

TeMA

Journal of
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This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

Tema is the Journal of Land use, Mobility and Environment and offers papers with a unified approach to planning and mobility. TeMA Journal has also received the Sparc Europe Seal of Open Access Journals released by Scholarly Publishing and Academic Resources Coalition (SPARC Europe) and the Directory of Open Access Journals (DOAJ).

INPUT 2014

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Smart City

planning for energy, transportation
and sustainability of the urban system

SMART CITY

PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

Special Issue, June 2014

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This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.



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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

SMART CITY PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM Special Issue, June 2014

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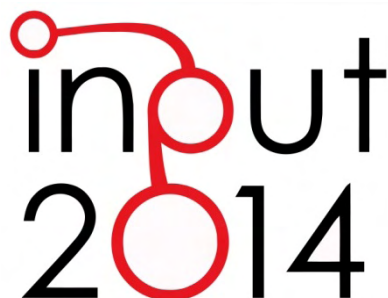
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SPECIAL ISSUE

Eighth International Conference INPUT
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The logo for the INPUT 2014 conference. The word 'input' is written in a lowercase, sans-serif font. The 'i' and 'n' are black, while the 'p' is red. The 'u' is black, and the 't' is black. Below 'input' is the year '2014' in a large, bold, sans-serif font. The '0' is red, and the '1', '1', and '4' are black. A red line connects the top of the 'i' to the top of the 'p', and another red line connects the top of the 'p' to the top of the 't'.

AN ONTOLOGY OF IMPLEMENTATION PLANS OF HISTORIC CENTERS A CASE STUDY CONCERNING SARDINIA, ITALY

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ABSTRACT

This paper discusses some key points related to the ontology of implementation plans of historic centers (IPHCS). We study this ontology by discussing its implementation in the context of the provisions of the Sardinian Regional Landscape Plan (RLP), and put in evidence some important general observations, coming from the case study, concerning the utility and effectiveness of the ontological conceptual framework in order to help planners and decision makers understand and structure the assessment process of implementation plans.

KEYWORDS

Implementation plans of historic centers, Ontologies, Urban renewal

1 INTRODUCTION

In the framework of regional and urban planning processes of Sardinia, in the context of the RLP, established by the Decision of the Sardinian Regional Government (DSRG) no. 36/7 of 5 September 2006¹, the IPHCs are planning tools which implement the Planning implementation code (PIC) of the RLP into the “Areas characterized by historic settlements”. For these areas, the PIC defines a set of prescriptive rules and planning criteria (articles nn. 51-53 of the part of the PIC related to “Cultural and historic spatial framework”, which is defined by articles nn. 47-59). More precisely, article no. 52 identifies the IPHC as a plan which has to be necessarily approved through the cooperation of the Sardinian regional administration and a municipality as a necessary precondition for a municipality to exert its ruling power over the local transformation processes related to the municipal spatial jurisdiction, which implies a considerable pressure on the local administrators in order to implement valuable and effective planning processes concerning the municipal historic centers.

Following the RLP's approval, the Sardinian regional administration provided municipalities and practitioners with a wide range of technical guidelines and documentation which are significantly influencing the implementation of the planning processes of IPHCs².

As a consequence, in the planning processes of the IPHCs, heavily influenced by the control of the technical staff of the regional offices, a strong consistency and implied uniformity do show up as: i. a strong attention to historical, typological and morphological characteristics in terms of the territorial analysis of historic urban settlement systems, which are identified by the RLP as “Centers of antique and primary development”; ii. A strong prescriptive ruling framework characterized by a markedly-conservative attitude.

With its approximately 24,000 square kilometers, Sardinia is the second-largest island in the Mediterranean Sea; its population density is rather low, as it counts less than 1.7 million inhabitants according to the 2011 National Census. The vast majority of Sardinians live close to the sea, and especially in the two densely urbanized areas around the two major cities (Cagliari and Sassari), while the inner areas of the island, hilly and mostly badly connected to the rest of the island, are sparsely populated. This uneven concentration of population parallels the island's unbalanced economic development, as in coastal areas the majority of economic activities takes place.

It is therefore not surprising, given this context, that the Regional Landscape Plan of Sardinia (RLP), the first statutory landscape plan with regional dimensions produced in Italy under the new legislation, focused on the coastal zone because of the complexity of development conflicts arising from tourism (on which a large part of the economy of the island relies) and other development, and owing to the fact that thirteen out of the fourteen previous landscape plans covering coastal areas, which contained some restrictions on coastal development, had been quashed between 1998 and 2003.

¹ An updated and revised version of the RLP was preliminarily approved by the Regional Government of Sardinia by the DSRG no. 45/2 of 25 October 2013. According to this DSRG, only a subset of the “Centers of antique and primary development” of the Sardinian municipalities are classed as “landscape goods”, as it occurs in the case of the RLP, while the majority are classed as “Identitarian systems: areas characterized by historic settlements” (art. 52 of the Planning implementation code of the updated and revised RLP; documents are available online at <http://www.sardegna territorio.it/j/v/1293?s=242464&v=2&c=11437&t=1> (accessed April 2014). If and when the new version of the RLP is established, this will imply some (minor) changes in the IPHCs' planning processes, which will make the approval processes of projects faster, since landscape authorization will be not required any longer.

² Guidelines and documentation are available online in the institutional Internet site of the Sardinian regional administration “Sardegna Territorio” [Sardinia Territory] at <http://www.sardegna territorio.it/j/v/1123?s=6&v=9&c=9560&na=1&n=10> (accessed April 2014).

Following approval of the plan in 2006, restrictions and prohibitions (on development of land and on certain changes in land uses) stemming from the plan are currently in force, in order to protect a part of the island considered economically strategic and environmentally sensitive. Restrictions and prohibitions are set out by the plan by means of a system of rules.

The planning activity of the regional administration of Sardinia has undergone a deep change after the approval of the RLP, which establishes the directions for nearly any future planning activity in Sardinia, and requires that actual sectoral and local plans, as well as plans for protected areas, be changed to comply with its directions.

Within the framework of the provisions of the RLP, and after providing the reader with a thorough presentation of some important technical issues related to IPHCs and a discussion on the semantics of the term “ontology” (second section), this paper discusses some key points concerning the ontology of the IPHCs procedure, that is the spatial analysis of the IPHCs and implied planning measures (third section). This discussion regards the IPHCs’ definition procedure in the context of the municipal planning processes stated by the provisions of the PIC of the RLP, with the objective of proposing the ontology as an important contribution to the definition and implementation of this procedure (fourth section).

We develop the ontology on the basis of these normative standpoints, and implement its construction through Protégé, a software program developed by the Stanford Center for Biomedical Informatics Research of Stanford University and freely available at: <http://protege.stanford.edu>.

2 BACKGROUND

2.1 IMPLEMENTATION PLANS OF HISTORIC CENTERS

The qualitative enhancement of historic centers represents a significant question in the national, regional and local planning contexts. In particular, the Sardinian regional administration, which identified in the historic centers’ renewal, improvement and promotion, a very important opportunity to support local, economic and social development, established the Regional Law no. 1998/29 titled “Protection and enhancement of the historic centers of Sardinia”, and, in 2006, approved the RLP, which recognizes the strategic role of the “Centers of antique and primary development”, which are defined through a cooperative planning activity by the regional administration and the municipalities, and are classified as landscape goods, and, as such, are subject to a special protection regime under the provisions of the National Law enacted by decree no. 2004/42 on cultural and landscape goods.

A critical analysis of the IPHCs of Sardinian municipalities, which reflect properly and precisely the planning guidelines of the regional administration, shows a lack of an explicit strategic vision which should characterize the planning processes, which instead are mostly concerned with the analysis of the historic urban settlement system and of the typologies of the buildings, which eventually found projects which mainly consist of limited and conservative interventions. So, there is no evidence of a strategic vision of IPHCs, which puts in evidence the lack of a strong link between planning processes related to historic centers and local economic and social development.

Under this perspective, we propose a system of objectives which aims at identifying the strategic potential of the IPHCs, on the basis of a detailed analysis which could eventually increase substantially the strategic effectiveness of these plans.

Effective strategic approaches to historic centers’ strategic planning can be recognized in some recent experiences implemented by the municipalities of Reggio Emilia (Strategic plan for the qualitative

enhancement of the historic center; Comune di Reggio Emilia, 2005, 2011) and of Vicenza (Masterplan of the historic center of Vicenza; Fantin, 2013). In both cases, a strategic approach is explicitly mentioned and implemented into the plans, in order to study the futures of the historic centers, on the basis of a system of objectives which comes from the overcoming of a system of problems (negative actual situations: a problem solving-based goal-oriented approach). A very similar logical framework can also be identified in the debate proposed in a monographic issue of *Urbanistica Dossier* related to LUDA (Large urban distressed areas)³. In particular, Mueller *et al.* (2005) propose a GOPP methodology, the so-called CoSGOP (Collaborative strategic goal-oriented programming), to define strategies and programs to address urban requalification programs towards cooperation between public and private stakeholders, based on the analysis of case studies related to the urban contexts of Bratislava, Dresda, Edinburgh, Florence, Lisbon and Valenciennes.

The analysis of the strategic approaches to the definition and implementation of plans for the historic centers provide the municipalities with sets of objectives which could be very useful to assess the strategic effectiveness of their IPHCs, and to identify suitable planning paths to improve the quality of life and to catalyze economic and social local development. These sets may eventually make more comprehensive and multifaceted the almost-monotonically conservative and philological character of the actual IPHCs.

In our view, a tentative general set of objectives to define and implement IPHCs could be the following:

first general objective: improving the quality of municipal life in the short run, which includes the following specific objectives:

- 1.1. promoting the urban system of the historic center and its relationships with the rest of the municipal area;
- 1.2. improving the quality of the historic centers' built environment, which contributes substantially to the historic centers' perceived features, which implies a particular attention to urban maintenance and renewal;
- 1.3. increasing the quality and potential of the historic center's public spaces in terms of aesthetic attractiveness, urban fabric and functionality;
- 1.4. organizing and increasing the quality of commercial and retail sale activities;
- 1.5. promoting the image of the historic center through marketing campaigns related to the local, regional, national and international tourist markets;

second general objective: promoting local development in the medium and long run, which includes the following specific objectives:

- 2.1. making housing in the historic center more interesting and attractive;
- 2.2. implementing cooperative actions between the public and private sectors to generate a system of urban services qualitatively valuable and competitive in terms of capacity of responding to social demand, also by means of innovative tertiary activities;
- 2.3. improving accessibility, mobility efficiency and the situation of thru-traffic flows in the historic center, by encouraging the use of public transport, pedestrian and cycling paths, and discouraging the use of private transport;
- 2.4. implementing participatory practices to support planning processes.

Our discussion is related to the IPHCs of four Sardinian municipalities, Assemini (Comune di Assemini, 2012), Cagliari (Comune di Cagliari, 2011), Elmas (Comune di Elmas, 2012) and Villacidro (Comune di Villacidro,

³ The issue describes the experience of "LUDA Project - Improving the quality of life in large urban distressed areas", funded by the European Commission through the Fifth Framework Program - Energy, Environment and Sustainable Development, Key-action 4 - City of Tomorrow and Cultural Heritage (Bentivegna, 2005).

2010), which are the only municipalities that studied an IPHC and a strategic plan as well⁴. We consider the strategic operations concerning their historic centers, which are identified in their IPHCs, in the logical framework of the set of objectives indicated above.

However, Elmas and Assemini do not show any evidence of strategic operations specifically related to the historic centers, since they have a general spatial scope. In any case, these strategic operations can possibly have important impacts on the historic centers' situation of the two municipalities. The municipalities of Cagliari and Villacidro identify site-specific policies related to their historic centers, regarded as peculiar parts of the municipal areas in the strategic visions of the plans.

With reference to the first general objective, "improving the quality of municipal life in the short run", which is taken into account much more than the second one, the four IPHCs address in particular specific objective no. 1.2 above. The four IPHCs, starting from context analyses which put in evidence a significant decay of their historic centers, project interventions aimed at protecting the comprehensive characteristics of their centers of antique and primary development, paying particular attention to conservation of the historic identity of the built environment. On the other hand, these operations not only focus on urban decay, but also aim at revitalizing the urban historic contexts characterized by insufficient endowment of public services. The municipalities also address this issue through projects which pursue specific objective 1.4 above. Moreover, even though all the IPHCs give provisions concerning enhancement and strengthening of public spaces in terms of aesthetic attractiveness, urban fabric and functionality (specific objective no. 1.3), only the municipality of Cagliari emphasizes the strategic importance of this objective in terms of enhancing their attractiveness and functionality.

Finally, it is certainly emblematic that specific objective no. 1.5 is almost totally neglected by the IPHCs. From this point of view, it has to be noticed that, in operational terms, the issue of the centers of antique and primary development is dealt with as an almost-exclusively local question, and, as such, as an issue that deserves only limited consideration. Only the municipality of Assemini underlines the importance of increased awareness of the local communities, even though no planning policy is explicitly defined. Specific objective no. 1.1 is addressed, even though in general terms, only by the IPHC of Cagliari, which proposes an analysis of the synergic relationships between the historic center and the rest of the city.

As regards the second general objective, "promoting local development in the medium and long run", the analyzed IPHCs do not show interest in strategic visions which go beyond a short run horizon, with the exception of Cagliari, since they identify, as their only focal point, what indicated by specific objective 2.1, that is "making housing in the historic center more interesting and attractive".

On the other hand, the municipality of Cagliari promotes interventions and operations aimed at improving the quality of housing in the historic center by boosting not only the stability of the present resident population, but also the demand for houses of new inhabitants, such as students. The other three specific objectives (2.2, 2.3 and 2.4 above) are almost completely ignored, with the exception of Cagliari. The municipality of Cagliari plans to strengthen and redevelop the historic center endowment of public services, and pedestrian and cycling mobility. Finally, the IPHC of Cagliari is built on a participatory process, based upon a set of public debates, and shows a strategic vision related to the local economic and social development in the medium and long run, and, by doing so, this plan goes far beyond the provisions of the regional guidelines.

⁴ Only Elmas and Villacidro have concluded the approval procedure of their IPHCs, under the provisions of art. 9 of Regional Law no. 1998/28, as stated by the Decisions of the Office for Urban Planning of the Sardinian Regional Government (called "Determinazioni") nos. 2012/4283 and 2010/2407.

2.2 ONTOLOGY AND ONTOLOGIES

A generally-accepted meaning of the term “ontology” in contemporary theoretical debates of urban and regional planning is “discussion of the substance of an object,” that is a discussion of the most important characteristics of its essence, especially in epistemological debates. For instance, Hillier (2010) points out that, according to some contemporary scholars, “ontology” indicates the paradigm of “relational ontology,” that is a discussion of the substance of the relations between agents and structures (capital, social classes, agreed-upon semantics, etc.) which do not possess their own essence, formed only through their being in relation. Moreover, Hillier stresses, with reference to DeLanda (2006), that the reference point of planning practice should be the observation and analysis of the relations between the elements which constitute the empirical reality (e.g., agents and structures), whose existence does not depend on the fact that human beings perceive it.

These relations generate emergences, that is unexpected phenomena, for those who are familiar with the single elements but who are not aware of their mutual relations as well: the ontology of agents, structures and relations is a “realistic ontology” of the scientific paradigm of the (planning) disciplinary paradigm, which is based on the empirical analysis of the relation. These emergences have an autonomous existence with respect to agents and structures. The realistic ontology (the ontology of relations) is an ontology of the reality (Hillier, 2010), and a scholar’s disciplinary role is to be aware of and to describe this reality, by identifying and analyzing its relational substance.

The “substantial” attribute of the term “ontology” leads to an effective comprehensive view of the contemporary debate concerning ontology and ontologies. In this context, ontology is not referred to, according to the meaning described so far, as one or a set of conditions which define the substance of a concept (reality–agents, structures, relations) as much as the substance of its agreed-upon representation, that is its formal definition.

Ontology is the identification of a concept, of a domain—in other words, the cognitive contents that a set of agents identify as the particular characteristics of a domain.

Therefore, ontology is not connected to substance, that is the essence of an object, as much as to the agreed-upon available knowledge (scientific, technical, based on traditions and on common sense, etc.) concerning an object.

Formal ontologies are not connected to substance or to essence, but to the essence of representations, or definitions; that is, they propose an agreement on cognitive contents, rather than the substance analysis of an object. According to Smith (2003), ontologies are descriptions of domains of objects as closed data models whose nodes define concepts. These concepts are strategically identified and make sense only in the context of the universe they try to model. Moreover, Smith illustrates that, historically, the use of formal ontologies comes from the fact that several disciplines are experiencing a dramatic Tower of Babel syndrome which needs to be addressed somehow.

Those who deal with complex systems of data and knowledge have peculiar and often idiosyncratic frameworks for representing information. The semantics used for the same term may vary, or the semantics for different terms could take the same meanings.

Formal ontologies could make it easier to deal with this syndrome. Also according to Guarino (1998), as quoted by Pretorius (2004), a formal ontology is a projected representation which consists of a specific agreed-upon set of words which describe concepts belonging to a knowledge domain and a set of agreed-upon propositions concerning the meanings of these word as well. Pretorius agrees with Smith since, in his view, the concept of ontology originated in the field of artificial intelligence.

3 THE SPATIAL ANALYSIS OF HISTORIC CENTERS AND IMPLIED PLANNING MEASURES

The starting point for describing the PIC-based technical approach to the definition and implementation of an ontology of the spatial analysis and implied planning measures of IPHCs is represented by the provisions of art. 52 of the RLP, titled “Areas characterized by historic settlements. Prescriptive rules.”

The article is articulated into four parts. First, it deals with the question of spatial analysis, which has to be carried out through: i. a description of comprehensive urban characteristics of the municipal area, such as orography, water resources and hydrography, natural resources, settlement system(s), municipal walls and ramparts and urban landmarks; ii. an analytic description of the historic centers’ built environment and open spaces, which is implemented through detailed and accurate records related to each public and private block, buildings and built structures, private yards and public spaces (squares, parks, gardens, widening-road areas, etc.), with particular reference to the built environment’s degradation and obsolescence state.

Second, a classification of the allowed interventions is proposed, which makes reference to the category definitions of art. 3, paragraph 1, of Law enacted by decree of the President of the Italian Republic no. 2001/380. The allowed interventions are limited to ordinary and extraordinary maintenance and conservative restoration and refurbishment. In this way, the RLP states, on the one hand, that the spatial analysis should result in prescriptive statements which constitute the normative core of IPHCs, and, on the other hand, that these statements should comply with a general conservative approach, which is implemented through very restrictive rules related to allowed operations on the built and unbuilt environment.

Third, the most invasive and transformative interventions, that is radical restructuring of the existing buildings and change of parts of the urban historic morphology (block shapes, streets, squares, etc.⁵), are limited to the parts of the historic centers where spatial analysis puts in evidence that the original characteristics of buildings and urban morphology are dramatically and irreversibly altered.

Even in the case of radical interventions, art. 52 states that restructuring projects have to focus on the general objective of defining transformations which will eventually generate conditions consistent with the not-irreversibly altered or well preserved parts of the historic urban settlements and morphology.

Fourth, the IPHCs should rule over the functional uses of the buildings belonging to the historic centers, by assuming, as a general normative point of reference, that the residential uses should be the most preferred, and, as a consequence, that houses should maintain their residential use status and the number of the existing residential units should possibly increase as a consequence of the IPHCs’ operations. Moreover, municipalities are encouraged by the provisions of art. 52 to strengthen the availability of public services for residents so that historic centers may become more attractive for people and families who are deciding about the location of their houses. Alternatives to residential uses are identified as accommodation activities for tourists, such as hotels, residences and multi-building hotels, private and public service activities, medical services, craftsmanship workshops and retail shops. Finally, art. 52 indicates that a careful consideration of the opportunity of maintaining unbuilt the areas which result from the demolition of ruins should be taken into account in the rules of IPHCs. So, the provisions of article 52 of the PIC of the RLP state that the IPHCs should be based on spatial analysis, whose interpretation of the urban settlements and morphology of historic centers is the point of reference for the conservative and transformative operations established by IPHCs. This is the conceptual framework of the ontology we propose in the following section.

⁵ For the normative category definitions of these interventions see points “d”, “e” and “f” of art. 3, paragraph 1, of Law enacted by decree of the President of the Italian Republic no. 2001/380.

4 AN ONTOLOGY OF THE SPATIAL ANALYSIS

As stated in the previous section, the spatial analysis for an IPHC comprises, among other, an analytic description of the historic centers' built environment and open spaces, to be implemented through detailed and accurate records concerning each spatial unit⁶ and detailing both conditions and provisions for each element in that unit. In this section, we describe how an ontological approach can support this task.

The ontology of the domain "Description of the historic centers' built environment for an IPHCs" was developed according to the phases suggested by guidance documents and methodological reports produced by the Ordnance Survey, according to which the process whereby an ontology is built can be broken down into a series of steps, the first being the identification of the purpose of the ontology and of its scope. These two aspects are crucial for ensuring both that the ontology is correctly formalized and that it is useful, meaning that it contains only those concepts, relationships and constraints that are judged to be relevant, with regard to the possible ways in which the ontology can be used. With reference to the first point (purpose), the ontology here proposed aims to represent and describe the built environment of a given historic center in order to support the making of IPHCs. With reference to the second point (scope), this ontology aims at providing plan makers with a robust descriptive framework on which they can ground the selection of allowed building activities. Once purpose and scope have been established, the following step consists of the construction of a glossary ("knowledge glossary"), comprising two tables. The first table ("table of concepts") contains a list of core and secondary concepts together with their definition in natural language, and of the source of the definition. The second table ("table of relations") lists and defines, again in terms of natural language only, relationships between concepts pertaining to the domain. The definition of concepts and relationships was based on documentary sources only, which comprise national and regional pieces of legislation and technical documents. The use of such sources was an attempt to ensure that definitions are agreed upon by, and shared among, domain experts. Through a series of checks at internal level of definitions and relations, the two tables were enhanced and modified recursively.

The knowledge glossary, in spite of its being an explicit and shared (at least, potentially) specification of the entities that constitute the abstract and simplified model of the domain, is not a formal specification of the domain itself, up to this point. For the computational aspects, the software program Protégé was next used; concepts were arranged in a hierarchical manner, that is they were organized and grouped into classes and subclasses on the basis of the relationship "is a." To state that a given element belongs to a subclass of a class is in fact tantamount to affirming that this element belongs to the class and therefore that it inherits its properties. In this way, key concepts identified in the previous phase were first organized in a taxonomy according to the following classes: "Activity," "Assessment," "Building," "Obsolescence," "Material," "Minimum Unit", "Part," "Use" and then the corresponding definitions were inserted for each class and subclass.

Next, for each class and subclass, appropriate slots were defined and created. Slots can be used either to characterize the elements of a class by means of attributes of different types (for instance, string, integer, float, enumerated), or to describe the relationships between instances, which are defined as the elements belonging to a given class; in other words, features represent the finest level of granularity and form the basis of the hierarchy. Figure 1 illustrates, as an example, the slots assigned to the class "Building."

⁶ Spatial units are identified through the first step of the required spatial analysis, that is upon analysis and description of the urban morphology, of typological, architectural and landscape features of the built environment in the historic district, also taking into account aspects such as blocks layout, streets' and paths' hierarchies, cadastral subdivisions and properties. The identification of spatial units (which can comprise more than only a single building) is of utmost importance because each spatial unit is treated as the minimum unit for projects and interventions, meaning that building activities should concern the spatial unit as a whole. For this reason, we refer to it as "minimum unit."

“Cadastral code,” “Code”, “Construction year,” “Area sqm,” “Height,” “Volume cubm,” “Storeys no.” and “Zone” are all descriptive attributes, all required and having single cardinality (meaning that only one value for each attribute is allowed); the type of the first, second and third is “string” (meaning that any alphanumeric string is allowed), while that of the fourth, fifth and sixth is “float”; the type of the seventh, accounting for the number of storeys, is integer, and finally the type of the eighth is enumerated, since an IPHC should concern only areas classed in the zoning scheme of the Masterplan as “A” (historic center zone) or “B” (residential completion zone) or “S” (essential services for a residential zone, such as for instance open-space leisure areas or parking spaces). As far as the other five (“Has assessment,” “Has obsolescence,” “Has part,” “Has use,” “Is contained in”) are concerned, they make the relations between the class “Building” on the one hand and, respectively, the classes “Assessment,” “Obsolescence,” “Part,” “Use” and “Minimum Unit” (or subclasses thereof) on the other hand explicit. Two of these five slots have single cardinality, that is, an instance of the class “Building” can have only one assessment value⁷ and it can belong only to a given minimum unit, while the remaining three have multiple cardinality, since a building can serve more than one purpose (for instance, a part of it could be residential and a part commercial), it can be broken down into several components or parts (for instance, roof, walls, porch) and it can have (in our framework) three different values of obsolescence (a structural/physical obsolescence, a functional obsolescence, and an image obsolescence). Some inverse relations are also defined, as shown in Figure 1.

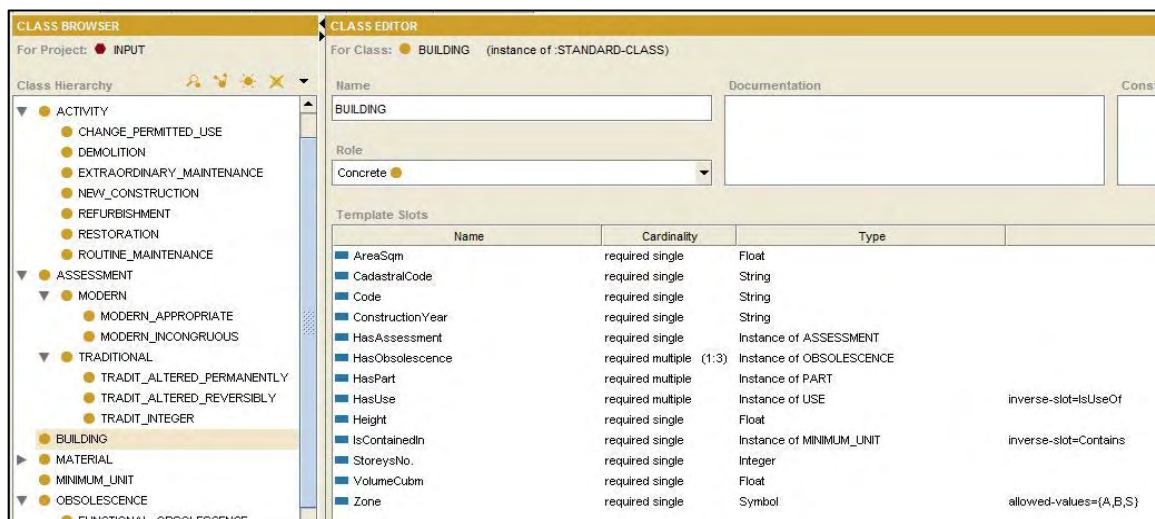


Fig. 1 Hierarchical arrangement of classes and subclasses (left) and descriptive and relational slots assigned to the class “Building” (right).

The construction of the ontology continues with the creation of instances and the filling-in of the values of the slots, and this is done by entering these values in appropriate forms that prevent users from including values which are inconsistent with the ontological hierarchy previously defined. Figure 2 shows one example of this phase, namely the characterization of a single building (coded “A.E.2.A”).

Once the instances have been created and their slots have been filled in, the ontology is fully and formally defined, even though it can be continually adjusted and integrated; moreover, the ontology can be represented graphically as a graph tree in which classes, subclasses and instances are represented as nodes, and relations as arches, allowing users to navigate the whole hierarchy, or only a part (Figure 3).

⁷ By “assessment” we mean the final judgment on whether a single building in the historic fabric has retained traditional characters, which have to be preserved, or it has been altered either reversibly or permanently. For modern buildings, this judgment states whether they are consistent with the historic fabric or not. The assessment is important because it entails strong directions towards allowed building activities and operations.

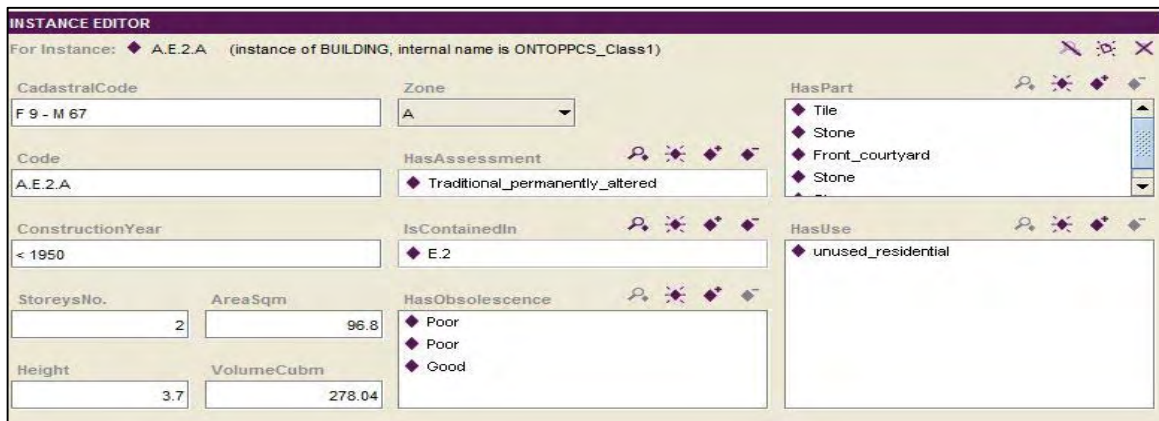


Fig. 2 Representation of an instance of the class "Building"

Graphs can be tailored to the user's needs, meaning that the user can choose whether to display all of the ontology, or only a part of it, by selecting the nodes to be represented or by filtering the relationships to be shown, which allows for a more effective and more understandable representation and exploration in case of complex ontologies.

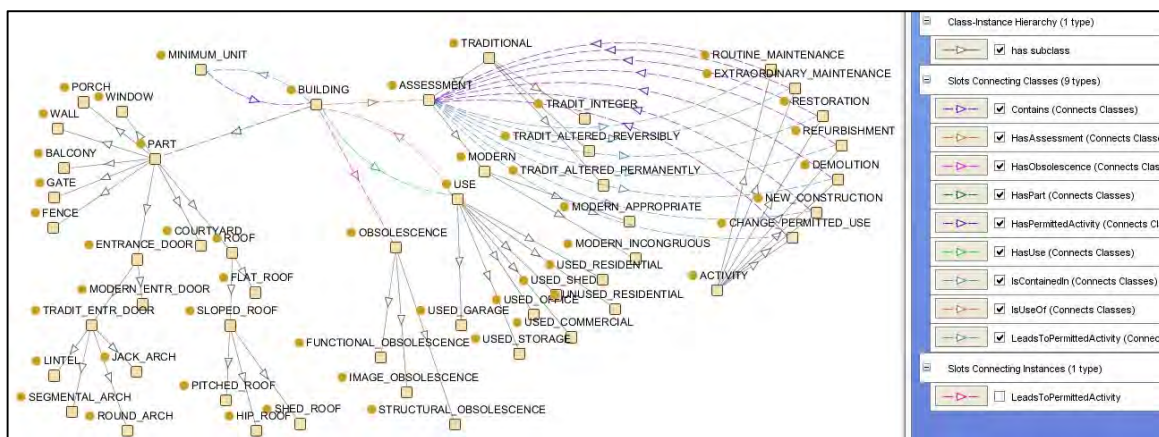


Fig. 3 Graph tree showing relations between the class "Building" and other classes and subclasses

5 CONCLUSION

This paper has attempted to build an ontological representation of the analysis of the built environment of historic centers as a means to support an IPHC, based on the interpretation of normative acts and documents. The ontology can be useful for at least two reasons.

First, this approach provides all the participants involved in the making and implementation of the plan (be they private citizens, planners, public officers and decision makers) with a better understanding of the domain of interest, through an iterative learning process that can continually be refined; this learning process is, in principle, inclusive, because the construction of the glossary can be improved by integrating the definition of concepts, relations, and descriptive attributes, here carried out solely on the basis of documentary sources in a participative way.

Such a collective conceptualization of the domain would also greatly improve the chances of sharing and reusing the ontology in the domain field.

Second, since the ontology here proposed is a domain ontology, therefore aimed at structuring, representing and communicating knowledge on a specific area of interest, the ontology can be updated, refined and

reused in the given domain, and it can lay the bases for the development of task-dependent or application-oriented ontologies in the same domain, for instance focusing on administrative and procedural tasks.

Third, the ontology effectively supports, as desired, the analytic description of the historic centers' built environment and open spaces; Figure 4 shows, as an example, part of the record sheet prepared for an IPHC currently under preparation and concerning one single building belonging to a spatial unit which parallels the ontological representation shown in Figure 1.

Fourth, a strong point of this paper is that the ontological approach here utilized can be readily exported; although the domain ontology here developed is grounded on the normative framework that regulates IPCHs in Italy, and more precisely in Sardinia, this ontology could be easily reused to describe in detail features and characteristics of historical settlements.

Finally, an important limitation to exportability of the ontology in other contexts lies in the fact that the definitions of concepts are based, at least to some extent, on Italian laws and regulations, technical documents and vocabularies; for this reason, the table of concepts was built in Italian in the first place, and afterwards translated into English, which can cause some issues of semantic precision in English.



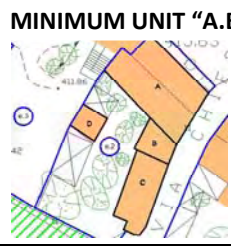
					
BUILDING "A.E.2.A"					
Building	Building code	Area (m²)	Height (m)	Volume (m³)	Construction year
A	A.E.2.A	96,80	3,70	278,04	pre 1950
Basement		Basement use			
Ground floor	<input checked="" type="checkbox"/>	Ground floor use	residential		
Upper floor(s)	1	Upper floor(s) use	residential		
Car entrance	gate	Walls: materials	stone	Walls: finishes	none
Doors: materials		Windows: materials		Blinds	
Roof: geometry	pitched roof	Roof: structure	wood	Roof: finishes	traditional tiles
Roof orientation	North-East South-West	Annotations about the building			
Structural obsolescence	Functional obsolescence	Image obsolescence	Global assessment		
poor	poor	good	Traditional – permanently altered		
Allowed construction activities					
Routine maintenance	<input checked="" type="checkbox"/>			Characterization:	
Extraordinary maintenance	<input checked="" type="checkbox"/>			Front courtyard – side entry	
Restoration work	<input checked="" type="checkbox"/>			Prescriptions	
Refurbishment					
New construction					
Demolition					
Change of permitted use					

Fig. 4 A record sheet designed for an IPHC building upon the ontological representation here presented

NOTES

Sabrina Lai and Corrado Zoppi have made substantial contributions to the paper's conception and design, background and concluding remarks. Corrado Zoppi defined the normative framework of the spatial analysis of the implementation plans of historic centers (IPHCs). Sabrina Lai designed the formal ontology related to the spatial analysis of IPHCs.

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