for environmental, social, psychological and other multi-discipline domains has recently become challenged by outputs being generated through AI art renderers that replicate/mimic/create outputs similar to those generated by the processes mentioned in this paper (Gao, 2021) (Figure 7). The challenge for researchers over the next period will be to empower the spatial domain through the integration of such tools to enable deep learning of the methods used to understand the physical, social and natural environments such that the power that these tools have are harnessed for the empirical research process, the operational aspects as well as the search for elements that human eyes may not capture but such tools do.

The jump from physical maps to 2D GIS layers to 3D pointclouds and meshes to immersive technologies has offered breakthrough for domains linked to a locational imperative. The use of enhanced tools to identify alternative or as yet hidden elements in spatial analysis would only enhance the outputs, always within the parameters of the digital transformation, protocols and protection levels detailed in this chapter (Figure 8). The use of technology to capture ever defined resolutions is paralleled by hi-end analytical and visualisation tools that will push spatial information towards the next transformation in urban planning (Pellegrin et al, 2021; Quan et al 2019).

Figure 7: Aerial imagery generated by AI

Generated by author through AI Art App



Generated by author through AI Art App

Figure 8: Development Planning generated by AI

Generated by author through AI Art App

Generated by author through AI Art App

Conclusion

Technology is as advanced as its users push it to understand the reality around them as well as create processes to enhance the research and societal outcomes emanating from such studies. The chapter defined the baseline elements that comprise spatial information, the digital transformation aspects and the methods employed to enable the visualisation of the outputs resultant from the spatial data cycle. The conceptualization of what constitutes data and information as well as its creation of knowledge goes only as far the innovative user can push the technology, hardware and software towards an understanding of the social constructs. Spatial information has come of age through the visualisation construct and how the user employs and understands the protocols regulating the same data flow.

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