Maltese technological steps towards integrative cities

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1. Introduction

Understanding how urban ecologies operate and how one can relate to the changes required for social change, entails a deep understanding of the structures that make up that society. This scenario is evident when one tries to understand how policy makers present their studies for decision-takers to act upon. In an ideal world the decision taker would have acquired knowledge of what planning entails, the situation at hand, the acquisition of a mental image of the area under study and would theoretically be able to decide on an outcome as based on such knowledge. Reality shows otherwise, since this process entails the full knowledge of how the data process is handled, how that data delivers meaningful information, which results in knowledge and eventually an informed decision is taken. However, the entire enterprise is based on access to information or the lack of same, to acquisition of information on the urban/rural structures and the environment in its wider aspects. Dealing with advocacy groups, non-governmental organisations and interested parties requires that the planner has a solid understanding of the physical, natural and social parameters that society is permeated with. A planner debating a decision on how to mitigate on urban sprawl would be required to understand how such urban ecologies morph from small hamlets to town and cities and eventually to metropolis, in addition to an understanding of the interactivities

that occur between the players as based on the sociological pillars: politics, religion, education, family and economy. Each part plays a crucial role in its attempts to sway a decision one way or another. Without basic information across the fields planners may find barriers being set up that may thwart informed decision-making.

1.1. Technologies and informations systems

With the advent of a plethora of technologies and information systems, such knowledge can be readily placed on the planner's desk. Technologies vary from digital replicas of analogue files and documents, to OCRing (extraction of text from scans) documents that allow searchable options, to real-time data capture and finally to dissemination to the interested and general public. The process enables the lessening of pressure on the planner in terms of potential accusations of withholding of information to the potential for the NGOs and interested parties to be equipped with the same information which would enable them to reach informed opinions and to debate change.

The case employed within the Maltese Islands was aimed at reaching these goals where the planning process would be enhanced by the digitalisation of the entire planning process and the subsequent structuring of information and eventual dissemination. This paper is aimed at helping planners understand the processes required to virtualise cities and the steps Malta took to create data layers that help this process. It concentrates on the unique situation where the legislative and operational tools available to planners were taken up through to the conceptualisation of a function that integrates baseline and thematic datasets for effective future analytical processes. The process is ultimately aimed at acquiring knowledge leading to the implementation of a smart cities approach where the data on every item and the relative flows are monitored in real time and where scenarios can be built to reflect the outcome resultant from every variable tweaking. As an example, understanding the effects of a new tall building would entail the insertion of a dxf model in a city model, the pooling in of spatial layers from transport, utilities, infrastructure as well as social information, with the resultant output where the different datasets are integrated in a model-based system and the scenarios tested as based on infrastructure load, increase in traffic, a growing elderly component and a myriad number of different variables. Though the latter can reach unsustainable proportions for the model, the choice of variables would be based on the knowledge gained from the expertise on the ground and other planners' knowledge-base.

In Malta, this process entailed the foresight requirement to enable smart-cities implementation, bearing on the virtualization of the planning process, the vision of a paperless system, the creation of a physical ICT (Information and Communications Technology) structure, funding options and methodological approaches to virtualisation. The ICT structure is essential for valorisation of the smart-city approach due to its capabilities in integrating disparate datasets, gather-once / use-many functionality and ready take-up by the planning discipline as governed by the need to base all development on the use of a basemap as its core, working from a centralised approach to governance but a bottom-up approach to creation and use.

The Malta experience depicts a scenario where data is held by the legally designated data-creation bodies, where data is made accessible through a web-service model that point the dataset toward a common-core server.

1.2. Limitations to achieve the goals

The concept of place is a not an easy one to understand. People struggle to visualise the ambience of a city when described by another person: they have to conjure their vision of what that street could look like, how it is structured, the dimensions and scale, the spirit of the place, a distinction atmosphere better termed genius loci. This, whilst at the same time trying to listen to the thematic aspects being described by the other person. Imagine an architect trying to describe how a new development would look like once completed. The planner rarely visits the area and might recall what it looked like some time back or if ever, thus communication at the stage is hindered by background noise. The Malta process sought to integrate various technologies to enable both

parties and even more such as third interested parties to visualise the area through technologies. The integration of spatial systems through to a 3D model has helped the process greatly. The model was based on a Lidar scan of the island, averaging a point density of 4.3 pts/m², with a classification of ground and nonground, which resulted in a DSM (digital surface model – includes terrain and buildings) and DTM (digital terrain model – no buildings) of the islands.

This process is still hindered by various factors; lack of an integrated information structure across all government entities, lack of protocols requiring standardisations as well retention of analogue systems only (paper-based) and the silo-effect mentality where data acquired by one entity is seen as the domain of that same entity and thus required protection and guardianship.

Malta is driving its efforts to digitalise these processes and has been successful in its initial phase to digitalise the planning stream through internal investment whilst also accessing external funding to implement various tools and data capture. This it did through the knowledge that online maps, GPS (global positioning system) devices and smart technology have now been around since the late-1990s such that the university generation and the subsequent generation, have been exposed to virtual tools to a level that has been unprecedented some years ago. The older generations may need further aid to reach this level through training programmes as a clear understanding of the spatial-awareness is required. In order to employ this process, Malta took up this process through a project aimed at creating a series of technologies and protocols aimed at generating a virtuality of the islands (Formosa, Magri, Neuschmid and Schrenk, 2011). This process to move from analogue to digital systems entailed scanning, the digitalization of the application process, the submission of digital plans, a GIS-based (geographical information system) planning process and acquisition of technologies that enable data capture, input, analysis and output. One such project entailed the creation of Malta in 3D using LiDAR (Light detection and ranging) technology and the ERDF (European Regional Development Fund) project entitled "Developing National Environmental Monitoring Infrastructure and Capacity" (MEPA, 2009).

2. The legislative aspects

The steps that MEPA took to understand spaces include various iterations of its legislative tools, as regulated by the Development Planning Act (DPA) of 1992 and the Environment Planning Act (EPA) of 2001, which were replaced by the Environment and Development Planning Act (EDPA) of 2010. In addition to these main tools, MEPA is governed by a series of subsidiary legislation that regulate planning and sustainability as well as the public participation process. In fact, the uniqueness of the amalgamation of the planning authority and the environment entity created the scenario that other legislative tools where integrated within the parameters of the governance such that the planning side now has a series of protocols for the datacycle that will be retained in place once the two entities part ways. Thus, in conjunction with the EDPA and its subsidiary legislation, a series of other tools were integrated, such that planners now have a plethora of objectives to follow in order to ensure that the data cycle is tackled in its entire process. These tools relate to access to standardised processes for information-creation which is being tackled from various legislative loci such as the Data Protection Act (OJ, 1995), the Århus Convention (OJ, 2003a; OJ 2003b), the Freedom of Information Act (OJ, 2003c; Malta Government, 2012) and the INSPIRE Directive (OJ, 2007), in addition to other guidance documents that are targeted to enable the smooth and free flow of effective information. MEPA through its Information Resources and Technology Unit (IRU) has created a series of protocols that ensure further governance through metadata structures, lineages, adherence to the European Environment Agency priority dataflows and its own ISO standardisation.

These tools enabled MEPA to create a process that focused on its core function as a creator and user of spatial data. The organisation uses geodata in almost all of its business processes and has invested heavily in spatial resources and capacity. Users have multiple-level requirements, such as those who need to create data within a defined application process, others who carry out spatial analysis and data creation and editing processes as well as casual users such as the general public who require view and occasionally download services.

Thus MEPA sought to create systems that provided a system that ensures a “capture once use many times” policy, employs a data owner/custodian

mind set, implements data and quality standards, introduces metadata and discovery tools as well as disseminates data to the general public in a mixed charging mode: free for environmental related datasets and chargeable for other datasets as per time taken to run such queries.

how such urban ecologies morph from small hamlets to town and cities and eventually to metropolis, in addition to an understanding of the interactivities that occur between the players as based on the sociological pillars: politics, religion, education, family and economy. Each part plays a crucial role in its attempts to sway a decision one way or another. Without basic information across the fields planners may find barriers being set up that may thwart informed decision-making.

3. Methods and processes

The method employed in the effort to integrate the different functions across the planning and technological fields is that termed the W6H (CMAP, 2002), a concept that was taken up through another discipline; criminology, which through its spatio-temporal concepts and requirements to convert thematic data into a spatial format, initiated a process to convert analogue data into digital forms. The ability of employing spatial data to form an analysis based on a what, why, who, when, where, why not and how phenomena (W6H) outlined by CMAP has helped spatial planning tremendously. GIS analysts seek to investigate each of the W6H pivots to identify patterns to reach conclusions on whether correlations exist or not. The six pivots (Who, What, When, Where, Why, How and Why Not) concept was employed as a basis for integration whilst the effort is currently being upgraded to encompass all spatial data creators and users entities that have a role in the foresight activities of the Maltese Islands. The main trust of this model is to ensure that all the process involved in the identification of activities relating of GIS analysis as integrated with other thematic data, are understood. The main functions were amended to focus on planning aspects:

- **What** categories of city-function can be identified: plans, streets, basemap, infrastructure, etc? What routines can be identified (category analysis)? What relationships are there between development applications and other variables?
- **Why** does a phenomenon occur? Why do applicants focus on specific zones (commonalities of a pattern – root cause of a sprawl trend)?
- **Who** carried out the activity? Who witnessed the illegal activity? Who was the victim (offender and target profiling)?
- **When** did an enforcement occur (temporal analysis)?
- **Where** did the infringement occur? Where did the applicant hail from (geographic analysis – environmental analysis) – (opportunity and routine activity)?
- **How** did an activity occur (deductive approach - classification and modus operandi analysis), how will climate change effect the coastal regions, environmental considerations?
- **Why not** investigate unrelated variables to elicit if some type of relationship exists (correlation between data layers)?

GIS has enabled information to be mapped over time. This means that statistics, such as those related to crime levels, could be understood in spatial contexts. As indicated in the W6H structure any data that has a link to a geocoded system can be analysed. In this way GIS has brought to the fore situations where previously non-spatial data (attributes) can now be linked to a spatial dataset and that same data would be integrated into a new GIS layer. Such a structure enables the evolution of thematic data to geographical data (locational data based on points on the earth) to a spatial construct (relationship between entities based on the earth) and across a temporal dimension. MEPA's role in this process was to create the base data to enable this foresight process.

4. Strategy employed

A series of procedures were introduced and which served as guidelines for the whole data management process. It aimed to identify sources of redundancy and multiplicity, and enhanced a streamlined dataflow methodology leading to a one-stop-datashop environment. Whilst the strategy covered the main data management issues, it delved into ancillary services such as data creation methodologies, GIS services and research & information practices. On a logistical side it also outlined document management, data acquisition process inclusive of scanning and digitising, as well as dissemination processes inclusive of pricing policy, archival services and dissemination processes.

4.1. Data Management Strategy (Why/Why Not)

This section identified the issues relating to data management within the organisation based on the complete data cycle. It investigated the processes required from design, data gathering, input, analysis and output as well as data dissemination procedures. A generic data model was identified for thematic data models that were implemented for the different processes. In addition, metadata and lineage system procedures and templates were drafted. The steps covered the following themes:

- *Define data structure for the organisation, planners and clients*
- *Create Data Model*
- *Draft Meta-Data strategy*
- *Data management strategy for monitoring and maintenance purposes*
- *Create procedures for data creation*
- *Integrate model in line with imaging and knowledge-based systems*
- *Harmonise structure in line with data storage function*
- *Establish data request and feedback procedures*

4.2. Implement document management solution in line with strategy set out in 4.1 (How, Where)

This section aimed to establish guidelines for the setting up of a repository system that aids data management control and maintenance. This was reviewed in line with the electronic-applications process, a service contract and other projects.

- *Establish a repository system with version control, management and searching facilities*
- *Devise procedures on use of repository system and provide training to users on both methodology and system*
- *Evaluate the possibility of developing on-line lineage forms for different data types*
- *Create streamline procedure to identify which system to use: e-applications or repository systems, mail-registry*

4.3. Document digitisation/uploading (When, What)

This section aimed to establish guidelines for the setting up of a data acquisition process in line with the data management and document management steps outlined above. The process looks at the required data formats, the necessary applications and any ancillary hardware requirements.

- *Review in line with point 4.1 above*
- *Scanning and conversion of documents*
- *Uploading to website – intranet/internet*

4.4. GIS data creation (Who, How)

This phase reviewed the current spatial data structures and layers within MEPA. The process aimed to source all data layers and developed common storage locations. It identified the available resources and GIS skills as well as bringing forward the need to follow strict meta-data and lineage procedures. Figure 1 depicts such a process that laid the foundations for the data management process, from remotely-sensed imagery to polygonal and point data to analysed outputs.

- *Set up a dedicated IR/GIS Unit that hold the necessary expertise*
- *Set up a pool of technicians within each MEPA Unit that report to the IRU management in order to ensure data cohesion*
- *Create and manage GIS data layers for inter- MEPA units*
- *Identify use of lineages and meta-data (as per IRU documentation). Incorporate in model*
- *Prepare layers for EEA uploads and convert to full-UTM until SIntegraM (a new ERDF project) is completed*

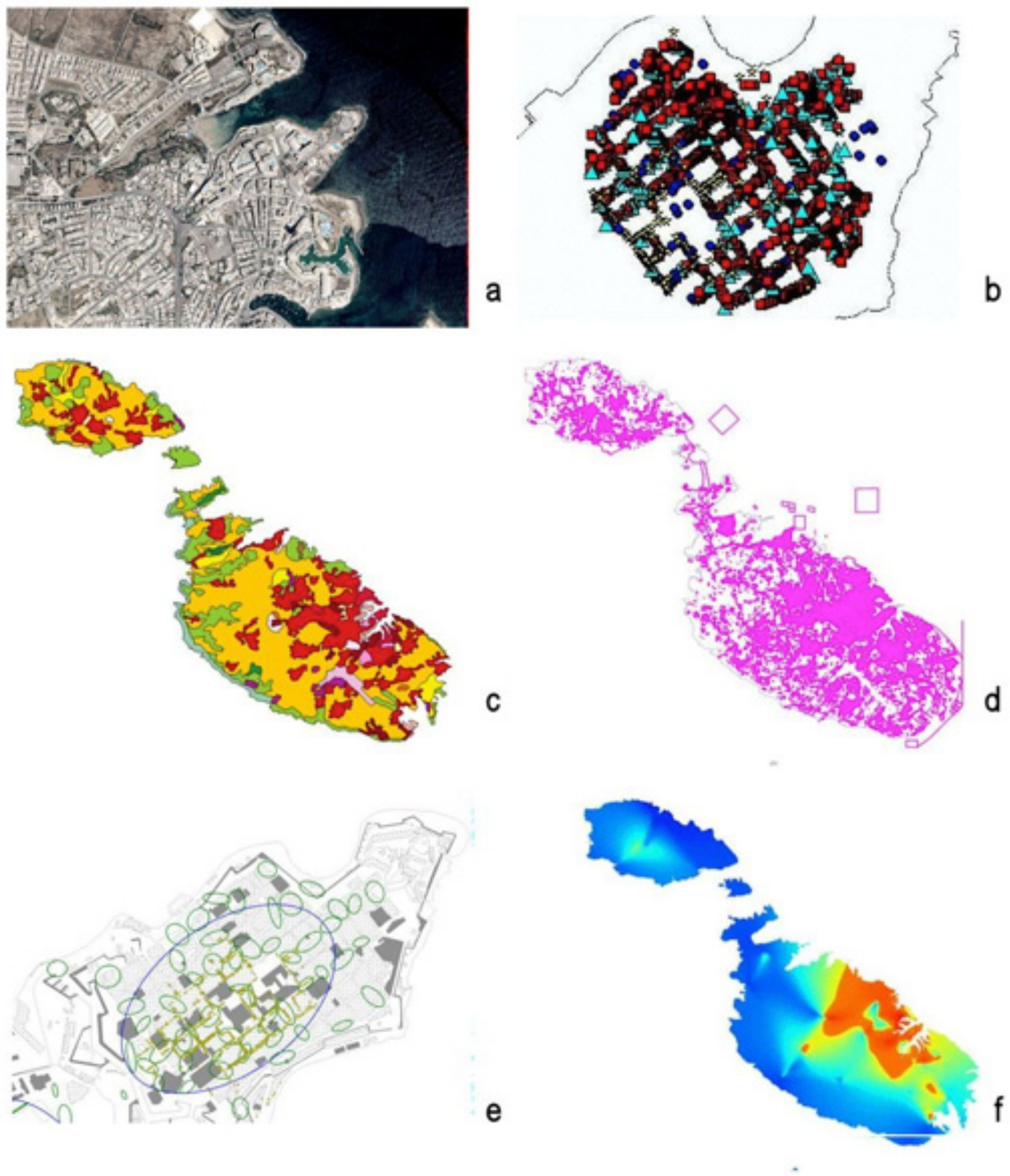

Figure 1. Process to create the first digital layers for eventual spatial data integration

(a) aerial imagery acquired for planning purposes and to be used as a basemap;
(b) creation of spatial layers from analogue data through automated vector data conversion and direct manual inputting, where figure depicts building locations by type;
(c) creation of maps for international reporting; Corine Land Cover CLC2006 that depicts landcover categories of the islands;
(d) finalized development application layer that is created at application stage pending a building permit, which layers shows that the entire islands are effected;
(e) first analysis based on spatial statistics which employed spatial statistics such as NNH (Nearest Neighbour Hierarchical Clustering) to elicit the concentrations of activities in specific zones, herein depicted as ellipsoids;
(f) hotspot analysis enabled through the data conversion and integration process, which figure depicts the spread of benzene in air prior to the elimination of lead additives in fuel.

4.5. Dissemination Policy and Management (How, What)

This phase reviewed the data dissemination policy in order to streamline its services towards a harmonised approach. It reviewed issues such as pricing policy, publication options, marketing of data services, and dissemination through webservers. Figure 2 depicts the outputs emanating from the integration of various technologies, proprietary and open-source that integrated the spatial layers and disseminated such through a dedicated mapserver.

- *Draft dissemination options document*
- *Draft process for MEPA-wide data dissemination and external charging rates through IR – one stop-shop for streamlining of data transfer into and out-of MEPA, where all data requests to MEPA are channeled through one source: currently IR.*
- *Update periodic monthly data updates*
- *Updating of IR-related intranet/internet webpages (NSO press, LN/GNs)*
- *Creation of interactive products and selling-point on website*
- *Presentations by MEPA staff to be converted to swf flash and uploaded on the net*
- *Disseminate data through on-line queriable datasets (refer to NSO StatDb)*

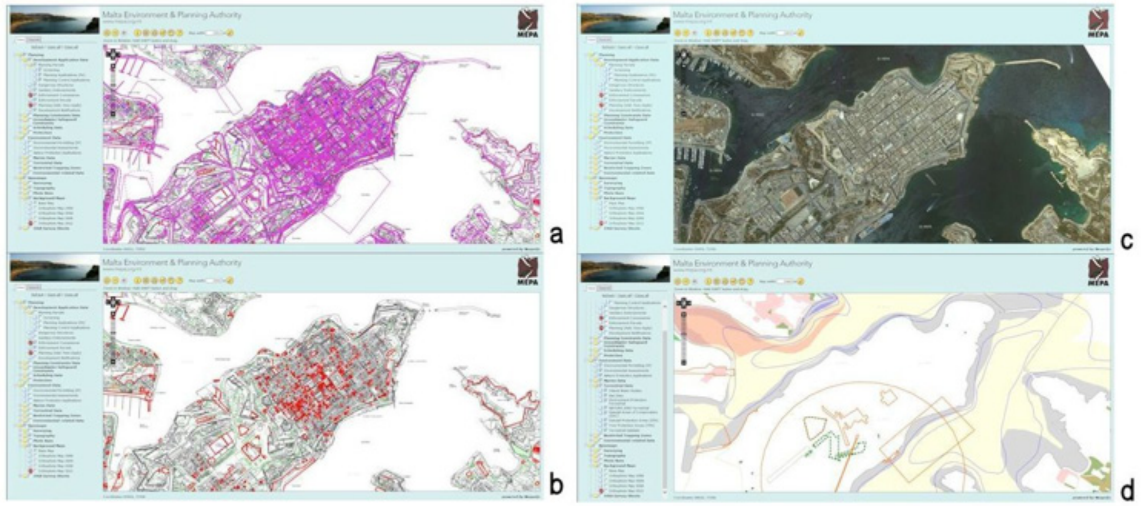

Figure 2. Data dissemination modes;

(a) establishment of a common dissemination format employing the basemap and thematic data inclusive of development application layers;
(b) highlighting of enforcement areas, eliciting the irregularities identified through the spatial analysis;
(c) integration of ortho-imagery with the basemap through a pyramidical structure where detailed layers are loaded as users zoom into the zones under review;
(d) initial thematic analysis, such as protected zones identified through the inputting stage and which depict the different land uses and potential activities or restrictions that could take place in such areas.

The output system showed that the limitations experienced through the use of tools that are not universal to all browsers, point to the need to create a system based on web map services that follow the INSPIRE dissemination rules, with the relevant security system put in place to ensure system integrity.

The method identified issues that related directly to operational and implementation operands inclusive of budgeting, resource requirements, capacity, tendering and post-project maintenance. Malta partook to these activities through various means: in-house business plans, national and international legislation transposition, acquisition of funding and capacity building exercises. The crux of such projects lies with the eventual management

and retention of the knowledge gained and its extension to other entities; a process that would ensure knowledge gain across the nation. The initial costs were significant, running close to EUR5million, with maintenance envisaged at EUR50000 plus retraining activities, which costings are mitigated through reduction of expert time on recreation or redundancy elimination.

5. Taking the Next Steps

The next phase that attempts to integrate the planning data with all other governmental entities' data within a central core has been initiated and is planned to take up the MEPA process and expand it to all entities enabling instant access as well as enabling societal benefits such as post-disaster management. The project entitled SIntegraM: Spatial Integration for the Maltese Islands: Developing Integrated National Spatial Information Capacity is aimed at satisfying three aspects: building the necessary infrastructure, enhancing the human capacity and ensuring a legislative and mentality shift in ensuring the free exchange of data and established dissemination protocols.

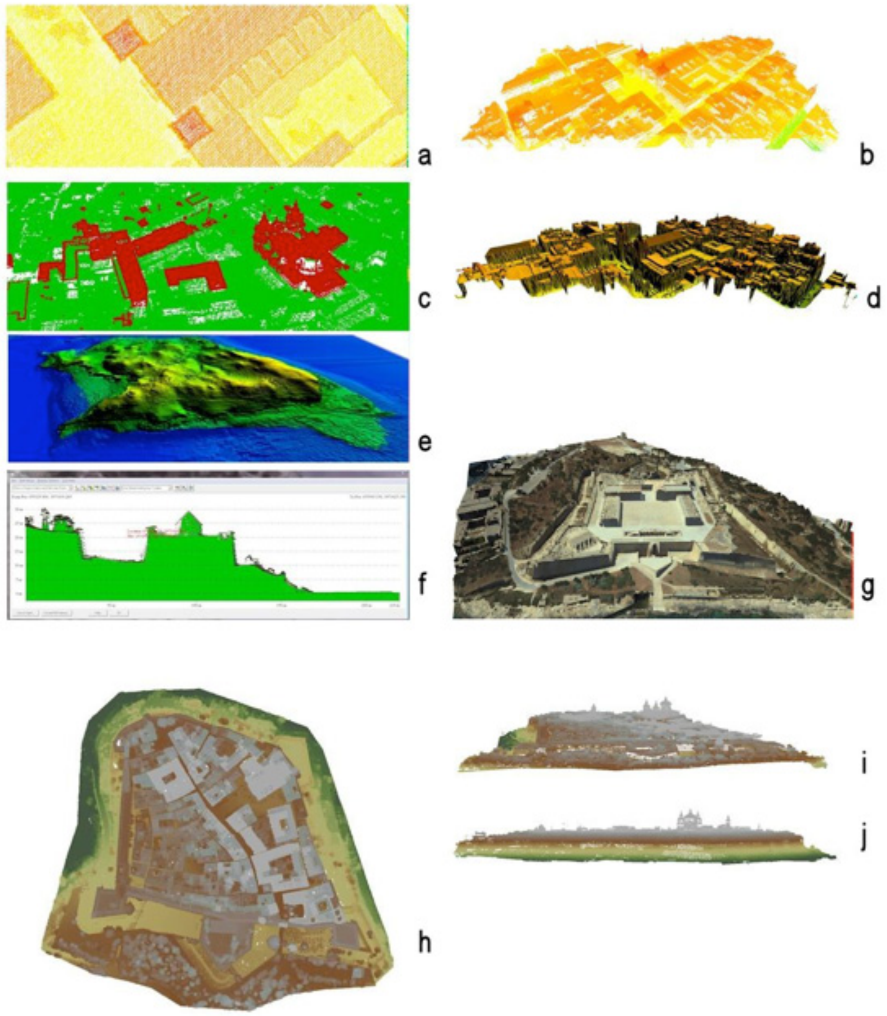

Figure 3. Steps towards smart integrated cities:

(a) LiDAR scan at 4 points per m.sq. was run to enable a time-stamped baseline for post-scan change analysis;
(b) 3D output based on figure a) where the height differences in the DEM (Digital Elevation Model) is analysed;
(c) extraction of potential illegal height developments, where the highest points are analysed against the established height limitations;
(d) TIN development layer outputs is resultant from a rasterisation of the LiDAR point data, which result enables users to view the zone in a 'landscaped' form;
(e) sea-level rise analysis that can predict potential zones that could be inundated as well as zones that were inundated in historical eras;
(f) cross-sectional analysis that planners employ to view landscapes and development shapes;
(g) 3D printed output enables planners to view the eventual outcome of their decisions;
(h-j) entire medieval city plan preparation in 3D visualisation enables users to interact with the LiDAR data and view the point files from different viewpoints.

The outcomes from the infrastructure aspect include the development of a new Basemap for the Maltese Islands, the alignment of all spatial data in a common projection, the creation of an online dissemination and analysis spatial information system, the setting up of necessary infrastructure to enable the entire data cycle (design-input-analysis-output-reporting) and the development of the necessary infrastructure to future preparedness. The outputs from the new project will enhance the outcomes from a project funded by ERDF that enabled MEPA to create an entire nation point cloud, rendered full public access to the information and enabled 3D views to all. The move towards a smart city approach will employ these datasets, integrate them within new infrastructure and allow immersive interaction within the new datasets, literally ensuring that planners are able to view the effects of their decisions in realistic scenarios. Figure 3 depicts such outcomes through its depiction of base point data (averaged at less than 15cm height accuracy), development processes, thematic analysis, and dissemination of derived data such as TIN/DEM models through the web-services or download services.

The second aspect will strive to building human capacity in the spatial themes across all governmental entities, whilst the third aspect will ensure adherence to the INSPIRE Directive and relevant legislation as well as the creation of a series of protocols that enable the free exchange of data and knowledge across the entities.

6. Conclusions

In conclusion, the creation of a spatial information system for the Maltese Islands was simply the first step at attempting to understand how to create systems for employment by planners in a realistic and achievable scenario. The project was successful in its attempt to bridge the gap between analogue information and spatial planning information that depends heavily on locational data. Through an analysis of the legislative tools and the implementation processes undertaken to initiate the process that will eventually lead to a smart city data construct, the results show that the base-data steps taken will ensure the eventual integration of baseline and thematic datasets for effective future analytical processes. The Malta case study was only made possible through the intervention of various initiatives as delineated by the different Directives and conventions as well as national legislation. As both planning and environmental data were readily available, these processes were easier to employ and the resultant project outputs showed that it was possible to create new tools and systems that planners could use in their day-to-day professional activities and knowledge development. The next step, that of integrative processes across all government entities aim to further widen this knowledge which will result in new data integration such as geological, underground infrastructure, street furniture, watersheds, road networks and hundreds of other currently stand-alone datasets.

Interestingly, the process is not without its successes and lesser achievements. The impact of such an activity in the Maltese state is not insignificant, with the resultant pressures effecting directly and indirectly the modus operandi of the entities that partook to the activity. Training, realignment of job descriptions, new staff intake, re-training and capital expenditure were experienced. The drive enacted by the entity running the process resulted in a cascading effect on other entities that might not have been ready for such a change and in turn bottlenecking occurred that might slow down the expansion of the process across other entities, leading to slower uptake of the national process. This said, the fact that the activity was successful in the driving agency and that the impacts have already been experienced have enabled the laying of the foundation-stone for information integration leading to smarter environments.

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