Defining and Applying Constraints for 3D Spatial Planning in Urban Areas using Dedicated Software

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Key words: spatial planning, geoinformation, GIS, 3D

SUMMARY

In this paper we want to highlight the advantages of using a dedicated software in the urban planning process. In this regard we chose an Esri solution, and as case study is an area from a city in Romania. The buildings comply with the restrictions related to the type of building set in terms of the number of floors per type of occupancy, but also comply with the basic zoning code, which may be either the current zoning or a proposed future zoning district. Potential buildings provide an image of what can be built based on zoning constraints. The potential buildings represent the basis of calculation of the capacity indicators that allow the quantitative comparison of the design scenarios, together with the empirical values regarding the associated built area for different uses of the space. It is also possible to view the proposed models of buildings in the context of the built environment.
All of applied constraints were defined in correlation with the provisions of the general urbanization plan. The major advantages of this workflow are highlighted.

REZUMAT

In acest articol dorim sa evidentiem avantajele folosirii unui software dedicat in procesul de planificare urbana. Am ales in acest sens o solutie Esri, iar ca studiu de caz o zona dintr-un oras din Romania. Clădirile respectă restrictiile aferente tipului de clădire setat în ceea ce privește numărul de etaje pe tip de procent de ocupare a terenului, ci respectă și codul de zonare de bază care poate fi fie zonarea actuală, fie un viitor areal de zonare propus. Clădirile proiectate oferă o imagine a ceea ce poate fi construit pe baza constrângerilor de zonare. Împreună cu valorile empirice cu privire la suprafaţa construită asociată pentru diferite utilizări ale spațiului, clădirile potenţiale reprezintă baza de calcul a indicatorilor de capacitate care permit compararea cantitativă a scenariilor de proiectare.
Toate constrangerile aplicate au fost definite in corelare cu prevederile planului de urbanism general. Sunt evidentiate avantajele majore ce rezida din acest flux de lucru.

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1. INTRODUCTION

After 1989, when the centralized planning system fell, Romania had to redesign the planning system in a new environment of market economy and democracy. This process had faced many difficulties, interruptions and restarts, and is currently in progress. The legal, regulatory and institutional framework have permanently evolved to respond to the changing needs and challenges. In the last 20 years, Romania has made the transition to a planning that has to conform to the rules of the market, and at present struggles to redefine and set new goals for the design functions of territory.
The main applicable laws are Law no. 350/2001 on spatial and urban planning, Law no. 351/2001 regarding the approval of the National Spatial Plan, Methodological Rules of February 26, 2016 for the application of Law no. 350/2001 regarding the territorial planning and the urbanism and elaboration and updating of the urbanism documentation.
Urban and spatial planning documents and regulations are consisting of maps and texts. According with Law no. 350/2001, spatial planning documents include directing provisions (main strategies and evolutionary directions for territories) and urbanism documents are operational (transpose in the territory the provision of spatial planning documents through concrete regulations related to land use and building permissions). According with [6], the relationship between strategic, spatial, and urban planning in Romania and the place of the general urban plan (PUG) in this context is illustrated in figure 1.

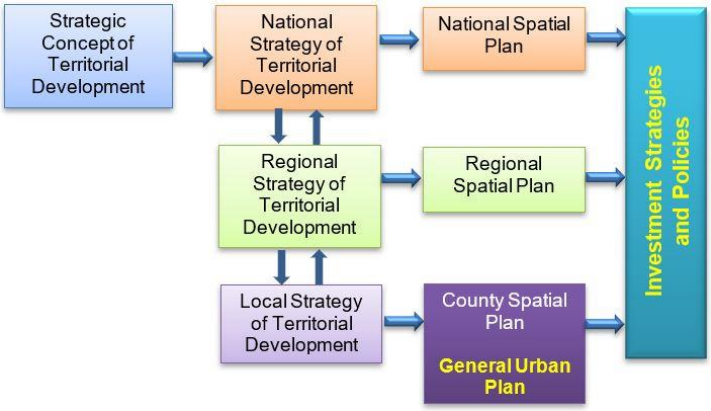

Figure 1 – General Urban Plan in the Strategic, Spatial and Urban Planning Context from Romania (adapted from [6])

Spatial planning is in fact a set of actions that concern the future states of space, taken up by the relevant public administration agencies on the basis of the existing state of space. Spatial planning provides an answer to the question of where the planned objects are going to be located. [5] It is important to mention that in this paper it was used the notion of "spatial

planning" with the broad sense of planning activity in GIS as using appropriate functions and instruments, not in the strictly urban sense.
At the international level, there are big municipalities that implemented Esri Spatial Cloud through ArcGIS Urban (http://www.bostonplans.org/3d-data-maps/3d-smart-model/3d-data-download, https://www.esri.com/arcgis-blog/products/urban/local-government/arcgis-urban-geneva/).

2. THE GENERAL REGULATORY FRAMEWORK

According to the Methodological Rules for the application of Law no. 350/2001 on spatial planning and urbanism and the elaboration and updating of the urbanism documentation, The Official Gazette no. 199, 17 March 2016, the limits of the administrative-territorial units (UAT) available in the geoportal of the National Spatial Data Infrastructure (INIS), managed by the National Agency for Cadastre and Real Estate Advertising, are used.
The documents of urbanism referring to cities (urban settlements) or communes (rural settlements) consist of the general urban plan (PUG), together with the local urban plan, according to Law 350/2001. The general urban plan (PUG) is elaborated in analogue and digital format (written and drawn pieces) on topographic support using the stereographic projection system 1970, updated on the basis of orthophotomaps or based on field measurements. The implementation of PUG in 3D GIS is not mandatory. The PUG is directive in nature and includes operational regulations, representing the legal basis for the implementation of development programs and actions. Although PUGs are mandatory urban planning documents, with a specific validity period (between 5 and 10 years), most local administrative units have urban planning documents that have come out of the validity term. This is also the situation in Bucharest. The realization of coordinating urban plans in each sector, however, partially solves the crisis in which Bucharest is in 2010, when the new PUG had to be issued, according to the law.
The sectoral coordinating urban plans (Zonal Urban Plan – PUZ) (figure 2) do not the power to offer a complete and modern vision on the development of Bucharest, although they are trying to help investors and citizens in the short term, envisaging urban regeneration operations.
The methodological guide regarding the elaboration and the framework content of the general urban plan was issued in March 1999 and was approved by order of the minister no. 13N of 10.03.1999. The issuer was the Ministry of Public Works and Land Use.
Among the main objectives established by the PUG, according to the guide, are the establishment and delimitation of the areas in which the construction is allowed, of the functional areas, of the areas with temporary or permanent building prohibitions, of the protected areas and of their protection perimeters, identifying the owners of urban land, setting the objectives of public utility; establishing the utility of the lands and the compliance restrictions for the buildings.
POT and CUT are urban indicators and specific working tools to control the sustainable development of urban areas regarding spatial and urban planning. POT is the abbreviation from the Procent of Occupation of the Land and is the ratio between the surface built to the ground (the footprint of the building or the projection on the ground of the perimeter of the upper floors) and the surface of the land on which it is being built, a result that multiplies by 100 because it is expressed as a percentage. The percentage of occupancy of the land is found in the urban

planning certificate and the maximum percentage allowed will always be mentioned. CUT is the abbreviation from the Coefficient of Land Use and is the ratio between the developed built surface (the developed surface of all the collected upper floors) of the building and the surface of the land on which the building is located. The coefficient of land use is mentioned in the certificate of urbanism and the maximum allowed coefficient will always be passed.

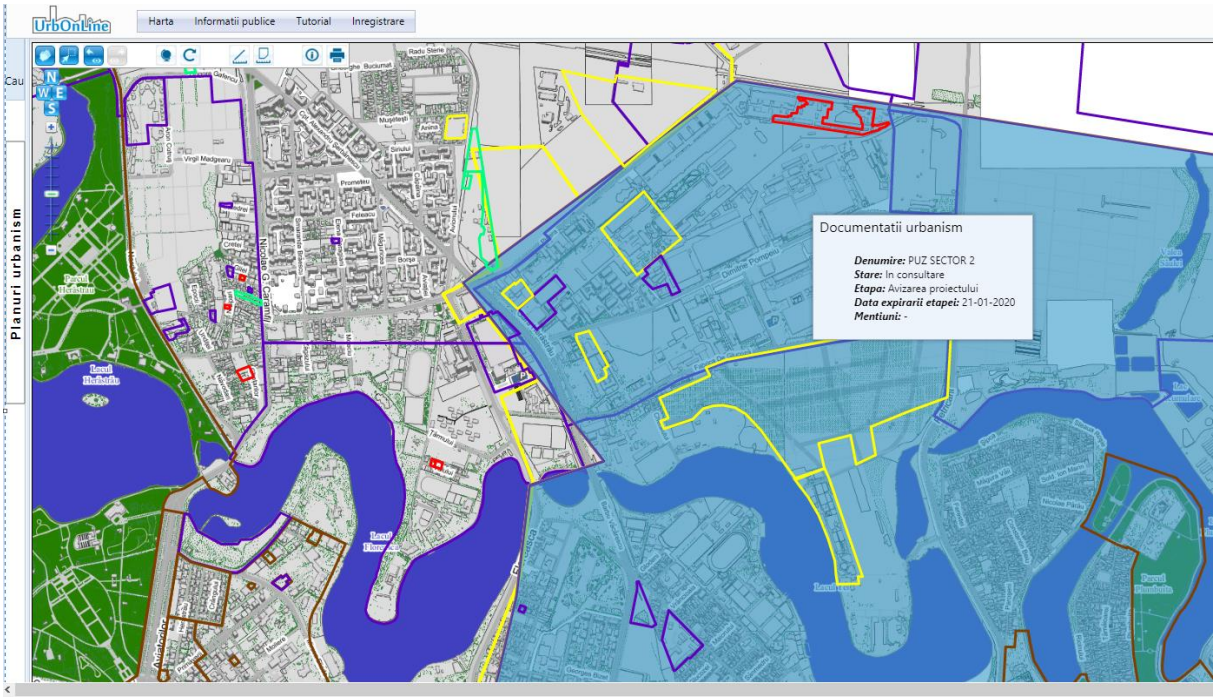

Figure 2 – UrbOnLine webmap – Zonal Urban Plan (PUZ) in 2nd District [18]

The major disadvantage identified in this 2D exclusive mode of work is that, for someone who does not have specialized studies, it may seem difficult to imagine the construction that will be built. Even if within the obligatory elements of a standard plan there are mentioned all the necessary information (in tables, as indices, etc.), they are not quickly accessible to be integrated into an image as close to reality, but also integrated in the built environment.
Therefore, in the following, we identified the advantages offered if all the elements would be used coherently and integrated in a dedicated software, which would also allow a 3D approach, including the texturing component of the constructions and their visualization in the a context as close to reality as possible.

3. METHODOLOGY AND MATERIALS

The conceptual work was based on existing national legal bases. It was used ArcGIS Urban as a planing tool. The case study developed to highlight the software advantages is an area from Bucharest, Romania. ArcGIS Urban is a part of Esri Geospatial Cloud, being a web-based 3D modelling tool designed to improve urban planning and decision-making and it consists of three components: a public-facing Urban Overview web app for standard browsers and/or mobile

devices; a back-office Urban Design web app; and Esri CityEngine for desktop workstations. [17]
Cadastral information is very important in this context, as shown in figure 6.

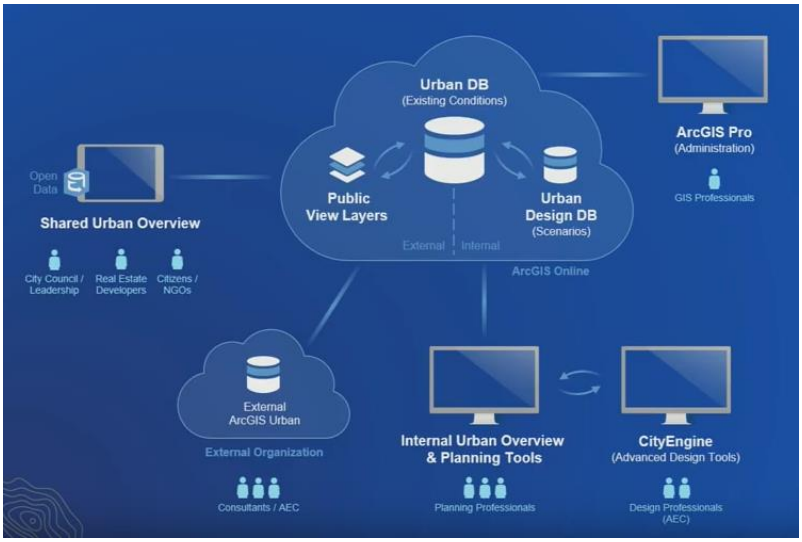

Figure 3 – System Architecture [17]

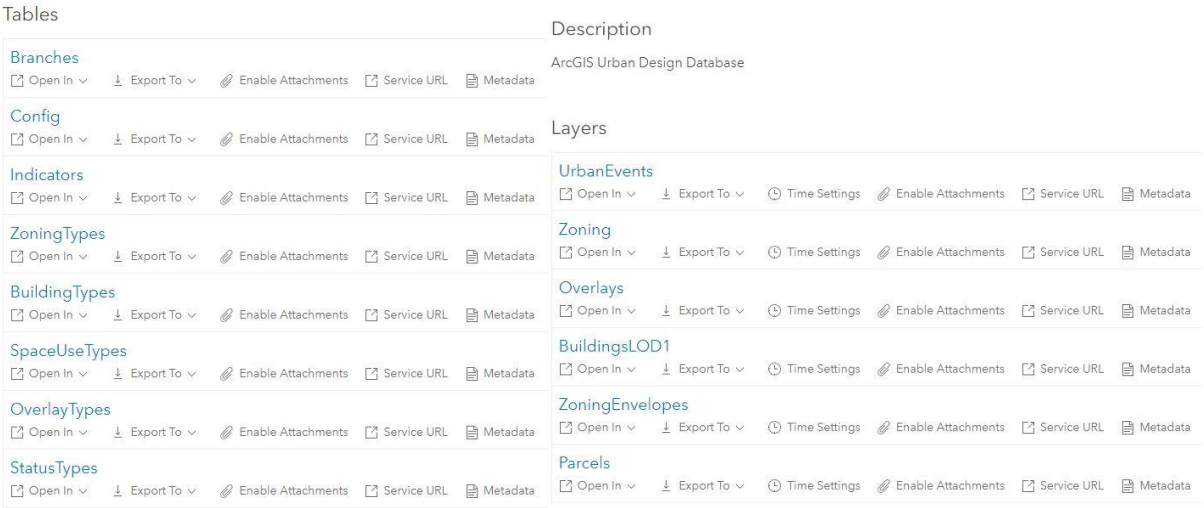

Figure 4 – Database Structure

Figure 5 – Using SketchUp with ArcGIS Urban

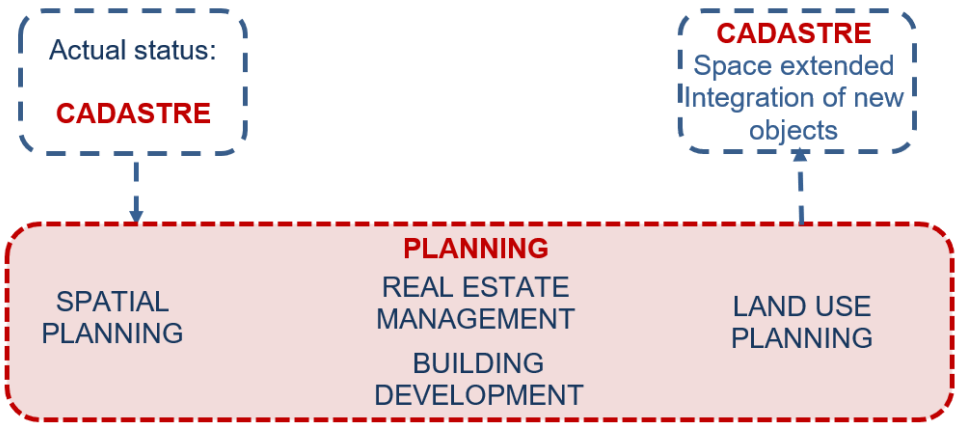

Figure 6 – Sinergy between Cadastre and Spatial/Land Use Planning (adapted from [5])

Even if architectural or building projects are most often created by applying programs that allow visualisation in 3D space, in Romania, the local spatial development plans are still being implemented on the 2D plane. This fact led to the following situation: the dimensions related to the height and depth of the objects that mans restrictions in particular areas according with local plans should be sought in the textual section of the planning papers and the traditional approach to 2D spatial planning is already insufficient.

We want to emphasize the application of 3D web-based tools in support of urban planning is an actual approach, including possibilities of defining or creating 3D Basemap, Zoning Types, Overlay Types, Building Types, Space Use Types, Project Status Types, according with PUG, focusing on GIS instruments. The vertical dimension was changed from the descriptive part to the 3D representation.

Cadastral registration involves colecting, updating and publication of spatial and textual information on real estates. According with [5], the data linked with real estates should be 3D data, because this approach would improve visualizing the complex legal situations and also enabling the registration of full information regarding the geometry of buildings. So, the links between cadastre and spatial planning make mandatory data integration.

The new created spatial objects created by planning workflow should be implemented in the real estate registration and management (division, merging and division, expropriation) and construction (development) processes. Mutually, some spatial planning information should also be recorded as 3D objects, which is certainly necessary for areas that are subject to various types of development restrictions. Such limitations may result from the provisions of legal regulations ordering other areas of life (e.g., environmental protection, protection of agricultural land, landscape protection, protection of monuments, natural hazards, etc.). 3D land use plans facilitate design and help in managing land for proper future land use. Their practical implementation is much more difficult than in the case of 2D representations.

All of the analyzed aspects lead us to a proposal to use ArcGIS Urban and implicitly the models in the urban planning activities in Romania, too.

As example, according with Romanian Local Regulation for Bucharest [18], zone L4 is a high collective housing area with P+5 - P+10 floors, located preponderently in residential assemblies, and the buildings are part of L4a - subzone of high floor buildings P+5-10 located predominantly in residential assemblies, outside of the protected area. H max is according with

PUZ, maximum POT is 20% up to 45% (with maintained lot entries), maximum CUT is 1,4 up to 1,3 (with maintained lot entries). Defining zoning types is presented in figure 6. It is necessary to specify contraints like Special Types, Building Parts Configuration, Space Use Type, Minimum and Maximum Number of Floors, Massing, Footprint Shape, Minimum Floor Area, Dwelling Units Density (DUA), Minimum Distance Between Units for defining building types. (figure 7, 8)

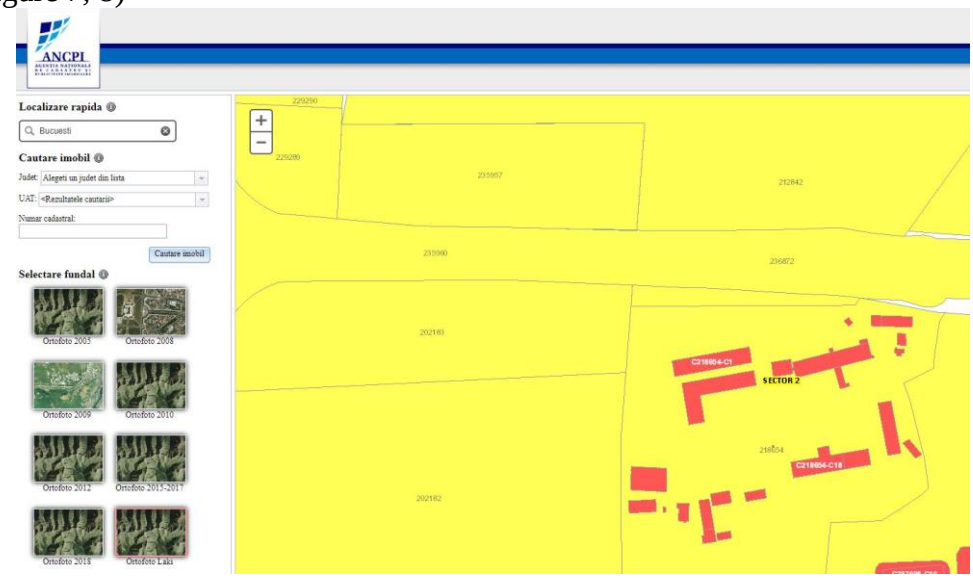

Figure 4 – 2D Cadastral Digital Map (http://geoportal.ancpi.ro/geoportal/imobile/Harta.html)

Figure 5 - Planning and Choosing Indicators

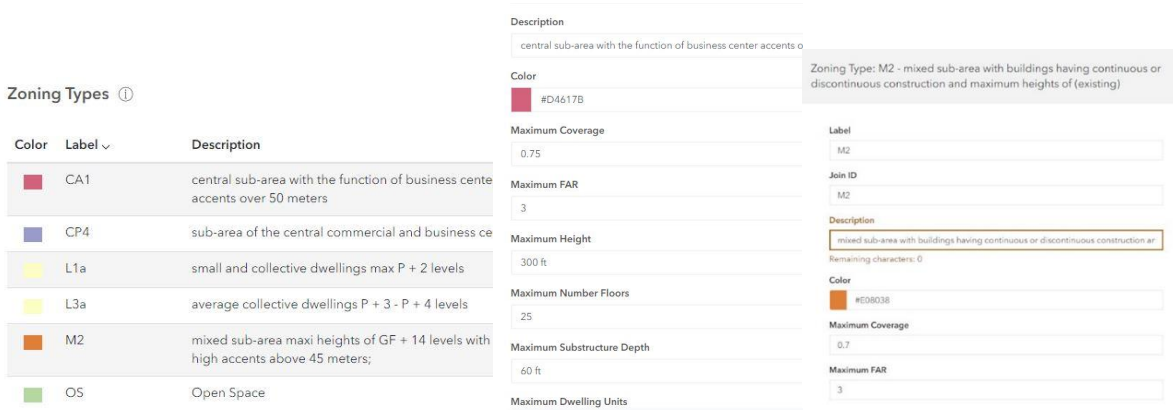

Figure 6 – Defining Zoning Constraints

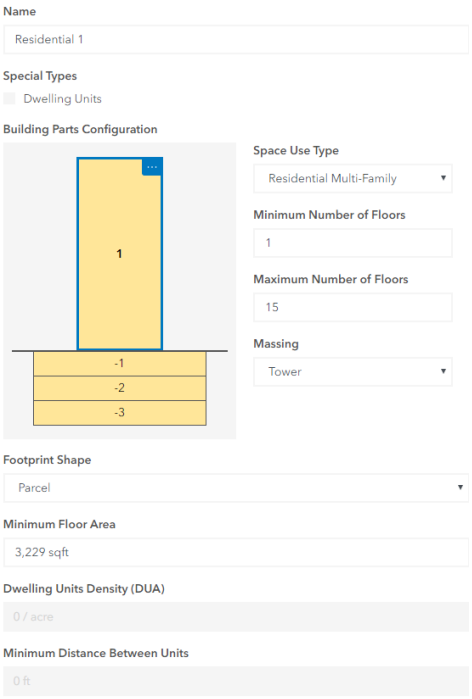

Figure 7 – Example of Constraints for Designing Building Types

Figure 8 - Building Regulation and Space Use Types with Highlighted Error

The errors due to non-compliance with the restrictions in the area are highlighted in real time, so they can be resolved quickly. At the same time, if the information is shared online, the decision makers and the community have the opportunity to see even those areas where the legal criteria were not respected. (figure 9)

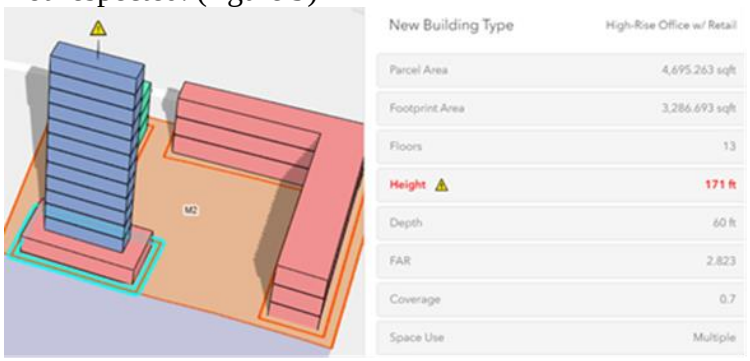

Figure 9 – Example of Identifying Errors by Software [1]

The Urban Design tools manages spatial information into a focused set of scenario planning capabilities. It can be used authoritative data on existing conditions to provide the basis for future scenario development and, it there are available, reporting on key performance indicators, such as the number of new households and jobs. (figure 10 and 11) Unfortunately in Romania all of these are not available yet to be easily integrated. In the following figures there has been defined as example some values for indicators.

Figure 10 - First Scenario

Figure 11 - Second Scenario

Figure 12 - Third Scenario (visible Envelopes and Underground Space)

It is possible an integration between CityEngine and ArcGIS Urban (figure 13) that enables users to access plans and projects directly in CityEngine by connecting to web GIS layers in Urban. The main advantage is acces to the possibility to have a detailed modeling in CityEngine. This approach can further leverage cross-platform interoperability with virtual reality (VR) platforms or other modeling software, including Unreal Engine or SketchUp. [17]

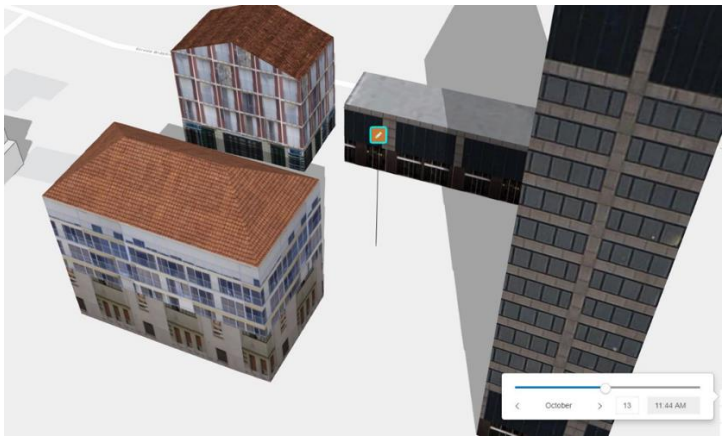
Figure 13 - Examples of Models Designed in CityEngine and Imported in ArcGIS Urban. Setting the Date and Hour for Visualizing Building Shadows

In figure 8 we have a possible model to be implemented in Romania in the future. This model can be implemented at central level, so that the municipalities can introduce the data into the centralized online system or integrate them on the basis of multiple sources and have the advantage of obtaining grounded analyzes. Basically, from these online 3D space analyzes can be identified, by the constraints imposed, the cases in which certain designed constructions do not respect the rules in the related area (using ArcGIS Urban, as a part of Esri Geospatial Cloud). Employees within the urban planning department of the city hall would no longer need to analyze a 2D documentation in analog or digital format, but should only know how to use the 3D model and the associated database.

Another strength is the use of cloud information. Here we refer to the existing 3D models of cities, layers with cadastral information, information that lead to the most real values of the indicators.

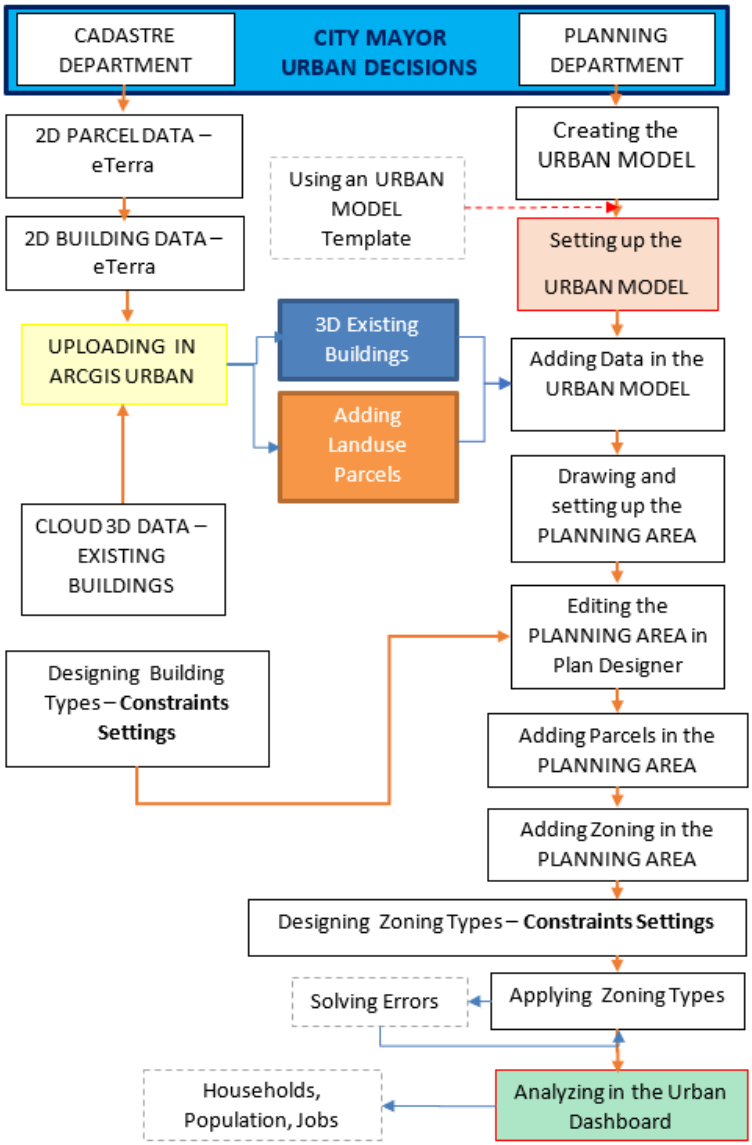

Figure 8 – A Possible Model to be Implemented in the City Hall Workflow

4. CONCLUSIONS AND PROPOSALS

In this paper is presented the need to introduce 3D geospatial database to Romanian spatial planning using dedicated software. As a future proposal, spatial planning objects linked with the cadastral database can create possibilities for quickly space analysis, facilitating decision-making related to development processes. A future integration of the 3D cadastre and 3D spatial planning could be appreciated by the professionals working with urban planning as well as surveyors.

Urban Overview allows stakeholders to visualize citywide projects in a standard web browser supporting to review of new projects. A shared view of the development pipeline also is increasing public transparency, lessens uncertainty, and promotes greater community

involvement in the review process, especially at a City Hall level. It could be a powerful alternative for actual UrbOnLine 2D working environment.

In Romania legislative systematization work is now underway on the so-called urban and construction code. In this context, the Ministry of Public Works, Development and Administration (MLPDA) elaborated the project proposal "Systematizing the legislation in the field of spatial planning, urbanization and construction and strengthening the administrative capacity of the specialized structures of central public institutions with responsibilities in the field". The project is implemented starting with 9.05.2018. One of its specific objectives is to ensure the systematic and optimized legislative framework by elaborating the Code of spatial planning, urbanization and constructions.

The code should influence the spatial planning system in our country. It could be useful that according to the future code, planning or the updating of planning documents should not be possible without the designing of a planning database that is included in the infrastructure for spatial information. The planned result should be the unification of planning work carried out throughout the whole country.

The legal framework in the area of spatial planning, urban planning, cadastre and construction currently needs to be adapted to the current needs and opportunities of population development, as well as to the prospects for economic growth. Subsequently, this complex approach involves the systematization of the legislation, the foundation of new concepts, the reformulation of some principles and the adaptation of processes aimed at ensuring a coherent and stable legislative framework, a quality built environment, ensuring the balance between the general and the individual interest, balanced and sustainable development, stability and the predictability of the investment environment and implicitly economic competitiveness.

Regarding the software, the main advantages of using ArcGIS Urban for local administration could be improving of planning activity, transparent decision making, 3D representation of normative regulations, enhanced planning workflow.

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BIOGRAPHICAL NOTES

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