An information management framework for optimised urban facility management

N. Moretti[a], M.C. Dejaco[a], S. Maltese[b], F. Re Cecconi[a]

[a]Department of Architecture, Built environment and Construction Engineering (ABC), Politecnico di Milano, Italy
e-mail: nicola.moretti@polimi.it, mario.dejaco@polimi.it, fulvio.rececconi@polimi.it

[b]Department for Environment Construction and Design (DACD)
University of Applied Sciences and Arts of Southern Switzerland (SUPSI)
Institute for Applied Sustainability to the Built Environment (ISAAC), Switzerland
e-mail: sebastiano.maltese@supsi.ch

Abstract –

Information management for Urban Facility Management (UFM) is a key enabler for a more sustainable built environment [1]. This paper presents a further development of a case study research concerning the implementation an innovative UFM service. The UFM process is enabled thanks to a robust data engineering approach and Information Technology (IT) tools, based on Database Management Systems (DBMS) and Geographical Information Systems (GIS). The proposed methodology allows to streamline the survey phase enhancing the UFM services already in place, according to a continuous improvement logic. The scope of the research concerns the implantation of effective facility management methodologies, [2] through the use of current Information Communication Technologies (ICTs). The case study research concerns a business district in San Donato Milanese, Italy. After two years since the kick-off of UFM service, thanks to data provided by the UFM company operating in this context, authors aim at presenting advantages of adopting the proposed methodology. Information available concerns cost, technical historic datasets and budget CAPEX data until 2019. This information is georeferenced and processed through geo-spatial algorithms, in order to obtain spatial analysis and representation for monitoring and improving the UFM service. In conclusion, it can be stated that the proposed approach can improve UFM process fostering information management among stakeholders and reducing operational expenditure.

Keywords –

Urban Facility Management, Data engineering, GIS, Information Management

1 Introduction

Management of the built environment is characterised in the last years by the increasing of the complexity of physical assets, as well as the high number of stakeholders and the pervasive use of Information Communication Technologies (ICTs). Real estate is providing constantly a huge amount of information which must be collected, managed and exploited for the optimisation of the management process and for the achievement of a more sustainable built environment.

Facility Management can be intended as an effective strategy for restoring performance of assets to a proper level of quality, in order to provide a good environment for human beings, within the sustainability framework. This concept, despite being wide and opening to further specifications and insights, can be extended to the urban environment. Accordingly, Urban Facility Management (UFM) can be implemented to provide an integrated array of services supporting operation, fruition and valorisation of urban goods [3].

This paper presents an update of a case study research carried out in 2015 concerning the support for the implementation of an UFM service in San Donato Milanese, Italy [4]. For this purpose, an information system supporting the survey phase has been developed. Information are gathered and managed thanks to a Data Base Management Systems (DBMS) jointly with Geographical Information Systems (GIS). The outputs of the process are thematic maps, used for leading strategic decisions on prioritisation of maintenance and restoration interventions in the neighbourhood. The system has been employed in the kick-off stage of the UFM service. The survey and reporting tool has been applied and partially embedded in management procedures of the company appointed for the implementation of the UFM service.

In §4 a quantitative and qualitative analysis of data concerning the maintenance cost and investment undertaken on the management of the urban precincts is presented. These analysis, show that, thanks to the implementation of the system, cost for corrective maintenance decrease, despite a different trend can be highlighted in the last year of analysis (2017). The paper concludes with some insights and further development of the methodology and the whole research. Moreover, drawbacks and limitations are highlighted.

2 Data engineering for UFM

Urban OM&R can be intended as a set of actions carried out to keep or restore performances of urban goods to an adequate level [5]. Therefore, they are primary issues in management of the built environment. Moreover, OM&R can be encompassed in a wider framework, namely the Urban Facility Management (UFM), which comprehends a series of services, procedures and actions for enhancement of operation, fruition and valorisation of the urban goods in order to achieve a better quality of the built and open environment [3][6]. Considering an overarching strategy of resource saving, these issues acquire outstanding relevance, to foster sustainability of buildings and, more in general, of the built environment [7].

Different players in the real estate, belonging both to the private and public sector, contribute to the management and production of information. The public player on one hand assumes a role of legislator providing guidelines and frameworks concerning the types of information that must be collected, recorded and certified for validating building procedures and operations. On the other hand, it produces and preserve itself a great amount of data. Thus, it assumes a double characterisation. It can be considered a supervisor, since it has a responsibility in terms of compliance checking of reliability and accuracy of information requested to the private player during design, execution, use and management phases of buildings. While executing this role, it must be also compliant with the rules and codes developed for the purpose [8]. As a consequence, the public player plays both a proactive and coercive role.

In the same context, it is needless to say that private player is forced to produce compulsory documentation related to its real properties. Moreover, it is appointed for the management, updating, and conservation of this information.

Nevertheless, it is not always easy to assess and determine the responsibility and compliance with codes and laws. Therefore, in those situations where the uncertainty increases, tools for information management acquire a key role both at the building and territory level.

For reducing uncertainty in OM&R, the authors identified a set of information both for building and urban precincts that should be taken into account. These core information collections are called *Building Logbook* and *District Logbook* [9]. Table 1 and Table 2 list the main information contents of the tools cited above.

Table 1 information categories and contents of the Building Logbook [9].

Section	Information to be collected
Building registry info	• Concerning the urban registry information and the updated internal subdivision in sub-units.
Information about the property, management and tenancy	• Updated documentation on ownership, • updated documentation on tenancy and related contracts and agreements, • documentation concerning the management structure, appointed to the management of the building (concerning leasing contracts and technical management contractors).
Technical info on building elements	• Building breakdown, • description of technical, typological and functional characteristics of components,
Operative info for management and maintenance	• Documentation related to technical, administrative and economic management of the building, • safety and certification documentation.

Table 2 information categories and contents of the District Logbook [9].

Section	Information to be collected
Urban and building registry info	• General information about the neighbourhood, • quantitative data and reference to infrastructures, urban facilities and buildings, • urban planning info.
Population registry info, property management and tenancy	• Data on the population of the neighbourhood, • data on city users, • data on management entities.
Technical info on urban goods and elements	• Location, • ownership/responsibility/manager, • geometric info,
Operative info for management and maintenance	• technical condition, • instructions/procedures/guidelines for maintenance and management, • safety measures, • plan/program for maintenance.

As can be seen, the information required by the two core information collection is rather wide and complex. Moreover, it can be considered as dynamic collection of data, updating time by time whenever a changing at the building or at the district level happens. The Building and the District Logbook should be used for the reduction of the uncertainty in transaction and use phase, since they can be considered as risk prevention tools for technical, economic and legal issues in management of the built environment. Through their use, crucial information could be easily found used as proof of compliance with laws, building or urban performances etc.

When the scale of the intervention is the neighbourhood, the District and the Building Logbooks should be used jointly, in order to enable the stakeholders to timely access information. In the following paragraphs a description and update of a case study concerning the implementation of a UFM service is described. This experience must be encompassed in the framework described above, especially for what concerns the implementation and management of the District Logbook for the sections titled *Technical information on urban goods and elements* and *Operative information for management and maintenance.*

3 Case study

The system, has been applied, fostering the setup of an Urban Facility Management (UFM) service for Quartiere Affari in San Donato Milanese, Milan, Italy.

The purpose of the information system, concerns the speed-up of the survey phase. Thanks to its possibility to manage a great amount of information, a Geographical Information System (GIS) has been adopted. GIS potentiality is enhanced through the joint use of a Database Management System (DBMS). These tools are integrated with a survey module, mounted on portable devices (e.g. smartphones and tablets). Exploiting the aforementioned tools, it is possible to ease and systematise the urban environment's assessment process. Accordingly, the times for urban components' detection have been significantly reduced. In Table 3 key data of the survey campaign are summarised.

Table 3 Survey key data

Description	Data
Tot. failures detected	476 (297 failure forms)
People involved	4 people in 2 groups
Roads	Approx. 2.500 m
Square	Approx. 9.000 m^2
Average survey time for 100 linear meters	1:00 h
Duration of the survey campaign	1 week

The survey has been carried out on the neighbourhood, to collect data concerning the status of urban components, identified according to a breakdown structure previously defined [3]. Information collected concern:

- typology of the pathology detected,
- different levels of necessity of intervention (from long term to urgent),
- safety for users,
- pictures of the pathologies on the urban elements,
- comments [10].

Information are gathered thanks to the use of a mobile application developed for the purpose and stored in a web database (*Assessment* phase in Figure 1).

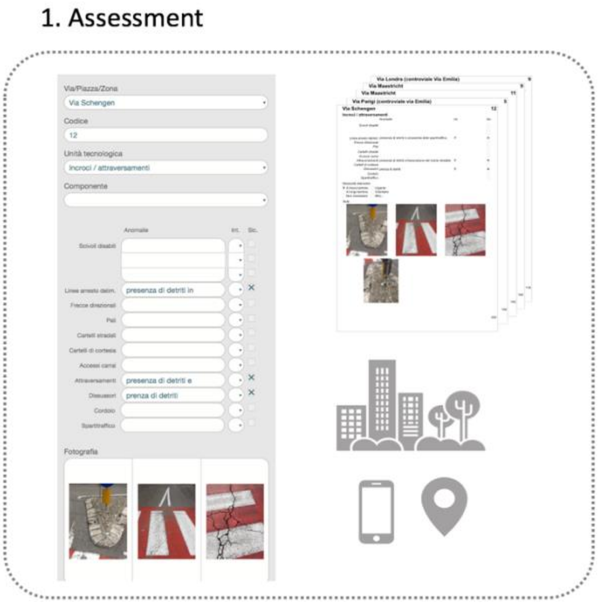

Figure 1. Survey process schema. Phase 1 Assessment

Data are then georeferenced using a GIS platform. In the *Data analysis* phase (Figure 2), information collected during the survey campaign has been processed and organised both through quantitative and spatial analysis. Combining these two types of analysis it has been possible to spot the most critical urban components and urban precincts (phase *Data output* in Figure 2).

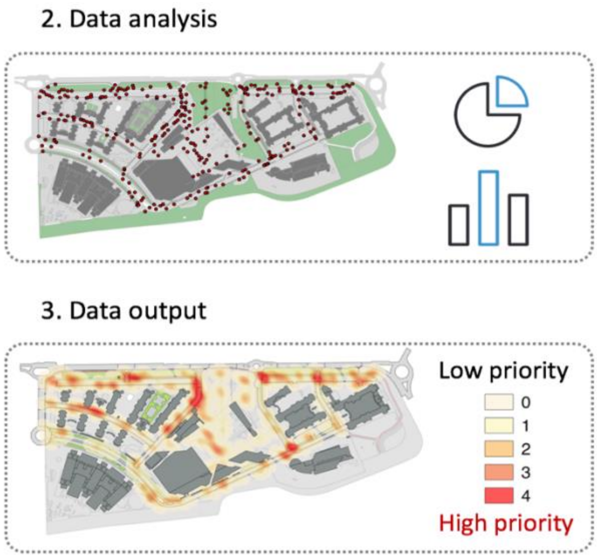

Figure 2. Survey process schema. Phases 2 Data analysis and phase 3 Data output

Identification of most critical entities, allowed to prioritise maintenance and repair interventions [4]. Most critical areas are highlighted in Figure 2 *Data output* thanks to a map showing the concentration of pathologies of components in a circle of 20m of radius.

Thanks to the analysis performed and described above, it was possible to identify that the crossroads are the most critical technological units presenting also issues related to safety for users (therefore, more critical). Following a descendent level of priority of intervention, urban drainage system is identified as second most critical technological unit. As for what concerns the crossroads, also this entity is subject to a high level of stress, especially if located in roadways characterised by heavy vehicular traffic. The third most critical technological unit is the walkway. Spatial analysis concerning the concentration of degradation in a radius of 20m has been carried out and combined with quantitative analysis. While the trends in degradation of technological units described before is confirmed, this data processing allowed to identify, the precise location where the degradation phenomena appear [4].

4 Maintenance costs analysis

The survey phase has been carried out in 2015, thanks to the information system described in the previous paragraphs. After that, the company in charge, developed the investment and UFM plan. Thanks to a collaboration with the UFM company, we could access the cost and technical historic datasets and budget data employed for the implementation of the intervention needed for bringing the maintenance and functional status of the neighbourhood in optimal condition. Moreover, the UFM company, partially integrated its management and survey procedure with the assessment and framework provided by the authors. Despite the complete adoption of new technologies and procedures, as recursive procedure to be carried out periodically, can be considered as a long term process, the cost trends in term of OM&R expenditure, confirm an improvement over the years.

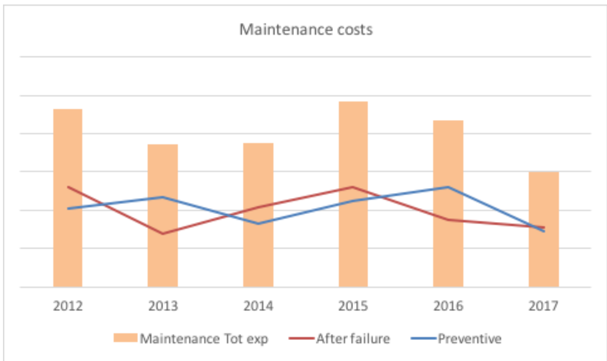

Figure 3. Maintenance expenditure trend from 2012 to 2017.

The cost chart in Figure 3, represent the trend of maintenance expenditure from 2012 until 2017, namely the period in which the UFM company has been appointed. As can be seen, the cost trend of the after failure maintenance (in red) and preventive maintenance (in blue) show a higher investment in preventive maintenance in 2012, namely the starting year of the UFM contract and in 2016, after the survey and assessment phase carried out by the authors. Nevertheless, in 2017 can be spotted an increase of the expense of the after failure maintenance. In 2017 can be also spotted an increase of the expense of the after failure maintenance, despite the total maintenance expenditure assumes the lowest value since 2012.

Lower investments in maintenance are compensated by high investments in CAPEX. Area in the neighbourhood identified through the survey as most critical in terms of safety for users, intensity and concentration of degradation phenomena etc. have undertaken a refurbishment process. In Figure 4 are represented the cost trends in term of investments for the rehabilitation of the areas described above and for maintenance (corrective and preventive). The trends depicted in the chart show that a higher CAPEX injection in rehabilitation of the urban areas, corresponds to a decrease in maintenance expense. Unfortunately, preventive maintenance expense forecasts for 2018 and 2019 are not available.

Figure 4, on the other hand shows an interesting trend for total CAPEX injection for years from 2016 to 2019. For privacy reasons, CAPEX, as well as the maintenance expenditure magnitude, is not reported in this paper as precise amounts but as a percentage of the total CAPEX injection during the investment period (2016-2019). The representations in Figure 5 and Figure 6 show a correlation between the localisation of failures, detected during the survey, characterised by the safety issue attribute and the urban precincts where more intensive investments have been dedicated.

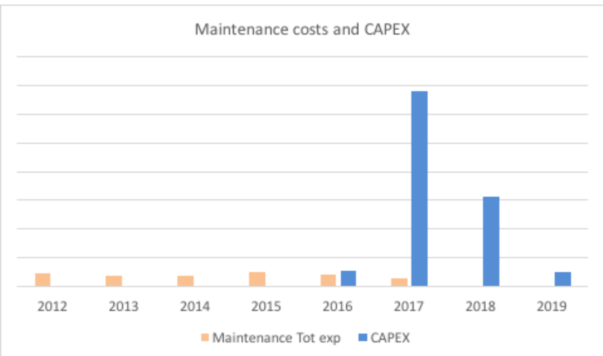

Figure 4. Maintenance expenditure (2012-17) and investment trend in refurbishment (2016-19).

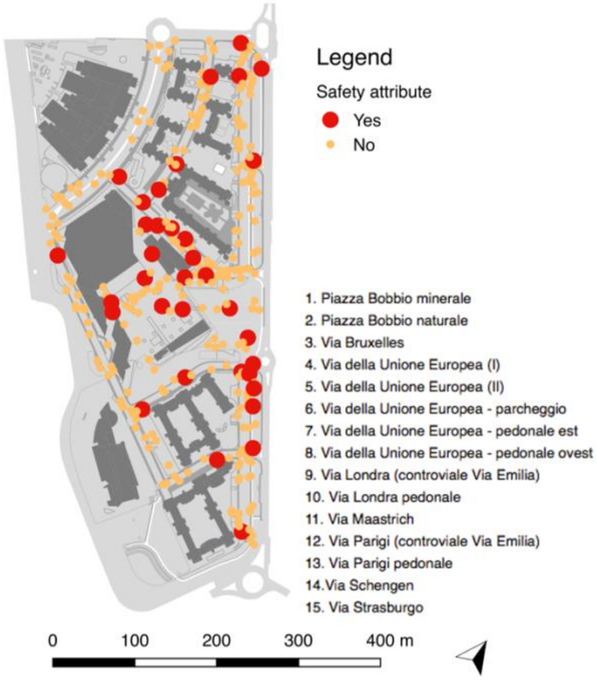

Figure 5. Localisation of failed components with safety attribute

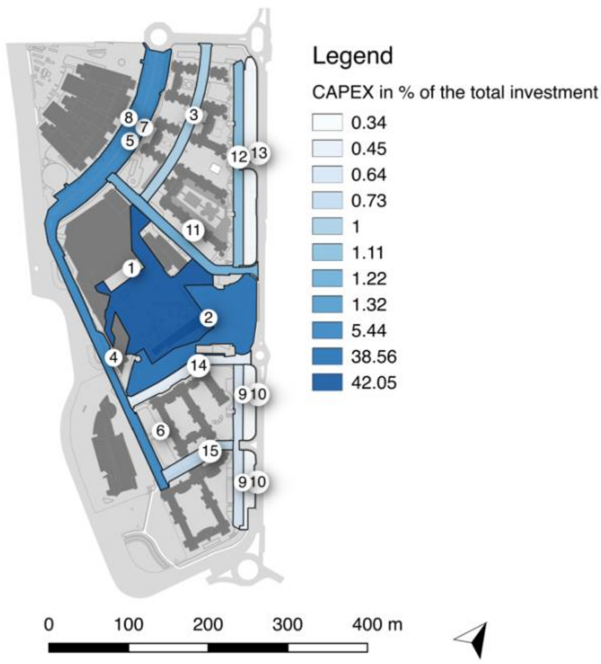

Figure 6. Localisation of CAPEX investments in percentage of the total

InTable 4 are summarised the number of detection of failed urban entities characterised by the attribute safety, in the urban precincts represented in Figure 6.

Table 4 Number of detections with safety attribute in the urban areas

Code	Area	Safety detections
1	Piazza Bobbio - minerale	9
11	Via Maastricht	6
10	Via Londra pedonale	4
3	Via Bruxelles	3
14	Via Schengen	3
2	Piazza Bobbio – naturale	2
9	Via Londra - controviale Via Emilia	2
12	Via Parigi - controviale via Emilia	2
13	via Parigi pedonale	2
4 – 5	Via della Unione Europea	1
15	Via Strasburgo	1
6	Park via Unione Europea	0
7	Via della Unione Europea - pedonale est	0
8	Via della Unione Europea - pedonale ovest	0

Among these areas precincts 1 and 2, corresponding to the neighbourhood’s central square are receiving more than 40% of total investments on the period considered. This peculiar situation is due to the fact that being a spaces frequented by many users during the day, the degradation phenomena where more critical than other urban precincts, thus they required a higher injection of capital for the refurbishment intervention. Moreover, this higher amount of resources is due also to the extension of the area (approx. 9.000 m^2). Other peculiar situation can be highlighted for what concerns the precincts 4, 5, 6, 7, 8 Corresponding to via dell’Unione Europea. Despite in this area can be found only one detection presenting the safety attribute, it is the third more expensive precinct in terms of CAPEX injection (5.44%). This is due to the fact that though not affected by degradation with safety attributes for users, the number of detection is rather high.

Nevertheless, it must be taken into account that the only economic data, does not provide a dimension to the kind of refurbishment or restoration intervention carried out. Accordingly, it is necessary to combine these evaluations with others (technical, qualitative etc.) in order to obtain a more comprehensive picture of the whole neighbourhood’s status. These further datasets could be obtained thanks to the recursive implementation of the survey phase. To conclude, it must be highlighted that Figure 4 does not represent the geographic representation of the total CAPEX. Values of investments on underground parking has been neglected, since they have been considered as separated entities for the whole development of the case study research.

5 Discussion and conclusions

Through the description of the case study research and thanks to the collaboration with the company appointed for the UFM implementation, it has been demonstrated how the precise definition of the information contents to be collected and management during the survey phase and for carrying out the UFM, it is possible to make informed investment decision of OM&R. This experience demonstrates that, adopting the survey system and the related procedure for assessment and data handling, UFM services can be better organised and performed faster, nevertheless, thanks to its modular structure, it allows the integration of different thematic modules [11]. Therefore, GIS software allowed to import information detected during the survey in thematic maps, exploited to define the level of degradation of some urban areas and to guide maintenance interventions. The system developed is dynamic and flexible and is updated through IT tools which take advantage of relational databases. Moreover, it can be considered as a risk prevention tool from both client and supplier point of view.

The system, despite being a powerful tool for data collection and analysis in the built environment, so far, lacks of integration with Building Information Modelling (BIM) editor software, even if it can be considered as compliant with the information management addressed by BIM procedure [12]. Thus, the system, can be considered as a first step toward the development of a more comprehensive Asset Information Model (AIM).

The methodology for economic assessment of the benefit in the adoption of the proposed system is based on the comparison between the quantitative data analysis against the spatial analysis allowed by the use of the GIS platform. This approach allows to describe and analyse cost performance trends in a wider and a more complete way. The economic expense for after failure maintenance and preventive maintenance can be related to the condition assessment of the neighbourhood, showing interesting trends before and after the survey has been carried out. Nevertheless, it was not possible to analyse the trend of the CAPEX injection, related to the current status of the urban areas. Only an assessment concerning the status as of 2015 compared to CAPEX budgeted from 2016 to 2019 has been possible. This is due to the fact that, despite the survey process to be implemented through the proposed system has been partially embedded in the procedures of the UFM company, it is not completely and periodically carried out. The process of adoption of new procedures in the well-established corporate practices is typically a long term process.

In conclusion, it can be possible to sketch an overlook of the proposed system concerning the integration of the core database with further modules belonging to different disciplinary fields. For this purpose, a case study concerning the possibility to exploit information collected during the survey for obtaining urban sustainability assessment is being implemented [11]. This case study demonstrates the possibility to exploit methodology underpinning the implementation of the system, within the context of the Neighbourhood Sustainability Assessment Tools (NSA) [13]. When management OM&R is addressed at the urban level, one of the keywords to be taken into account is complexity. For this reason, the system can be further developed, through the integration with a module for community involvement in urban maintenance prioritization [10]. Nevertheless, allowing users belonging to a given urban area to detect anomalies on the urban environment, requires robust data handling procedures, to be developed jointly with the implementation of the community involvement module.

This experiences show the potentiality of a structured data engineering for management and control of UFM service. Nevertheless, more testing and further validations in case studies are desirable. This will allow to integrate the proposed methodology and system in a more and more effective process for management of the built and open urban environment.

Acknowledgements

Authors would like to express their deepest gratitude to GEA S.r.l. for having allowed us to test the model on site and for having made their data available.

References

[1] Pärn E.A., Edwards D.J., Sing M.C.P. The building information modelling trajectory in facilities management: A review. Automation in Construction, 75:45–55, 2017.

[2] ISO, BS ISO 55000:2014 *Asset management Overview, principles and terminology*, 2014.

[3] UNI 11447:2012. Urban Facility *Management Services.* Guidelines to set and program contracts, 2012.

[4] Maltese S., Fradegrada G., Moretti N., Dejaco M.C. GIS application in urban district maintenance. *41st IAHS World Congress. Sustainability and Innovation for the Future* 13-16th Sept. 2016 Albufeira, Algarve, Portugal, 2016.

[5] Lotfi S., Habibi K., Meshkini A., Koohsari M.J. New Multicritera Approach for Urban Facility Management by Applying GIS. World Applied Sciences Journal, 3:56–59, 2008.

[6] Sharifi A., Murayama A. Viability of using global standards for neighbourhood sustainability assessment: insights from a comparative case study. *Journal of Environmental Planning and Management*, 58:1-23, 2014.

[7] Chastenet C.A., Belziti D., Bessis B., et al The French eco-neighbourhood evaluation model: Contributions to sustainable city making and to the evolution of urban practices. *Journal of Environmental Management*, pp 176:69–78, 2016.

[8] Italian Parliament D.Lgs. 50/2016 *Codice dei contratti Pubblici* e s.m.i. 1–203, 2016.

[9] Dejaco M.C., Moretti N., Re Cecconi F. Streamlined management of the built environment: the district and the building logbook as risk prevention tools. *ISTeA 2017 - Re-shaping Constr Ind*, pp 185–194, 2017.

[10] Re Cecconi F., Moretti N., Dejaco M.C., et al Community involvement in urban maintenance prioritization. *In: 2017 AEIT Int. Annu. Conf. IEEE*, pp 1–6, 2017.

[11] Moretti N., Maltese S., Dejaco M.C., Re Cecconi F. GIS Supporting Surveys for Urban Sustainability Assessment. *LC3 2017 Vol I - Proc Jt Conf Comput Constr (JC3), July 4-7, 2017,* Heraklion, Greece Volume I:905–912, 2017.

[12] BSI (2014) PAS 1192-3:2014. Specification for information management for the operational phase of assets using building information modelling, 2014.

[13] Sharifi A., Murayama A. Neighborhood sustainability assessment in action: Cross-evaluation of three assessment systems and their cases from the US, the UK, and Japan. *Building and Environment* 72:243–258, 2014.