D.T.2.2.2. METHODOLOGICAL MODEL FOR AN INTEGRATED MONITORING SYSTEM

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INDEX

FOREWORD

Methodological model for an integrated monitoring plan is based on deliverable 2.2.1 State of the art and monitoring system requirements and describes steps of the monitoring process in more concrete details that include proposals for an efficient and effective monitoring system. It describes why monitoring is needed, what is possible to monitor, who is active in the monitoring process and briefly described possibilities for monitoring. Methodological model is focused on the more detailed description of how to implement monitoring and steps in it.

Also in DT221, the monitoring process is defined as a set of procedures that can be divided into:

1. data collecting
2. data processing and analyzing
3. data sharing

CHAPTER 1

FIRST STAGE

The first stage consists of the definition of:

- Main interests (topics for monitoring)
- Selection of data for monitoring (indicative list of available data and needed data)
- Role definition (description of active parties)

More information is a part of DT221 within chapters 1. A brief introduction to the needs (Why monitoring), 2. What is possible to monitor, 3. Active parties in monitoring (Who monitoring).
The following table represents a try to summarize the results of the analysis made among the partnership to produce DT111 and DT221.

This analysis is the base on which it was possible to build this deliverable, by combining technical issues and opportunities with the specific features and needs of HBAs, as know through the previous project's activities.

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D.T2.2.2 Methodological model for an integrated monitoring system

	DATA OWNER *(who has the data now)*	DATA COLLECTOR *(who should search for and collect the data)*	VALUE *(why to monitor those facts, which purpose and importance)*	PROBLEMS *(main difficulties in collecting and using the data)*
BUILT SPACES AND OBJECTS CONDITIONS	Several Building offices of the Municipality & private owners and technicians for "common" historic buildings National offices, big private owners and municipal officers for monumental buildings	Ideal solution would be a shared Data Base where every involved subject inserts its specific data. Then, 1 responsible person monitors the situation	These are basic data; from them it's possible to start specific monitoring activities	The data, if existing, are sprawled among different actors. The ICT solution to collect and process the data are often not interoperable.
ENVIRONMENTAL FEATURES	Municipal Offices Energy Agency Energy/ Multiutility company Private/public owners or lodgers	According to the goal of monitoring.	Environmental behaviour of HBA is not to be treated as the one of a new built area, it needs specific competences and specific approaches, when environmental issues should be balanced with aesthetic and cultural-historic value.	Often, environmental data are really technical and related to single buildings; the challenge is to find a way to identify the right level of degree to involve this phaenomena among the general monitoring on a HBA.

SOCIAL COMPONENTS	Municipal offices (often not related to constructions or heritage) Private associations	The involvement of private subject could be the best wat to collect data in a shared DB	The social dynamics should be integrated among the policies related to spaces and buildings, because pro-active participation of final users, possible financers and managers is the only effective way to ensure durability and effectiveness of the actions, especially on areas with cultural and identity's value like HBAs	Moreover, many data are not already available and would be to be ad hoc collected for this approach to the management.
ECONOMIC ASPECTS	Municipal Offices Energy Agency Energy/ Multiutility company Private/public owners or lodgers	Municipal offices (only for public goods) National Bodies (for monumental public goods) Private owners Technicians.	The monitoring of maintenance and intervention's costs on HBA represents the base to plan priorities and urgencies and to identify the possible sources of financing processes.	The data are sprawled among different subjects and also not so easy to be interpreted in an effective, shared way

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CHAPTER 2

DATA COLLECTING

3.1 Selection of the monitored area

Demarcation of interest area is an essential step for efficient monitoring. Data should be collected for a specific area. The extent of this area is individual and may vary in size. It is possible to select an extent for the main monitored area and for wider area of interest.
The extent of selected area may affect a definition of the degree of detail (monitoring scale) and access to data. These two factors must be taken into account.
The main monitored area can be defined as one building, several building, compact historic building block, compact historic area, or separate areas.

3.2Description and selection of methods

Almost every research in an early stage begins with the **desk research method.** Desk research is basically involved in collecting data from existing resources (currently available data, historical records, archaeological records, photography, geometric plans, …) hence it is often considered a low-cost technique as compared to field research. This method requires a relevant knowledge of researcher. Desk research is very effective in starting phase and a base for next monitoring procedures. The output is a wide range of collected information.

Next useful method is a creating and completing of **forms or standard checklists** based on site visit, familiar information, recorded observations, photographs, or on the output of desk research. The monitoring forms comprise a series of boxes promoting the collection of structured information, together with free-format fields chosen to reflect the particular characteristic of monitored subjects. The output is a structured database of descriptive information about monitored subjects (buildings, areas, constructions, …).

The monitoring requires the acquisition of some new necessary

using **measuring methods.** These methods include remote sensing, measurement of energy flows, statistical and technical measurements using some sensors and meters.Some monitoring objectives can require a cooperation with the public to get some data about the selected area. This method is called the **crowdsourcing.** It consists of using people as living sensors. It requires some interactive actions such as questionnaire survey, information submitting via the Internet, social media or smartphone apps.

3.3 How to identify a right scale for monitoring

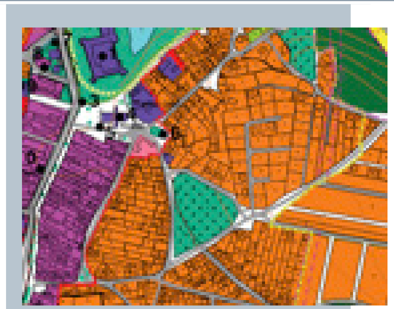
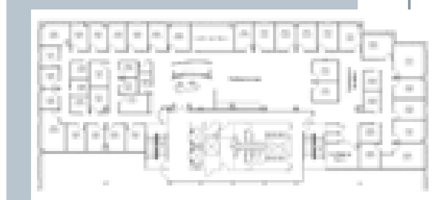
Monitoring methods should be applied at a specific scale. The scale selection depends on the extent of selected area and on the ability to get needed data. This choice will affect a degree of details. The more accurate information on existing objects may lead to an optimal design of monument restoration. Some information related to the scale for monitoring are part of DT221.Different levels of monitoring in historic areas are recognized in table 1 and relevant tools for monitoring according to scale are specified in table 2.

3.4 How to set a periodicity

Following DT221, the periodicity of monitoring is a next aspect that must be taken into account. It is not generally possible to determine how often every HBA should be monitored. The frequency depends on the nature of monitored data and on the organization, which is responsible for monitoring. However, rules for periodicity must be specified. These rules are divided into a strict and ad-hoc periodicity.

Strict periodicity can be realized in short-term or long-term fixed cycles. There is an option to link it to some local strategy or development program if it is bound for some period (e.g. City Development Programme for 5 years).

Ad hoc periodicity is based on needs (e.g. new planned activity in the area) or milestones (e.g. before and after intervention).
However, there is a need for first time monitoring that is essential for strategy making including some measures and recommendations for intervention.

LEVEL OF SCALE	MAP SCALE	VISUAL CHARACTERISTICS (main focus)	SAMPLE OF DETAILS
SMALL	1:5 000 and less detailed	Whole city/town, Urban districts, large urban blocks, land-use, schematic maps, land-use plans, ... (typical area 500 ha and more)	
MEDIUM	1:1 000 – 1:5 000	Urban blocks, building blocks, streets, master plans, ... (typical area 5 ha – 500 ha)	
LARGE	1:200 – 1:1 000	Urban zones, detailed building blocks, buildings, zonal technical maps, ... (typical area 0,5 ha - 5 ha))	
DETAILED ON BUILT STRUCTURES	More detailed than 1:200	One or pair of buildings, floor plans, building details, architectural plans, ... (typical area 0,5 ha and less)	

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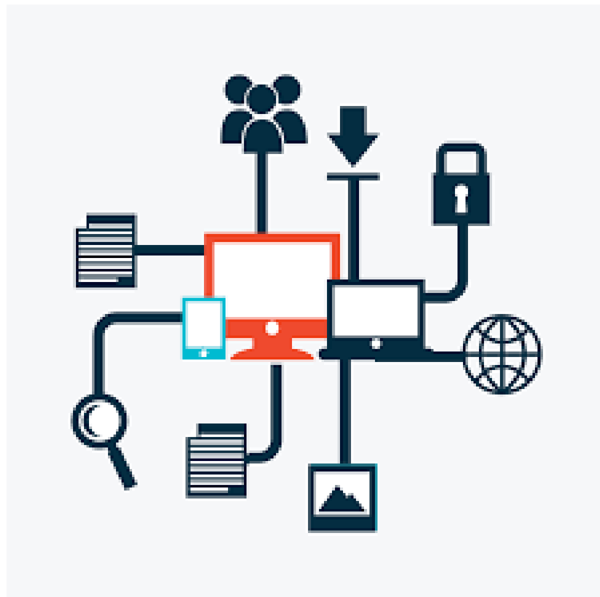
TOOL	MONITORED AREA	SMALL SCALE	MEDIUM SCALE	LARGE SCALE	DETAILED SCALE
GIS	wider area of interest	↔	↔		
GIS	main monitored area		↔	↔	
BIM	wider area of interest		↔	↔	
BIM	main monitored area				↔

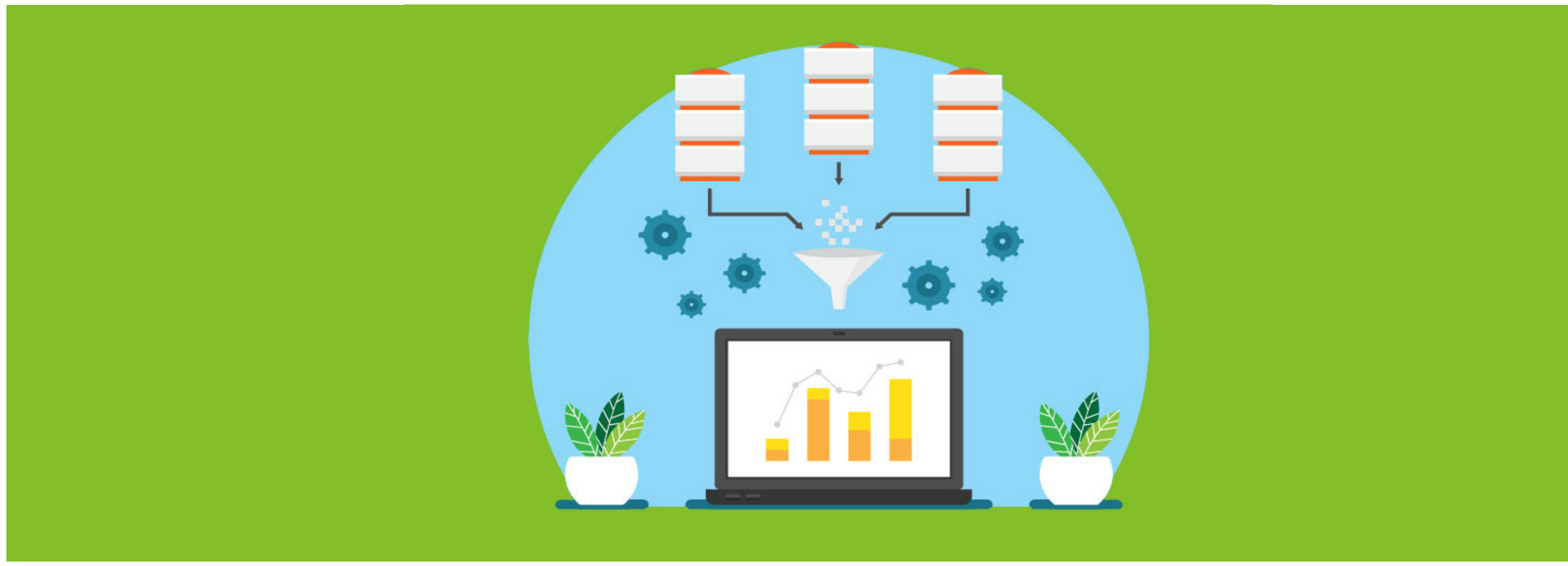
Table 1: *Scale for monitoring*

Table 2: *Relevant mapping tools*



CHAPTER 3

DATA PROCESSING AND ANALYZING



Data processing is, generally, the collection and manipulation of items of data to produce meaningful information (French, 1996).

3.1 Data processing functions

Data processing may involve various processes, including:

- Validation – Ensuring that supplied data is correct and relevant.
- Sorting – arranging items in some sequence and/or in different sets.
- Summarization – reducing detail data to its main points.
- Aggregation – combining multiple pieces of data.
- Analysis – the collection, organization, analysis, interpretation, and presentation of data.
- Reporting – list detail or summary data or computed information.
- Classification – separation of data into various categories.
- Transformation - converting data or information from the format of a source system into the required format of a new destination system

3.2 Data processing requirements

Data and information collected in the previous stage must be processed to provide clear and comprehensive information. This process uses different processing functions. The aim is to review and to evaluate monitored data in the context.

For example, contextual evaluation for energy efficiency is a result of the comparative analysis that uses data about measured energy consumption recalculated per building volume, floor area, number of inhabitants/ occupants, etc. Then the output can be used as an energy rating of buildings.

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It is important to follow indicators that will show gaps or problems and prove the necessary interventions. This procedure requires to find tolerance ranges and the threshold level, and to use some database operations such as query and statistical analysis.

3.3 Using of ICT tools

DT221 declares a potential of modern digital technologies such as Geographical Information Systems (GIS) and Building Information Modeling (BIM) to provide a clear information, identify vulnerabilities, measure and register changes, and to process comparative analyses. The main advantage is the ability to link spatial (geometrical) and non-spatial (descriptive) data of physical features. It allows knowing the conditions of the object practically with one click on the map or model.

3.3.1 Using of GIS

A geographic information system (GIS) is a computer-based tool for mapping and analyzing spatial objects and data within some territory. GIS uses a wide range of processing functions that can be divided into location-based and analytical.

Location-based functions provide the identification or estimation of the real-world geographic location of some objects. For spatial data creation is commonly used placement of new features (polygons, polylines, points) directly into the map with geographic coordinates. Next examples of most used location-based functions are:

- Geocoding - This process assigns geographic locations to features directly from attribute data that contain locational information within a data file. There are two types of geocoding: coordinate locations and address matching.
- Georeferencing of raster data - Any image can be entered into a GIS, but to be useful, the image needs to be placed in its proper geographic location. Georeferencing aligns images to their spatial location.
- Georeferencing of vector data – a similar process like with images, but with vectorized data such as CAD outputs.

- Spatial adjustment – This function is used when some spatial features are located with wrong coordinates.
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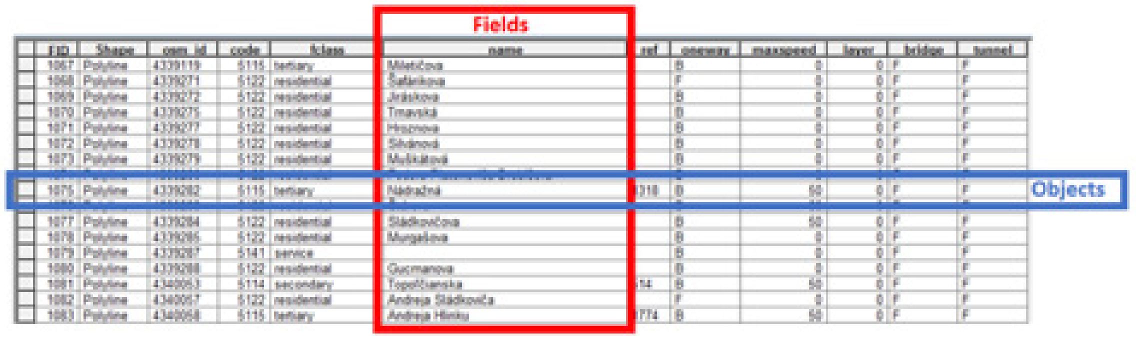
Analytical functions work with located features and integrate a wide range of query, statistical and spatial analyst tools. Outputs can include



Picture 1: Example of attribute table in GIS

new generated spatial data or new attributes assigned to existing data.
Spatial data is displayed as objects with a geographical location in the form of points, lines, and polygons (areas) to which descriptive information is attached in the form of attributes. Attributes are visualized in the table, to every single object is assigned one line and characteristic information is sorted in columns that are called fields (see picture below).
The output of GIS processing is called the spatial data infrastructure (SDI). SDI is a set of collected or processed spatial data that can include vector data (e.g. shapefiles, geodatabases, …) and raster data (e.g. georeferenced images, generated raster during geoprocessing, …).

3.3.1 Using of BIM

Building information modeling is a computer-based process for modeling and managing buildings, constructions, and relevant data. Many users and software developers stop at the first benefit of BIM. They consider BIM to be a kind of glorified computer-aided design (CAD). Traditional CAD applications are based on tools for drawing 2D drawings or creating geometric 3D models. BIM offers a new way of working using intelligent elements of the information model and helps to reduce costs and accelerate construction schedules (Taylor, 2017; CAD studio, 2018). The

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most used formats for BIM projects are .rvt or .dxf.
BIM uses processing functions that can be divided into modeling and analytical.

Modelling functions allow creating a model of the building and detailed elements of objects and spaces. Analytical functions include tools for processes such as calculating areas, energy consumption, structural properties, simulation of building performance, etc.

Using BIM as a software application gives users the following advantages:

- 3D visualization of buildings
- Data management - different kinds of project data (schedules, photos, scans of handwritten notes), Building Document Management, Project Data Management
- Operational management - check building performance over the lifetime of a building
- Advanced analysis - energy analysis, static analysis, collision detection, coordination, construction simulation, feasibility assessment, mechanical simulation, airflow, thermal comfort, etc.

CHAPTER 4

DATA SHARING

The aim of data sharing is to provide comprehensive information that is easily accessible and simplifies the process for obtaining the required information about HBA.
Spatial data processed in GIS can be visualized on the web via WebGIS technology. Data processed by BIM technology can be published on the web via BIM portal. Next opportunity for spatial data sharing is to publish it in the way of open data. These data must be harmonized for publishing.

Picture 2: *Scheme of data sharing process*

4.1 Data harmonization for sharing

The data harmonization consists of data transformation following some rules and requirements. These rules concern:

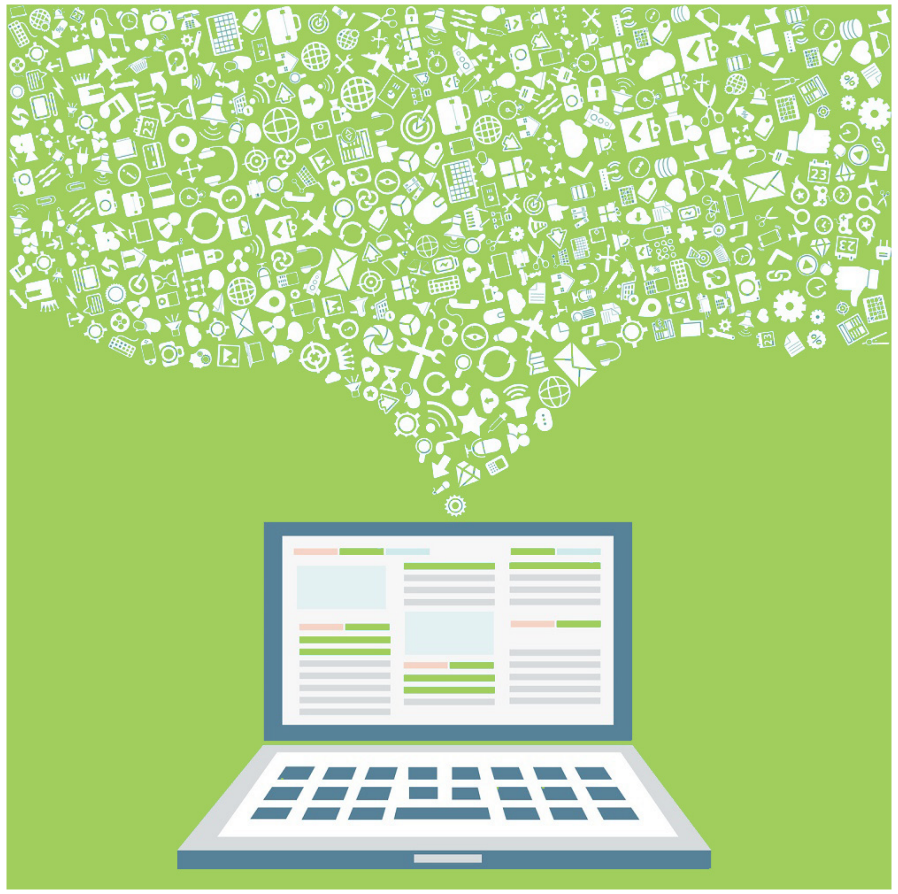
- Data format requirements
- Setting of the graphics and attributes
- Metadata1 and data description

Listed aspects will be specified in later steps of this project. The formulation of rules can be inspired by Directive 2007/2/EC, an EU initiative to establish an infrastructure for spatial information in Europe (INSPIRE).

CHAPTER 5

COMMON RISKS, CHALLENGES, AND RECOMMENDATIONS

The main goal of monitoring is to get data that will be contextually evaluated and show potentials, key problems, and differential comparison. Following DT221 and chapters above, there are some risks and recommendations how to avoid them. Some of these risks and recommendations are described in the following table.



RISK	RECOMMENDATIONS
A lot of unnecessary data	Every data must have a purpose and follow relevant interests for certain HBA.
A wide range of stakeholders	Cooperation managed by municipality and role definition. Parties can be involved in the various monitoring activities.
Generic statistical or indicative analysis of the urban area is not sufficient. Detailed analysis of the area is time-consuming and can require expensive professional expertise.	Monitoring methods should be applied at a specific scale. An ability to get needed data, an extent of selected area and a degree of details must be taken into account.
Inability to record changes and to evaluate	The focus must be on indicators that can change their value. The frequency of data acquisition and analysis must be defined. To find tolerance ranges and the threshold level.

Some processing operations can require an advanced IT background:

- **Structured Query Language (SQL)** is a domain-specific language used in programming and designed for managing data held in a relational database management system (RDBMS), or for stream processing.
- **Python** supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library.
- **JavaScript (JS)** is a high-level, interpreted programming language that is also characterized as dynamic, weakly typed, prototype-based and multi-paradigm.

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