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Information-representation methods and tools or the Smart Swap Building strategic project

Metodi e strumenti informativo-rappresentativi per il progetto strategico Smart Swap Building

Within the Smart Swap Building project for the housing renewal, the representative tool is an integrated part of the building design process and becomes an element to support complex decision-making processes, integrating different skills in different stages of the building life cycle. The use of Building Information Modeling (BIM) tools not only allow a transparent design phase but covers the whole building process, relating technological and structural elements with construction scheduling (4D), cost estimation (5D), certification (6D) and management of the life cycle (7D + CAFM), allowing more sustainable and aware choices.

All'interno del progetto strategico Smart Swap Building per la riqualificazione del patrimonio residenziale immobiliare regionale, lo strumento rappresentativo, inteso come parte integrante del processo edilizio, si configura come elemento a supporto di complessi processi decisionali, in grado di favorire il dialogo tra differenti competenze, a diverse scale e in diversi momenti del ciclo di vita degli edifici. L'impiego di strumenti di Building Information Modeling (BIM) permette infatti non solo di condurre in modo trasparente le fasi progettuali al fine di realizzare elaborati tradizionali corretti ma, mettendo in relazione elementi compositivi, tecnologici e strutturali con le fasi di rilievo dell'esistente, di costruzione e cantiere (BIM 4D), stima dei costi (BIM 5D), certificazione (BIM 6D) e gestione del ciclo di vita (BIM7D + CAFM), permette di effettuare ragionamenti sulla sostenibilità dell'opera ben più consapevoli ed approfonditi.

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INTRODUCTION

In early 2013, the economic and financial crisis and its impact on the construction industry had already shown the end of an unlimited growth expectation. The state of the market, characterized by significantly lower levels of use of real estate, generated a considerable amount of unsold newly built and greater investments on built. Indeed, last investments on built environment has already clearly showed a growing interest in value-conscious and sustainable strategies, to translate existing assets into widespread refurbished housing stock. Based on this scenario, to which was added, in the context of the Emilia-Romagna Region, the dramatic peculiarity of the seismic events occurred a few months earlier, has arisen the need to develop methodologies and innovative intervention' models in order to turn into effective procedure the great potential of sustainable growth.

The main challenge of *Smart Swap Building* project, carried out in collaboration with Aster and TekneHub Laboratory by Construction Platform of Emilia-Romagna High Technology Network[1], is to identify possible solutions to the crisis that is severely affecting the construction industry, through new approaches to urban regeneration based on housing refurbishment and soil consumption reduction.
The wide-range research project has indeed prompted the need for cooperation of an interdisciplinary team, in relation to the entire asset life cycle, from the construction to the management, as well as the evaluation of behavioral habits of residents. The integration of existing assets and the new unexploited buildings specifically refers to *multifamily* residential construction that characterizes the region. Therefore, the *Smart Swap Building* project is part of the building process innovation and, given its complexity, opens up different areas of investigation.
Considering what outlined at interdisciplinary level, it was found that, taking into account that in the construction sector many professionals are involved with different expertise in the processes of design, construction and management, the knowledge of the various actors compared to the complexity of the supply chain is only superficial. At the same time, the turnaround identified by the market, which most likely will lead refurbishment processes to become the majority of the professional works over the coming years, requires a strong need to define advanced information tools to support complex decision-making processes, able to integrate different skills, at different scales and in different stages of the buildings life cycle.

The representation as an instrument of knowledge thus becomes one of the predominant *Smart Swap Building* research fields: all information on building, generated during the entire life cycle, improve overall efficiency of the role of all professionals involved from the beginning. Hence the need to structure, store and disseminate information on building in an organic, integrated and accessible way, through the establishment of an inclusive digital workflow over the entire process of regeneration.

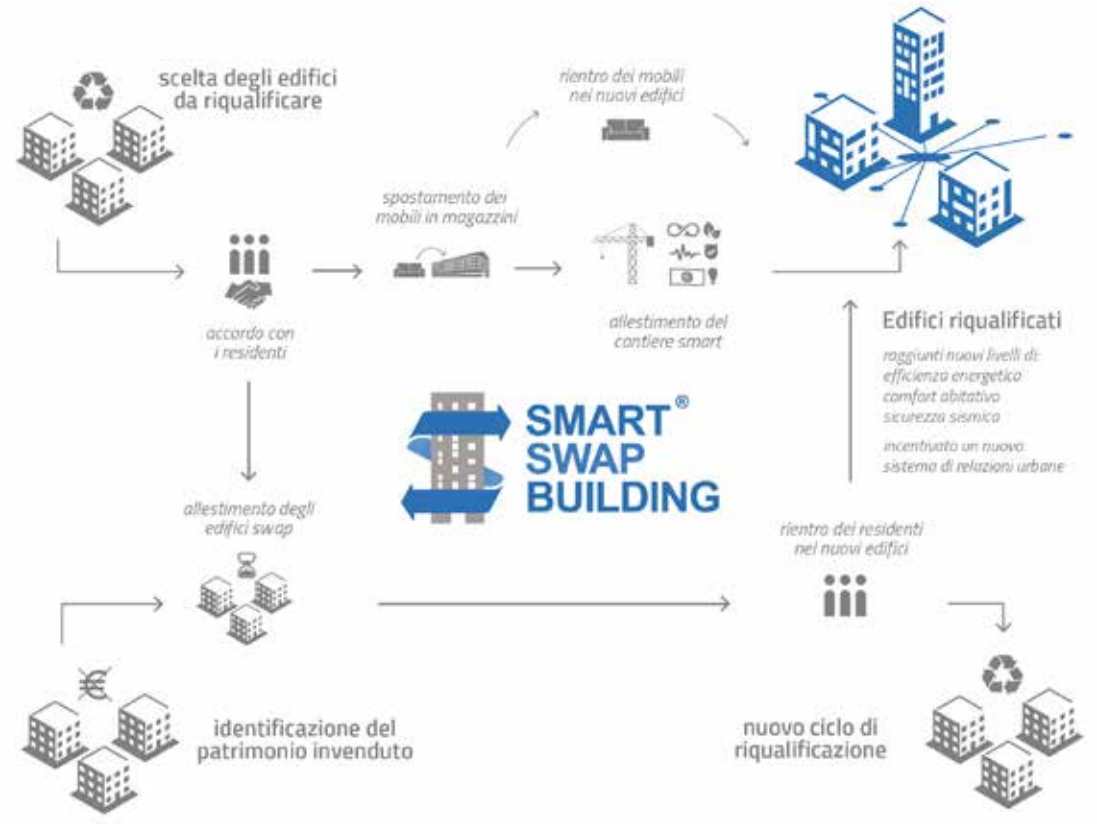

Figure 1 - Smart Swap Building workflow diagram highlighting main phases - original drawing

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THE DIGITIZATION OF THE BUILDING PROCESS

The digital workflow, especially with regard to regeneration projects on built environment up at the urban scale, is emerging as a real integrated representation, in an inclusive way throughout the supply chain, in relation to the need expressed by different professionals to use a common language. The representation tool is therefore an integral part of the design process and, since innovations are always connected to the building process, from design, to construction and management, becomes itself a topic to be evaluated to define the project quality.

It is now clear that the digital representation of the project is directed, in an ever more constant and progressive evolution, towards a marked shift from the static nature of the drawing to the dynamic models. The digital model of an existing building is a physical representation, a simulation carried out by software, designed to study its behavior in different situations. According to the thought of Jeff Rothenberg[2], modeling is one of the basic processes of the human mind, while excluding a comprehensive representation of reality. In parallel this process rather enriches our experience, to "give us more experience of what we could gather, without the imaginal mediation, in an empirical relationship, we say, with the reality"[3]. The model, actually, as a critical outcome of a *creative-interpretative*[4] act, represents a contribution to knowledge on the building. "Lo studio del modello come rappresentazione geometrica non solo della forma, ma quale contenitore di tutte le proprietà fisiche, dimensionali e peculiari della genesi di quella costruzione (pieno/vuoto), è la logica conseguenza della costruzione di un modello conforme, discretizzato che nelle analisi per operare si sostituisce al vero, nel caso dell'esistente, o materializza una idea progettuale"[5].

Therefore, before going on in deepening and analyzing how such technological advances will result in the building and architectural practice, it is necessary to consider three fundamental aspects characterizing each model, in line with the three essential attributes *reference*, *purpose* and *cost-effectiveness* outlined by Arto Kiviniemi[6]:

- to each project field it is necessary to assign different models or a different ability to query a model, in order to avoid the overflow of unnecessary data at a given time [efficiency];
- in order to build an appropriate model it is necessary to define the aim (the aims) in advance in order to achieve the desired results [effective];
- the integrated model should include (at least) the parts needed for the desired level of integration in order to produce a beneficial result [cost].

From the point of view of professional practice, in line with the H2020 Community strategy, aimed at smart, sustainable and inclusive growth, as well as with the new European directive on public works, it is possible to group the most advanced digital tools, available on the market, aimed ad the design and management of the features and functionality of a building, under the name of Building Information Modeling (BIM).

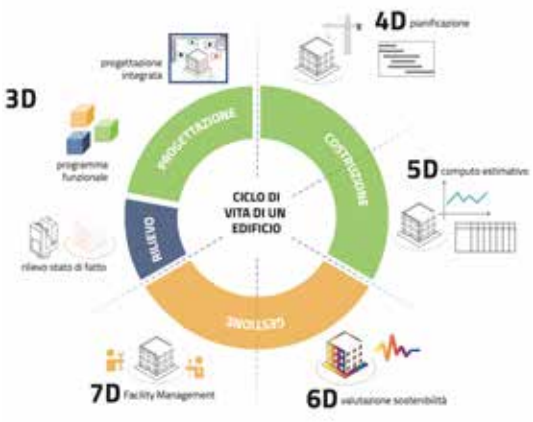

Figure 2 - Building Life Cycle diagram and correlated "BIM" dimensions - original drawing

Even though an exhaustive and definitive definition of BIM does not exist, the different software tools are evolving rapidly and without setbacks, and use practices vary accordingly considering alternatives that are beyond the more conventional approaches. These electronic tools not only allow a transparent design phase but covers the whole building process, relating technological and structural elements with construction scheduling (4D), cost estimation (5D), certification (6D) and management of the life cycle (7D + CAFM). It thus becomes possible to achieve much more informed and detailed arguments about the sustainability of the work.

REPRESENTATIVE MODELS FOR THE PROJECT ON BUILT ENVIRONMENT IN THE TRANSITION FROM CAD TO BIM

Although it is possible to assume the BIM as a natural evolution of computer aided design tools (CAD), it is necessary to point out that these are not based on the same technology. BIM goes far beyond a tool to generate digital drawings, 2D and 3D. BIM is qualitatively different from the CAD because it is not only a description but rather an object-based definition of the building. The information enclosed in the BIM also differ from the information enclosed in the CAD: in most CAD applications a constructive element, for example a wall, is a set of lines that define the geometrical limits, in projection, of the wall. In BIM, on the contrary, the wall is an object that contains a large set of structured information together with the geometry or shape. Rather than draw lines that describe a product dimensionally, using the BIM designers are inclined to organize smart objects within a project.

Thanks to this methodology emerges the possibility to explore an additional level of design analysis: BIM is no longer just a project documentation, but can be extended beyond the information contained in the object-based models by enabling and encouraging the Data Management System (DMS) when all informa-

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tion becomes connected to a central model.
BIM is not, however, a ready-to-use solution or software package: BIM must be customized on any subject or project. The collaborative framework, the model-building approach, the structure and level of detail of the model as well as tools to support these processes must be outlined based on the complexity of the project and the objectives of the different actors involved in the process of refurbishment.
By using BIM all process and product information are combined, stored, processed and interactively distributed to all stakeholders. As a centralized model for all stakeholders in all project phases, BIM grows and evolves in parallel with the project's progress. It is designed to be a living model that can be used during the planning, design, construction and building management. Using BIM architectural and engineering solutions can compete with the requirements and performance expectations set by clients.

THE STRATEGIC PROJECT SMART SWAP BUILDING TO FACE THE MAIN PROBLEMS IN THE CURRENT BUILDING PROCESS

Smart Swap Building, as a building innovation process, assumes to use the unsold housing stock as a temporary accommodation for the inhabitants of existing areas to be refurbished by energy and resources saving strategies and new standard for comfort. It is also relevant to emphasize that the focus does not go uprising, considering redevelopment processes, to the individual building but as urban aggregations to trigger regeneration of infrastructures and urban fabric.

Given the complexity related to the reorganization of an overall building process, from negotiation to construction, up to the placing on the market, it was crucial the involvement of public and private stakeholders to check the entrepreneurship' interest in the project and test its feasibility. The willingness to cooperate in the new workflow verification by several specialized operators allowed applying a real confrontation strategy according to technical panels. In line with the major industry researches, it is possible to state that the increasing complexity of the building process is interpreted by a large number of players in the sector as a critical issue that can cause a progressive impoverishment of the quality of interventions[8].
A first step involved regional stakeholders in order to explore unsold assets and the actual feasibility on built environment. Technical panels have therefore been addressed on costs and times of refurbishment processes or demolition and reconstruction. As an outcome of these technical meetings, the state of the art is confirmed by the empirical experience of the players involved in the preliminary stage of the Smart Swap Building project, in particular regarding the lack of data transmission along the construction steps. If this, on the one hand, it is not perceived as an overwhelming obstacle to the work's conclusion, it is clear on the other side that costs and timescales are heavily affected by these gaps.

Based on the needs expressed by stakeholders of the Smart Swap Building project and technical availability of operational tools to be introduced on the field, comes out the definition of an integrated digital work-

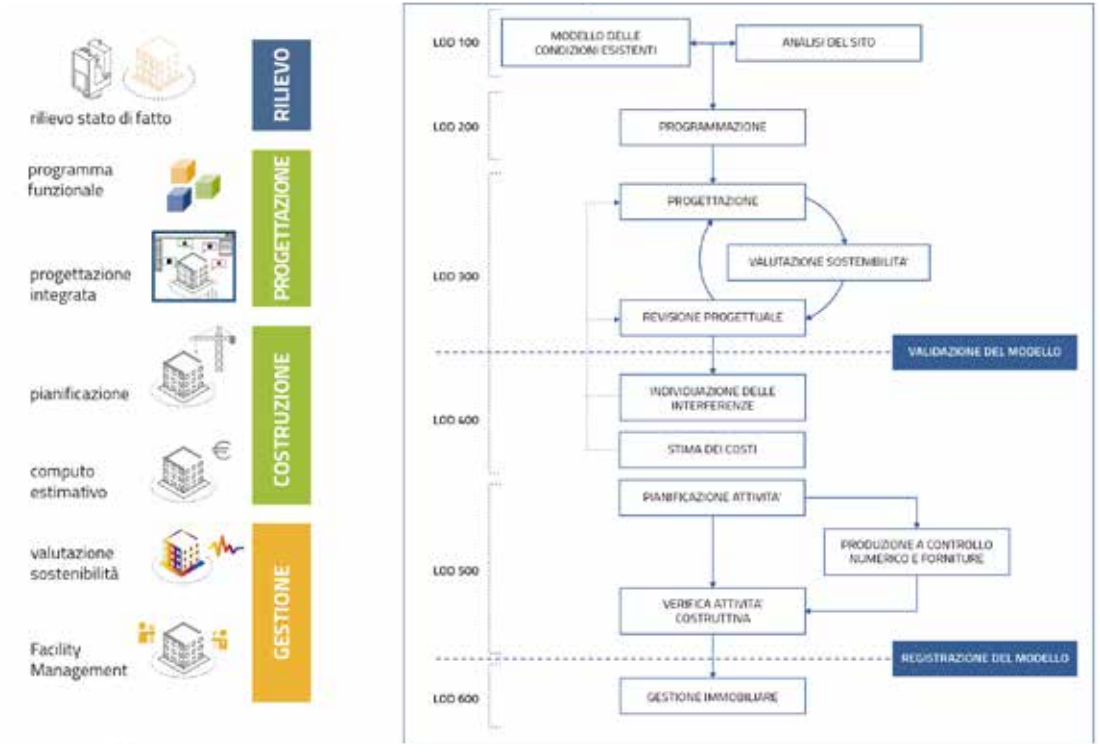

Figure 3 - Guidelines diagram of identified phases and their control steps in order to check the model coherence increasing the Level of Development (LOD) - original drawing

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flow for process innovation.
From a methodological point of view, it is possible to define, in particular, three key actions for the integration of BIM tools in the regional strategic project:

- drafting of guidelines for the adoption of Building Information Modeling tools in the Smart Swap Building process;
- application of the guidelines on case studies located in the region;
- structuring of a conference format integrated with a digital platform for training and the continuous upgrading.

Guidelines - The goal of the Smart Swap Building guidelines for the management of the process by using BIM tools is to provide procedural and technical guidance for the deployment of an advanced digital information standard. This guide is useful for all the construction supply-chain actors, up to real estate managers that in this framework designed to clarify the need for coordination and management of dedicated BIM tools, will find practical guidance on how to structure their skills to be shared with the other actors. In addition, customers can also benefit from transparency of the overall process.

The guidelines, in the first instance, can also be configured as a useful tool to constrain the respect of the players of Smart Swap Building redevelopment workflow that, in the desire to embark on a path of assisted implementation of BIM tools, declare themselves available.
The first draft of the guidelines is intended to consider the application for pilot cases since the sector is rapidly evolving technique: an updated and dedicated widespread application will be made available, as a result of validation through pilot cases. The guidelines, in the first instance, can also be a useful tool to drive the actors to follow the Smart Swap Building redevelopment workflow.
The first draft of the guidelines is intended to consider

Figure 4 - From point cloud to BIM environment importing process diagram - original drawing

the application on pilots since the sector is rapidly evolving: an updated and dedicated widespread application will be made available, as a result of validation through pilot cases.

For the preliminary drafting of the guidelines some industry standards have been taken as a starting point, adapted to the specific panorama of the Smart Swap Building project:

- New York City - Department of Design + Construction, BIM Guidelines - In these guidelines, published on July 2012, are set out the application of the BIM guidelines developed by the New York-based Committee on public projects in New York City. They are probably the most advanced standards currently available in this area. However, is not adopted an open interchange format.
- CRC Construction Innovation, National Guidelines for Digital Modelling - Released for the first time in 2009, these guidelines refer to the Australian territory. Developed by a research consortium, they are not mandatory although sponsored by several municipalities and the Australian Institute of Architects. They constitute a very complete search but, unlike New Yorkers guidelines, are not addressed directly to a professional use.
- AEC (UK) BIM Standard - Published for the first time in 2009 and based on the Bristish Standard BS1192:2007, were developed by a team of talented professionals and refer to use of BIM in the UK. This standard defines a workable path to undertake the transition from the use of CAD

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tools to that of BIM tools. It is an extremely technical and application document.

Case studies - The guidelines outlined are a preliminary draft that needs to be verified: a first validation was therefore carried out by application to case studies or test-beds located in the region in accordance with the territoriality of the strategic project Smart Swap Building.
The cyclical nature of the construction process involves countless professionals: this concept is translated into the professional practice of using BIM tools with the concept of authoring. Any professional contributes to the creation of the part of the model of its authority, by using dedicated software tools and compatible with the common working standards (e.g.: IFC), in order to put together the different portions in a federated model, that is the building in its complexity.

Alongside the authoring software it is also possible to identify two further types of software:

- Processing software - aimed at facilitating the workflow, information exchange and continued and coordinated collaboration between operators;
- Reviewing software - aimed at verifying the consistency of the data, possible conflicts between different authoring and quality assurance.

Thanks to the application of case studies, it has been possible to test the actual applicability of Building Information Modeling tools to the real stages of the construction process as well as the substantial interoperability between tools, hardware and software.
In the first stage, starting from the acquisition of the actual state of the building by means of integrated 3D laser scanner survey instruments, data consistency has been checked through the three-dimensional representation in databases BIM.
Particular attention was paid to creating a project

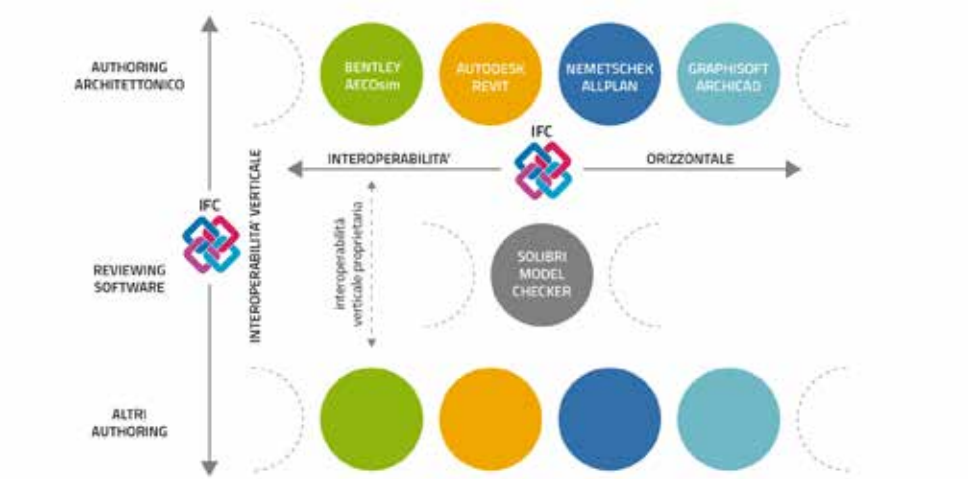

Figure 5 - Vertical and horizontal interoperability between BIM tools, relating to guidelines - original drawing

template characterized by complex geometries, as necessary in-depth study of BIM tools, which allowed good modelling skills. The partial difficulty of implementation of the BIM model, however, has made necessary a check of data interoperability.

Finally some experiences of implementation of BIM tools in the Facility Management procedures were developed. The implementation of real-time data directly within the BIM database is still far from being achieved, in particular due to computer limitations. However, the increasing complexity of devices installed directly in real estate requires an ever greater need for three-dimensional information file to be used for maintenance. It is already possible to find that most of the key benefits that BIM can bring into the Facility Management are related to its semantics nature. The BIM model is an object-based description of a building: the possibility to investigate the individual elements, with particular reference to the semantic methods, thus freeing from the need to manage the entire model, is one of the basic requirements for data sharing with the highest number of professionals.

Training and dissemination - The *Smart Swap Building* project, aimed at the implementation of informative and representative tools in the refurbishment process, cannot ignore dissemination and technical training on specific skills. As stated by Angelo Ciribini[9] in a recent online contribution to the Italian debate on the use of Building Information Modeling tools, those dissemination and training tools must be set consistently with process innovation.
In mid-2013, the implementation of a dedicated format started from the involvement of an extended partnership for dissemination at national level.
The research dissemination strategies is based on three main key actions:

- scientific publications and conference proceedings;
- technical training one-day workshop;
- online platform for outputs dissemination and continuous professional training.

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Figure 6 - Compagnoni Fenulli District in Reggio Emilia: different visualization of different models aimed at Facility Management - BIM authoring in different software environment and render

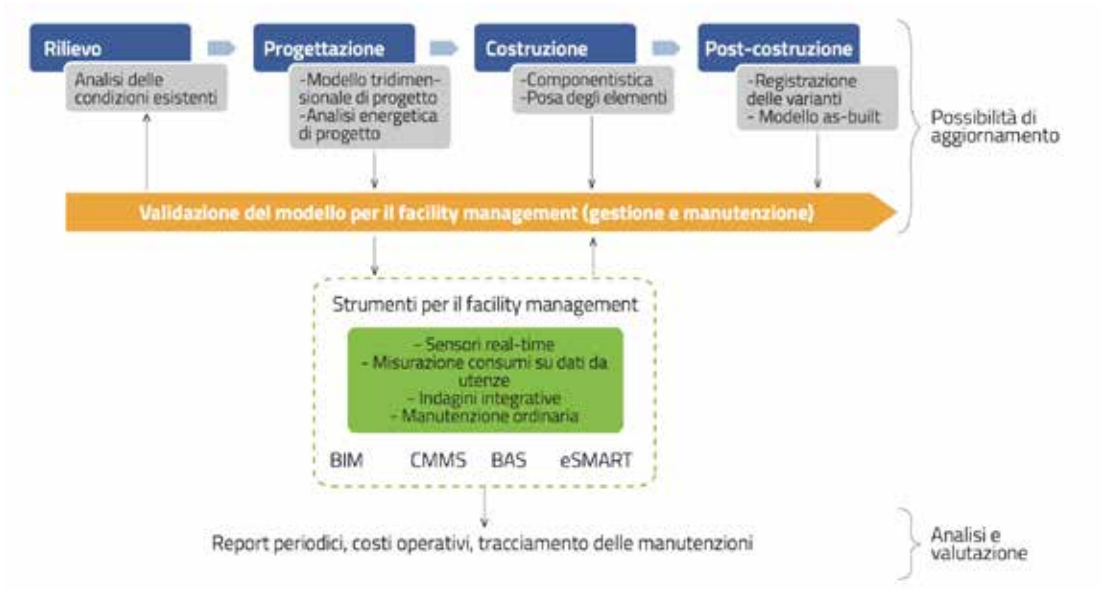

Figure 7 - Process diagram from BIM authoring to Facility Management - graphic reworking on U.S. General Service Administration source

CONCLUSION

Much of the software tools available today on the market offer or promise unlimited application possibilities but the key point of a "digital workflow" is the ability to data sharing and interpretation in a consistent way among all professionals. The use of standard interchange formats such as IFC, while allowing the transmission of nearly all of the data necessary to the process, it is still incomplete in terms of editing and reuse. The consolidation of advanced features, such as the generation of advanced parametric geometries or the management of objects derived from point-cloud database for existing documentation, will probably take place within a short time, but at present, it is need to refer to proprietary software to ensure the proper functioning. It is possible to overcome this gap through the application of standardized procedures, such as those defined by the guidelines.
At the same time, it is also necessary to emphasize that professionals at regional and national level are extremely fragmented, that is one of the main limitations to the implementation of the digital workflow. Since the collaborative feature of these instruments requires that all professionals adopt such systems for measuring significant benefits, this situation may slow down the adoption at national level.
Digital representation as an instrument of knowledge, documentation and construction process protocol should evolve into new standards and dedicated professionals, together with technical research on the available digital tools in order to structure a realistic chance of implementation that, at national level, has not yet found a real application.

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