Geodesign Process Model: the Role of Visualisation in Feasibility Study of Urban Parameters

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Abstract. The paper investigates the Geodesign framework in designing a building according to existing normative, using the case study of Belo Horizonte, Brazil, to illustrate the process. The methodology is descriptive and based on an interview with an expert in this area and on the consultation of relevant local official urban regulation. The aim is to decode several steps and tools that are part of the everyday practice of a professional who deals with normative in Belo Horizonte. Thus, the main objectives are: (i) capture the process steps and bring it into a visual plan; (ii) highlight the tools used by professionals to decode local normative; (iii) visualise the entire set of actions that make up the process; (iv) elucidate an important step that may eventually become part of a Planning Support System. In particular, the main goal is to focus on one situation and identify possible tools and processes that might contribute to truly sharing the urban codes which determine the construction of the urban landscape today in Brazil.

Keywords: Visualisation, Geodesign, Urban Parameters

1. The Role of Visualisation in Planning Practice

This research assumes that the communication of values and parameters that shape cities have to be accessible and understandable by citizens and professionals who participate in the building of the urban landscape. In this sense, the paper investigates how visualisation tools can facilitate and increase the understanding of processes that involve urban parameters and the management of urban projects, while increasing public awareness on spatial issues. Considering that urban planning is mainly based on dialogue between different actors, such as decision-makers, professionals and local representatives, the need for a shared code that effectively promote communication between the parties shows to be essential.

Scientific literature points out how visualisation is an effective method to enhance the understanding of spatial issues. At the same time, it highlights how visualisation can be used to present data and information, simulations and modelling, likewise it can enhance knowledge building (Tukey 1977, DiBiase 1990, MacEachren et al. 2004).

It is considered that PSS and Geodesign can answer this premise, since both are based on building a framework to orchestrate processes, supported by the visualisation and proposal of shared rules. The difference is that PSS relate to a process in general terms, allowing the detailing and structuring of a metaplanning, while Geodesign, is a specific framework for providing design solutions through the iteration and juxtaposition of six spatial models (Steinitz 2012). Therefore, PSS can be implemented through the different models of Geodesign which are the representation of goals, the reaching of the understanding of process, evaluation, control of changes, simulation and proposal of specific territorial performances.

Since this case study mainly concerns the process of building up a *feasibility study* according to the urban normative of Belo Horizonte (Brazil), among the six Geodesign models, only the *process model* could potentially contribute to PSS logic. This connection is important, especially for the mentioned case study, because it aims at investigating the means for making users to understand the logic application of urban parameters in architectural design. In fact, except for the first testing proposed by the EA-UFMG team of geoprocessing (http://geoproea.arq.ufmg.br/publicacoes) this investigation did not detect any other Brazilian experiences concerning PSS and Geodesign applications nor metaplanning studies. Therefore, a test on the Brazilian context is justified to be presented as a case study to contribute, albeit initially, with a first investigations.

Therefore, this research look at two main goals: first, investigate tools and methods that might clarify, in order to visualise, one situation and identify possible tools and processes that might contribute to build a shared urban code which determines the construction of the urban landscape today in Brazil. Secondly, start the construction of a framework that, when developed, might be an important base for a dialogue between planning actors.

2. Theoretical Framework: Concepts and Arguments

Nowadays, the research on Geodesign offers a large number of tools which aim at improving the daily activity in the urban planning practice. Nevertheless, existing tools are underused. Despite the multitude of tools and technologies made available for professional planning and design, the combination of technology with professional practice does not seem to provide successful results. Generally, planners and decision-makers seem to not trust on the use of computer tools (Vonk, Geertman, & Schot, 2005, Geertman & Stillwell 2003, Batty 2003, Uran & Janssen 2003, Stillwell et al. 1999, Sheppard et al. 1999, Bishop 1998, Harris & Batty 1993; Scholten and Stillwell 1990, Couclelis 1989, Klosterman & Landis 1988).

As revealed by a questionnaire addressed to a significant number of planners in the Netherlands and reported by Te Brömmelstroet (2010), the main obstacle in applying PSS to real case studies is the general lack of transparency. In fact, these tools are too often perceived as "sophisticated black boxes", which Latour (1987) identified as an attitude to be avoided, reiterating the need of transparency in scientific research.

The usability of spatial models has been debated for many decades, and Lee (1973) already pronounced their end. Even the enormous development of graphics capabilities that computers knew during the eighties, bringing new opportunities for their use, did not delete this mistrust in their use. This shows not only a serious doubt towards a wide world of research in planning tools, but also a substantial immobility by professionals in perceiving possible applications of mathematical models to spatial interactions. Thus, from a technical point of view, scientists continue their research in order to find new parameters for quantifying the world, often paradoxically aspiring at creating models as complex as the reality (Borges 1960). This kind of scientific research brings to planning tools which Vonk et al. (2005) defines as “too generic, complex, and inflexible, incompatible with most planning tasks, oriented towards technology rather than problems, and too focused on strict rationality”. On the side of planning practice, the perspective is completely different. Planners and decision makers look for simple methods for evaluating spatial issues through easy linear connections. According to the questionnaire discussed by Te Brömmelstroet (2010), PSS are not largely diffused among the professional activities because perceived as “not user friendly”, “not interactive” and, above all, with a "low communication value". Planning is a complex process of interaction between people, who have to communicate, exchange ideas, share information and, in particular, defend their interests and compare their reasoning.

For this reason, despite the complexity and validity of many PSS and DSS tools, their low communication power often hampers their usability, causing a general decreasing of the interest in applied technology. Meanwhile, communication is an important element for planning practice, so it should be considered as the essential key point for structuring a decision process.

2.1. The visual communication as form of knowledge

Urban and regional planning are processes which require the agreement of several decision-makers, professionals and local representatives. Thus, planning processes generally involve a large number of actors, who generally come from different disciplinary fields, represent different interests and, above all, speak different languages. The personal background, as well as the technical skills, of each actor may limit the understanding of planning issues.

Due to the complexity of territorial issues, communication between the parties can fail and a lot of information can be lost. Experience has shown that visualisation is an effective method to enhance the understanding of spatial issues, well illustrating both quantities and qualities of a spatial system (Tufte 1983, Globus & Raible 1994, MacEachren 1994, 2004, Card et al. 1999, Batty 2000, Spence 2001, Batty Steadman & Xie 2004, Thomas & Cook 2005, Andrienko et al. 2007, Simao et al. 2009). Visualisation can activate forms of intuitive knowledge (McCormick et al. 1987), so that it can be an effective way to engage both citizens and decision-makers (Kwartler & Longo 2008).

The art of visualising data is part of human history, witnessed by a huge number of representations that go back in the centuries. It is even more, it is the basis of the progress of the human species, it is an act of cognition (MacEachren 1992, Card et al. 1999). However, the technological evolution occurred during the last three decades in computing brought the visualisation to new application fields, making it a scientific discipline. Nowadays, scientific visualisation can be considered as a natural consequence of the evolution in computing. Its purpose is not providing numbers but an insight into the meaning of numbers, thus improving the knowledge of data through the use of intuitive skills of human minds. Visualisation is a method for creating an order between data. By transforming data into geometry, it localises the information and shows the relationships that exist between data, thus generating a structure for collecting and understanding information. Visualisation stands at the basis of a process of knowledge building which can reach a large audience, implementing the communication and problem solving (DiBiase 1990).

Within the field of scientific visualisation, a specific branch named geovisualisation is dedicated to the production of maps and, in general, to the visual communication of spatial data. In particular, geovisualisation is by definition the discipline that allows the exploration and analysis of spatial information through interactive visual interfaces (Andrienko & Dykes 2011). Including the terms exploration and interactive, geovisualisation focuses on implementing the process of knowledge by activating the human intuitiveness in relating data to their geographical location.

In fact, visualisation can be used just to present data and information, but it can offer also other uses which can increase the opportunities for knowledge building (Tukey 1977, DiBiase 1990, MacEachren et al. 2004). In particular, it can be used to analyse data, so to study trends and clusters, or it can be employed to explore the information so to “easily and intuitively browse and forage through the information space” (Dodge 2005). At the same time, interaction is essential for the formation of a self-constructed knowledge, where visualisation works as a Socratic maieutic who support people in learning from their own experience.

Through exploration and interaction, visualisation can improve the process of knowledge building. Providing a shared common language, its use can benefit the communication process between people, even with different skills and expertise (Masala & Pensa 2014, Pensa et al. 2014). As a consequence, visualisation can have an important role in the development of spatial processes, deeply affecting decision-makers in taking their choices.

2.2. The role of visualisation in Geodesign

Since scientific literature shows as visualisation can affect the knowledge of users, it can assume different roles when applied to Geodesign.

Geodesign is, by definition, a design and planning method which tightly couples the creation of design proposals with impact simulations informed by geographic contexts (Flaxman 2010). This means that Geodesign is strictly connected to the use of geospatial technologies, oriented to produce an iterative design proposal which grows on the basis of geographic information. In that sense, Geodesign aims at offering technologies for improving the whole process of design practice, integrating different spatial technologies such as modeling, simulation and visualisation, into a single system conceived for offering design solutions.

Thus, Geodesign aims at supporting professionals in their practice, offering also solutions for sharing their work. Nevertheless, although the assumptions of Geodesign look at involving practitioners in the use of geospatial technologies, professionals still seem to be very far from using these tools in their daily activity. From the one hand, Geodesign is proposing again tools, which have costs, different levels of usability, easiness, compatibility with other systems, and, in particular, have new rules that should be followed by users. On the other hand, planners, stakeholders and decision-makers still have difficulties in communication and need a support for sharing their opinions and ideas (Pensa & Masala 2014). The bottlenecks between technology and professionals still remain and more reasoning are required to understand where difficulties lie.

Many examples show that several new tools implemented visualisation features, providing easier interface or outcomes. Nevertheless, visualisation has different roles in the planning of cities and regions. First of all, visualisation enhances the imagination of people, offering pre-figurations of possible configurations. The future of a place can be evaluated before it happens, opening the mind to new visions. Secondly, it enhances the possibilities for sharing ideas, providing an easy and common language for communicating. This is particularly important when planning and design processes involve people with different expertise and skills. Thirdly, visualisation can be used to illustrate where specific data are concentrated or dispersed, showing groups, clustering or lacks of data. In this way, visualisation can be assumed to draw the guidelines for new projects, becoming essential for the choice of a strategy or project option.

As a conclusion, it is clear that visualisation contributes to the productions of plans and projects and its role is particularly important to define the whole process of study, analysis, evaluation and building of a project.

2.3. Code sharing: a way for avoiding black boxes

The fact is that the progress on visualisation is not enough for increasing the usability of planning and design support tools. Elements such as interactivity, easiness of use, compatibility are essential for increasing their use but one of the most important bottlenecks towards the use of PSS and DSS is for sure the lack of transparency. Mostly based on spatial mathematical models, planning and design tools appear as *black boxes* which cannot be explored nor modified. Their working features are generally not clear, nor readable. Planners, stakeholders and decision-makers are requested to trust on their outcomes, without knowing how tools manage data.

Planners and designers are usual to work basing their assumptions on their personal experience. Tools are not able to reproduce the human know-how, neither should they aim at (Andrienko et al. 2007). Therefore, in order to be really usable, tools should help professionals in sharing their experience with other people, who can have different knowledge. Professionals should have the possibility to express and communicate their ideas, without needing complicated mathematical formulas. Given the exploratory task of spatial models, tools should be very simple (Klosterman 2012) and support the understanding of spatial dynamics instead of providing solutions.

This point becomes a key feature for conceiving support tools. Firstly, they should be easy; they should be intuitively understood at a glance. Secondly, they have to be simple; they should propose linear connections between causes and effects in order to avoid complicated, low communicative formulas. Thirdly, mathematical functions and parameters should be readable by users and, overall, have to be customisable; users should have the possibility to manage in real time the code of the model, so to have the possibility to define specific behaviors. Furthermore, the back end of the tool has to be explorable. Every user should have the possibility to understand why their actions produce a specific outcome. Even better if users can control the effect of every single action, so to distinguish the changes due to each variable. Only in this way, the tool can result transparent to users (Pensa & Masala 2014). Finally, the tool should provide a way for collecting and comparing the ideas of users, so to highlight how a different planning choice can affect a plan or project.

Therefore, it is essential that Geodesign tools could provide opportunities to their users for investigating and, eventually, customising the formulas and parameters that allow an input to become an output.

3. Methodology

The selected case study is part of a wider context composed by several actions that an architect must comply to have a project approved by the Municipality of Belo Horizonte (Figure 1).

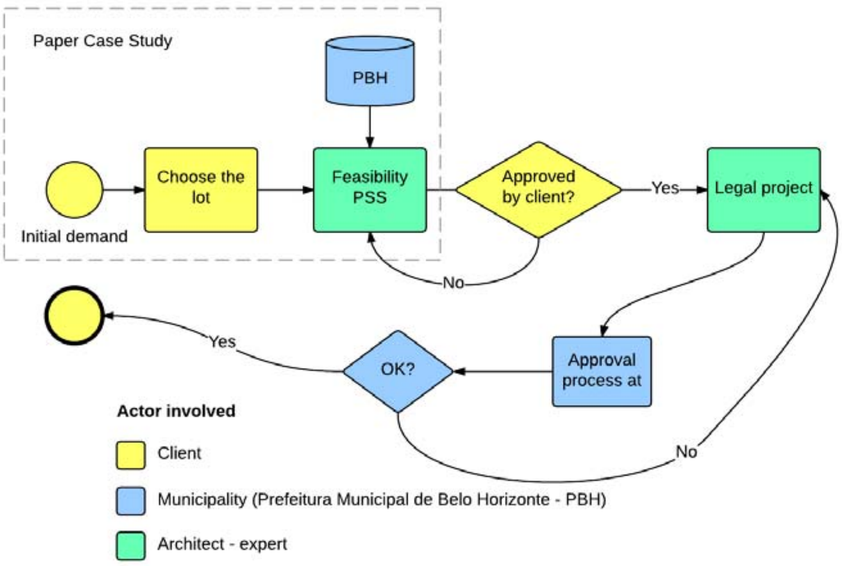

Figure 1. The wider context: structure of a feasibility study according to the urban normative.

Within this context it was found that the *feasibility study* is a complex cut-out of a wider context (Figure 2), where a gap was identified related to the understanding and control of processes. Because of this constraint, there are many cases in which the projects are developed off legality (Raso 2013).

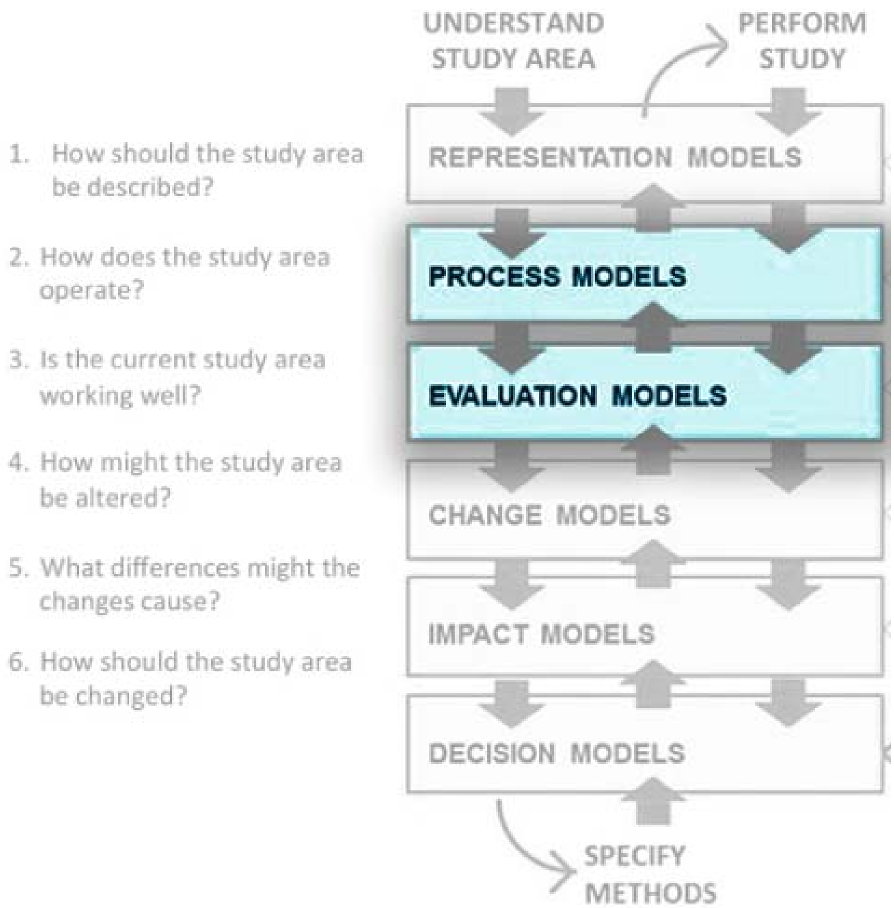

Figure 2. Case study relations with Geodesign models: the Process Model and the Evaluation Model. Source: adapted from Steinitz (2012).

Previous researches (Raso 2013, Zyngier et al. 2014) showed the presence of a slowdown when approving architectural projects based on feasibility study (Figure 3) according to urban parameters of Belo Horizonte. Thus, considering a lack of understanding of the shared code as a possible cause, a description of the process is required, in order to bring the above-mentioned process steps into light and understand it to find a common basis to create public awareness.

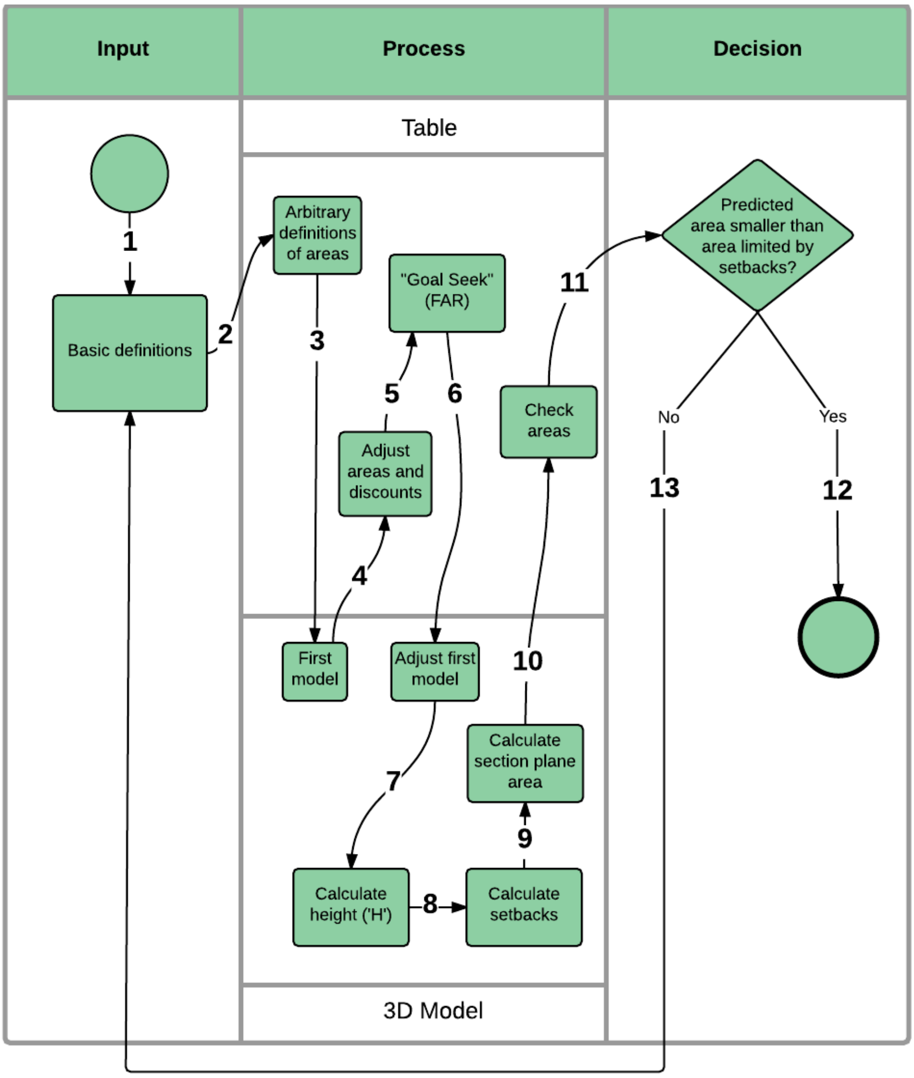

Figure 3. Case Study structured as a PSS

Having a focus on *feasibility*, the case study went through all the stages of elaboration, aiming at translating and decoding the practice of a specialist in this field of knowledge.

The methodology can be transcribed into a series of steps which have been used to structure a PSS based on visualisation resources in order to clarify the process of choosing a better architectural design from the application of urban parameters. These steps are the following:

- Interview with a specialist who selected the lot for the practice;

- Drafting descriptive sketches from the step-by-step process pointed out by the specialist;
- Query the relevant documents used by the specialist and available at the municipality's website (tables, manuals, tutorials, Zoning and Land Use Code, etc.);
- Complementary three-dimensional modelling of any elements always when necessary;
- Interpretation of expert thinking through the production of drawings and diagrams using software for process design.

It is worth to mention that the *Feasibility Studies* here dealt are represented by the technical analysis of how doable is a real estate development under the parameters of the chosen lot. This type of preview study is a frequently used tool by the real estate market in the city of Belo Horizonte and helps clients to take a decision in order to continue or start a project. For its elaboration, it is taken into account the specific area, its location within the city's zoning laws and, then, the urban parameters (*floor area ratio,* building potential, permeable area, setbacks, allowed uses, etc.) according to the *Land Use and Zoning Code.*

As a case study for this paper, it was empirically evolved a *Feasibility Study* for a multifamily residential building development in a *Zone for Priority Densification* (*ZAP* – acronym in Portuguese), with *Floor Area Ratio* of 1.5 and cover area of $360m^2$. These empiric indices were chosen with the support of a specialist, who indicated them as the most requested references for its studies.

4. Case Study

The Municipality of Belo Horizonte (Brazil) makes available online an Excel table (http://goo.gl/C4ekI8) and its tutorial (http://goo.gl/uakvqe) to fill out information about the project yet to be approved. The table includes links between different cells that help calculating the maximum total floor area according to the plot and the exceptions and discounts to certain uses within a building. The table also allows one to fill in the areas for vertical and horizontal circulation, the private residential areas, balconies, parking, and lobby. By doing so, the responsible for the project can see if his/her project fits within the city laws and approve it prior to the construction.

The following quotation describes the steps delineated by an expert in the area and is based on the diagram shown in Figure 3, whose number sequence can be described as follow:

(1) Choose the lot and basic definitions involving legislation applied, number of stories desired, typology, etc.;
(2) Define arbitrary areas for circulation and private residential areas according to experience and fill it out in the table;
(3) Check, in an initial 2D or 3D model, more precise values for the areas of general circulation, areas for deposits, parking and lobby (Figure 4);

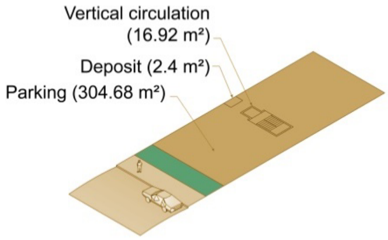

Figure 4. Definition of areas

(4) Bring those areas back to the table and correct them accordingly;
(5) Using the Excel tool *Goal Seek*, set the *Floor Area Ratio* (FAR*:* ratio between the total floor area of the building and its lot's) cell to the maximum value according to the law (e.g. 1.5), by varying the *Private Residential Area* cell for the first floor. The other floors must have their cells of *Private Residential Area* related to the first floor, so that they vary together when using this tool;
(6) Apply the new values to the model, adjusting the first model;
(7) Calculate the height of building according to the number of floors (height per story used = 2.88m, according to experience with stairs; ground floor not considered);
(8) Calculate the Setbacks[1] according to the height (commonly, the Setback required for the top story is applied to the whole building, due to structure costs). The method used to visualise these setbacks is the *Building Height Limitation Plane*: a virtual sloping plane varying according to the height, which cannot be penetrated by any part of the building (Figure 5);

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[1] Another important law regarding construction limits in Belo Horizonte is the *Setback code* (http://goo.gl/uakvqe). It determines how far the limits of the building must be from the lot lines. The higher the building, the farther from the border it must be set. Therefore, it comes to a point where, depending on the size of the lot, the Setback limits the maximum built-up area. Therefore, it comes as another variable to be considered, besides the maximum FAR. It must be applied to the model as well as in a 3D model, 2D drawing or table.

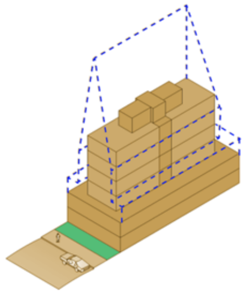

Figure 5. *Building Height Limitation Plane*

(9) Calculate the section plane area that fits within the new *envelope* (maximum tridimensional space on a lot within which the structure must be built) determined by the Setbacks;

At this point, it is necessary to come back to the table and check the new areas (10). The *floor area per story* allowed according to the *Height Limitation Plane* must be compatible with the area achieved at the table after applying the *Goal Seek* tool (11). In that case, the project predicts the highest possible built-up area according to the *FAR* laws, without further limitation from Setback legislation (12). Otherwise, if the section area without the Setbacks is lower than the one on the table, the Setbacks is excessively limiting the buildable area (13), so that the developer would consider the project to be underachieving and possibly uncompetitive, as other projects in the same area can reach the maximum *FAR* and have more private residential area to be sold. If the latter, undesirable situation happens, one way out would be to reformulate basic assumptions for the project (12), for example by adding one story. In order to keep the same maximum *FAR*, this would decrease the buildable area possible per story and by following again the steps, it can be checked whether the new area matches the Setbacks limits. If adding one story does not solve the problem, other assumptions can be changed:

- Return to the basic definitions of the lot, questioning if dimensions, legislation, size are compatible to what is to be built commercially;
- Consider acquiring more lots into one project, so that the Setback laws have little effect on the form of the construction;
- Consider building below the maximum *FAR*, if the project has other differentials that would guarantee economic viability.

5. Conclusions

Further advances within the general local planning framework are expected as well as further interviews and records of the experience of other specialists. This future expansion might be used to elaborate a framework whose visualisation can contribute to the selection of appropriate planning tools and methods for each stage that compose a more complete PSS including the six steps indicated by Carl Steinitz.

Geodesign studies contributed to this investigation providing a more general visualisation of concerned planning processes. On the other hand, the PSS structure helped to detail and visualise the sub-steps that comprise referenced Steinitz' models. In this design process, the relation between Architects and steps that they have to follow in order to deal with the legislation should be analysed because this technical group represents a bridge towards the non-technical citizens (clients) that need the approval of a project. The experience of the respondent contributes to understand how the flow of the design construction happens from a detailed point of view, very important for modelling, describing, understanding the processes. When analysing and interpreting the experience described by the expert, it became clear that there is a difficulty in dealing and understanding the data that determine the constraints of a project. This results obviously amplified when a non-expert have to understand the codes that determine the urban parameters and shape the urban landscape.

For these reasons, the use of visualisation should be an essential step for understanding and disseminating the urban codes, in order to provide a support for both expert professionals and non-expert citizens who have to deal with the urban morphology.

References

Andrienko G, Dykes J (2011) International Cartographic Association, Commission on GeoVisualisation. http://geoanalytics.net/ica/ Accessed 3 November 2012

Andrienko G, Andrienko N, Jankowski P, Keim D, Kraak MJ, MacEachren AM, Wrobel S (2007) Geovisual analytics for spatial decision support: Setting the research agenda. International Journal of Geographical Information Science, 21(8), 839-857.

Batty M (2000) Visualizing the city: urban design to planners and decision makers. CASA, working paper series, 26.

Batty M (2003) Planning support systems: technologies that are driving planning. In S Geertman, J Stillwell (eds), Planning Support Systems in Practice, v - viii. Springer, Berlin.

Batty M, Steadman P, Xie Y (2004) Visualisation in spatial modeling. CASA - working paper series, 79.

Bishop I (1998) Planning Support: hardware and software in search of a system. ComputersEnvironment and Urban Systems, 22, 189-202.

Borges JL (1960) El hacedor. Emecé, Buenos Aires

Card SK, Mckinlay JD, Shneiderman B (1999) Readings in Information Visualisation: Using Vision to Think. Morgan Kaufmann, Burlington, MA.

Couclelis H (1989) Geographically informed planning: requirements for planning relevant GIS. 36th North American Meeting of Regional Science Association. Santa Barbara.

Di Biase D (1990) Visualisation in earth sciences. Bulletin of Earth and Mineral Sciences, 59, 13-18.

Dodge M (2005) Information Maps: Tools for Document Exploration. CASA, working paper series, 94.

Flaxman M (2010) Geodesign: Fundamental Principles and Routes For-ward. 2010 Geodesign Summit.

Geertman S, Stillwell J (Eds) (2003) Planning Support Systems in Practice. Springer, Berlin.

Globus A, Raible E (1994) Fourteen Ways to Say Nothing With Scientific Visualisation. Computer, 86-88.

Harris B, Batty M (1993) Locational models, geographical information and planning support systems. Journal of Planning Education and Research, 12, 84-98.

Klosterman RE (2012) Simple and complex models. Environment and Planning B: Planning and Design, *39*(1), 1-6.

Klosterman RE, Landis J (1988) Microcomputers in US planning: past, present and future. Environment and Planning B: Planning and Design, 15, 355-368.

Kwartler M, Longo G (2008) Visioning and Visualisation, People, Pixels and Plans. Lincoln Institute of Land Policies, Cambridge, MA.

Latour B (1987) Science in action. How to follow scientists and engineers through society. Harvard University Press, Harvard, MA.

Lee DB (1973) Requiem for Large-Scale Models. AIP Journal, 163-77.

MacEachren AM (1992) Visualisation. In RF Abler, MG Marcus, JM Olson (Eds), Geography's Inner Worlds: Pervasive Themes in Contemporary American Geography (pp. 99-137). Rutgers University Press, New Brunswick, NJ.

MacEachren AM, Taylor DR (1994). Visualisation in Modern Cartography. Pergamon, Oxford.

MacEachren AM, Gahegan M, Pike W, Brewer I, Cai G, Lengerich E, Hardisty F (2004) Geovisualisation for knowledge construction and decision-support. Computer Graphics & Applications, 24(1), 13-17.

Masala E, Pensa S (2014) Visualisation: An Approach to Knowledge Building. In I. M. Lami (Ed), Analytical Decision-Making Methods for Evaluating Sustainable Transport in European Corridors (Vol. 11, pp. 159-174). Springer International Publishing.

McCormick BH, De Fanti TA, Brown MD (1987) Visualisation in Scientific Computing. Computer Graphics, 21(6).

Pensa S, Masala E (2014) InViTo: An Interactive Visualisation Tool to Support Spatial Decision Processes. In N. N. Pinto, J. A. Tenedorio, A. P. Antunes, & J. R. Cladera (Eds), Technologies for Urban and Spatial Planning: Virtual Cities and Territories (pp. 135-153). Hershey, PA: IGI Global Book.

Pensa S, Masala E, Lami I, Rosa A (2014) Seeing is knowing: data exploration as a support to planning. Proceedings of the ICE - Civil Engineering, *167*(5), 3-8.

Raso MC (2013) Construções Clandestinas em Belo Horizonte. Centro Universitário Metodista Izabela Hendrix, Belo Horizonte.

Scholten H, Stillwell J (Eds) (1990) Geographical Information Systems for Urban and Regional Planning. Kluwer, Dordrecht.

Sheppard E, Couclelis H, Graham S, Harrington J, Onsrud H (1999) Geographies of the information society. International Journal of Geographical Information Science, 13, 797-823.

Simao A (2009) Web-based GIS for collaborative planning and public participation: An application to the strategic planning of wind farm sites. Journal of Environment Management, 90, 2027-2040.

Spence R (2001) Information Visualisation. Addison-Wesley/ACM Press, Boston, MA.

Steinitz C (2012) A Framework for Geodesign: Changing Geography by Design. Redlands, Esri Press.

Stillwell J, Geertman S, Openshaw S (1999) Geographical Information and Planning. Springer, Berlin.

Te Brömmelstroet MC (2010) Equip the warrior instead of manning the equipment: Land use and transport planning support in the Netherlands. Journal of Transport and Land Use, 3, 25-41.

Thomas JJ, Cook KA (Eds) (2005) Illuminating the Path: The R&D Agenda for Visual Analytics. IEEE Press, Los Alamitos.

Tufte E R (1983) The Visual Display of Quantitative Information. Graphics Press, Cheshire, CT.

Tukey JW (1977) Exploratory Data Analysis. Addison-Wesley, Boston, MA.

Uran O, Janssen R (2003) Why are spatial decision support systems not used? Some experiences from the Netherlands. Computers, Environment and Urban Systems, 27, 511-526.

Vonk G, Geertman S, Schot P (2005) Bottlenecks blocking widespread usage of planning support systems. Environment and Planning A, 37(5), 909 – 924.

Zyngier C, Pensa S, Masala E (2014) Considerations on the Use of Visual Tools in Planning Processes: a Brazilian Experience. Tema. Journal of Land Use, Mobility and Environment, [S.l.], maio. 2014.

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