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Integrated Information System for Sustainable Urban Regeneration

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1 ABSTRACT

Information systems are widely used in urban planning process for communication between different side actors. However, most of them have been implemented without providing possibilities for decision makers to participate together with urban planners in the process. This research aims to outline a framework where an interactive model for decision making plays a key role in creating a collaborative environment. The proposal regards the information representation as the main instrument for encouraging a constructive dialog between different actors. The focus is on the relationship between three elements of information representation: level of detail, type of visualization and interaction. Combining these elements, information can be provided in a dynamic way enabling more effective exploration and understanding. The proposed strategy implements a digital model that operates on different scales and levels in order to support the key stages of the planning process for sustainable urban regeneration in Bulgaria. Positional approach is used to define the functionality and decision making operation for the selected process. As a result research ideas about the use of the digital model are presented.

2 BACKGROUND

Today's planning process for sustainable urban regeneration can be described as a strategic approach, whose main element is the mind-set for action and implementation through links between budgets, projects, citywide and regional infrastructure. The quality and effectiveness of the plans can be greatly enhanced through the integration of multidisciplinary and multi-actor insights, intelligence and perspectives that are usually not considered within the formal planning process (Kunze, A. et al. 2012). In order to support and manage this process urban planners create urban information systems which are the main instrument for work and communication between experts and nonprofessionals.

Most of the urban information systems consist of three main cores – Urban and Regional Information Infrastructure, Digital Environmental Model and Platform (fig. 1). The first one represents the datascape in which data from agencies, periodically refreshed sources and real time data is collected (Laurini, 2001). Data acquisition is not limited to the basic city planning surveys but includes data about all social, economic and environmental issues, concerning the concrete planning process. All this variety of files is classified in spatial and non-spatial data. The first one consists of location and attribute information whereas the second contains only attribute information. Both of them during the data preparation are collected and combined in common database and handled on an unified base map in a Geographic Information System (GIS) (Asami, 2008).

The management of this huge datascape for the purposes of sustainable urban regeneration requires creating a Digital Environmental Model. Essentially, it includes all the information organization and analysis that professionals are doing in all stages of the planning process. Supported by the necessary handling systems it defines the Analysis Module of the urban information system. The third project's core, the Platform, generates diverse range of traditional output materials, that are the main instrument for communication between the planners, decision makers and representatives of the interested parties. Usually web-based in GIS, it is used by limited actors and represents the information system's Decision Module.

The connection between the Digital Environmental Model and the Platform uses the means of geovisualization. This traditional visualization of urban spatial models has been rather abstract and not easy to read and consists mostly of information associated with 2D maps (Kunze, A. et al. 2012). Professionals produce maps and other conventional output materials in the end of each stage with an intention to communicate with different side actors in the planning. This way of work creates one direction

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communication and do not provide any possibilities for decision makers to participate together with urban planners in the process.

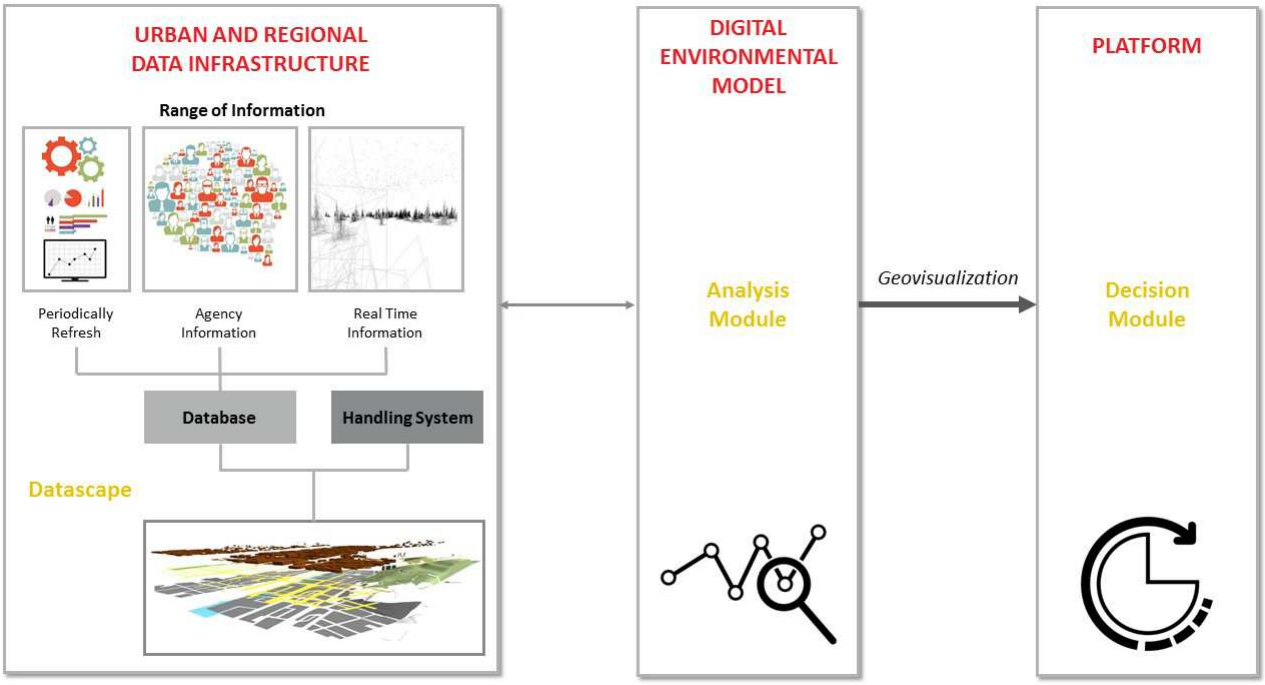

Fig. 1: The three parts of the Urban Information System

The urban information systems still have limited capabilities mainly designed for professionals who stay their only users. Kunze argues that when expert tools become more interactive they will be able to be used by non-experts. He envisions the use of Decision Support Tools together with collaborative environments in planning agencies of the cities and regional administrations. However, the current lack of integrated instruments for creating urban plans does not allow the professionals and decision makers to combine efforts and work together from the beginning of the planning process. This predetermines the planning process and reduces the quality of response plans.

3 RESEARCH OBJECTIVES AND METHODOLOGY

The initial question comes from the observation that most urban information systems fail to create conditions for communication and constructive dialog between professionals and decision makers in the planning process. As they are primarily designed to perform certain actions, but not the different participants execute this actions together, systems remain to serve only experts in long-term. This aspect requires rethinking how current information systems can be improved and how to involve decision makers more actively in the planning process.

The main objective of this research is to propose an interactive model for decision-making in a collaborative environment. The suggestion presents a framework that operates on different scales and levels in order to share and use understandings. It can also serves as a strategic instrument for the formal planning process so it could reach the standards of sustainable urban regeneration. In order to structure the strategy of the system it is necessary to:

First of all, understand and analyze the actors in the planning process for sustainable urban regeneration, research their formal relations and tasks to be performed during each stage of the process. Regarding the crucial actors, their resources and interdependencies current relations in co-operative work are identified and present in the form of graphics. This analysis is based on the experience in integrated urban regeneration in Bulgaria and the production of the first kinds of such plans in the country, aiming at integration of resources, participants, projects and financial sources, as well as the economic, social, environmental and aesthetic objectives.

Second, examine the opportunities that current urban information systems provide for communication and decision-making on the different stages for the selected planning process. Research how the means of

information representation can improve the collaboration between urban planners and decision makers in key stages where mutual commitment is essential for consensus building (fig. 2). The rate of information is considered for each stage of the planning process regarding the type of visualization, level of detail and provided possibilities for interaction.

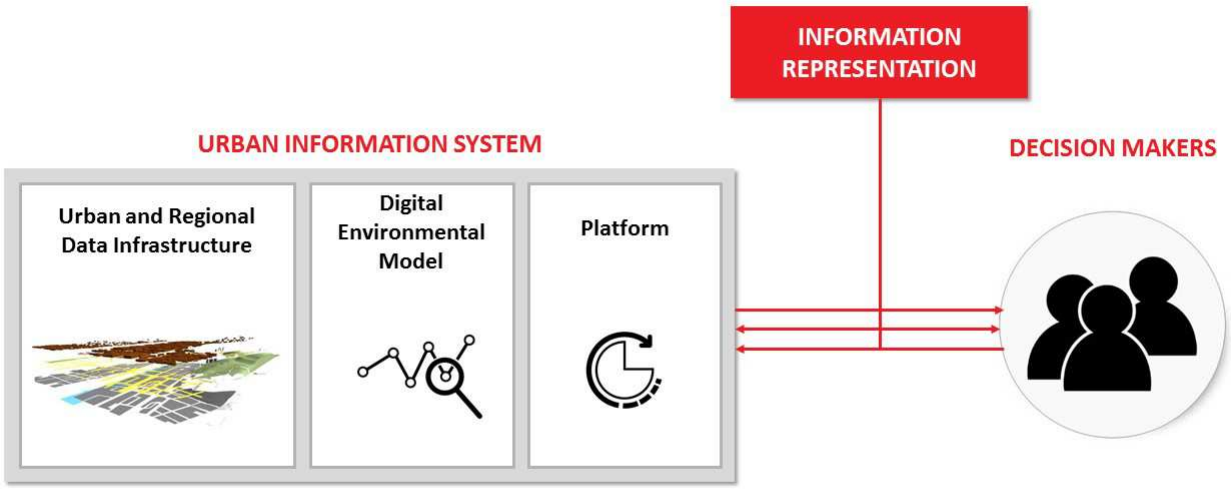

Fig. 2: Information representation as a link between urban information system and decision makers

Finally, suggest a framework for integrated information system. The proposal gives a general idea how this system operates and what kind of opportunities it provides to enrich the connectivity between urban planners and decision makers. Relation between the system's structure and the level of information technology is modeled on conceptual level in order to reach the strategy for co-operative dialog.

4 ACTOR ACTION TIME ANALYSIS

The implemented research methodology involves actors action time analysis in context of the stages in the statutory planning in Bulgaria. The latter is divided into urban planning system and urban monitoring system (fig. 3). The first one includes the plan preparation and approval procedure, having four stages: target analysis, strategic planning, detailed planning and design, programming and budgeting. Each stage contains fixed tasks and combines concrete actors to complete it. Second system continues during plan performance and includes implementation and management, monitoring and control. In this paper under the term planning process is accepted urban planning system or the focus is on the first four stages. In the case of Sofia city, this was a consecutive process with small overlaps continuing a total in 17 months until June 2013.

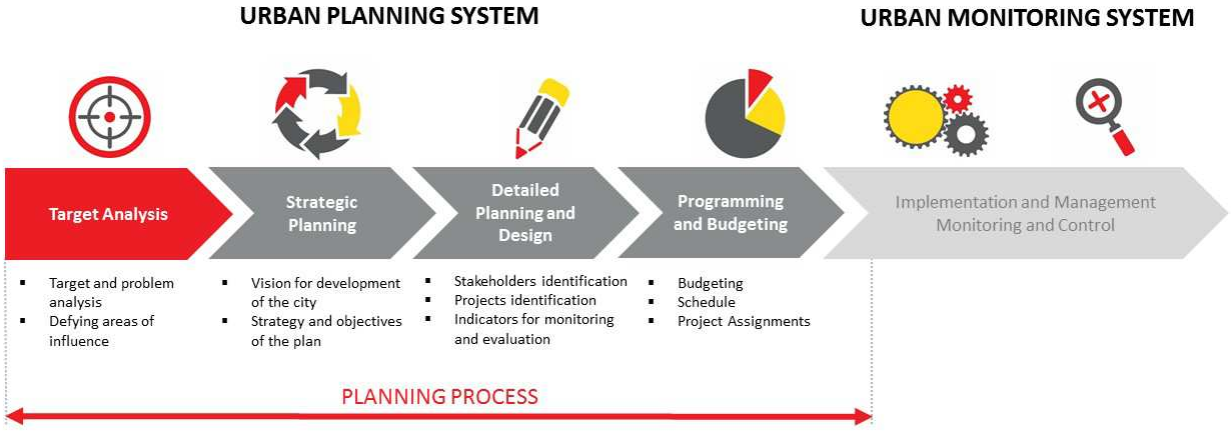

Fig. 3: The stages of the planning process in Bulgaria

In the planning process for sustainable urban regeneration, the operation is formatted through a specific set of procedures and control under the legislation of each country. Usually, this framework is organizing the government, the technical team and the public. Ding proposed a segmentation of decision-making operation process dividing all actors in four paths: operating path, guide path, creative path and participative path. In the case of Sofia city plan operating and guide paths are represented by ministry and municipality

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departments, which are responsible for finances, guidance and realization of the plan and control. Creative path is presented by design team which is a consortium, independent from municipality, combining wide range of professionals and technicals. In the last one are included all groups that are not part from of the first three and have a regard to the plan preparation.

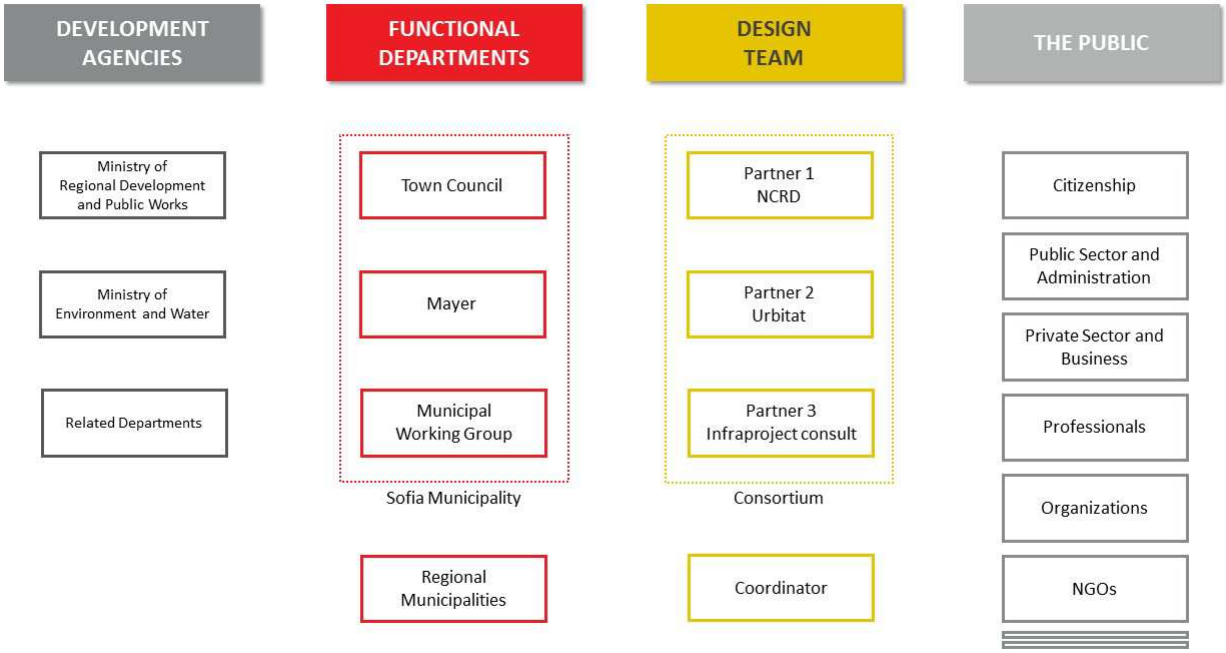

Fig. 4: The four paths in Bulgarian planning process for sustainable urban regeneration

To structure the characteristics of the actor network and the inventory of all involved actors was used positional approach. The study showed that two actors participate with more than one of their parts in the planning process. First composite actor is Sofia municipality presented by three actors that take different roles in each planning stage and have interdependent relations. The second one, the consortium, combine three separate partners with many independent experts and during the planning process is participating with more than one part. All other actors, even if they represent a group of participants are regarded as separated actors (fig. 4).

Stakeholder analysis gained insight into the roles and positions that actors take during tha planning process. For each process stage the formal positions of actors were characterized, their tasks and responsibilities as well. This step required a review of the laws and legislation procedures under plan was performed. Figure 5 below shows the formal relations between actors in the first stage: target analysis. One side arrows show hyerarchical relations whereas two side arrows indicatie relation between key actors.

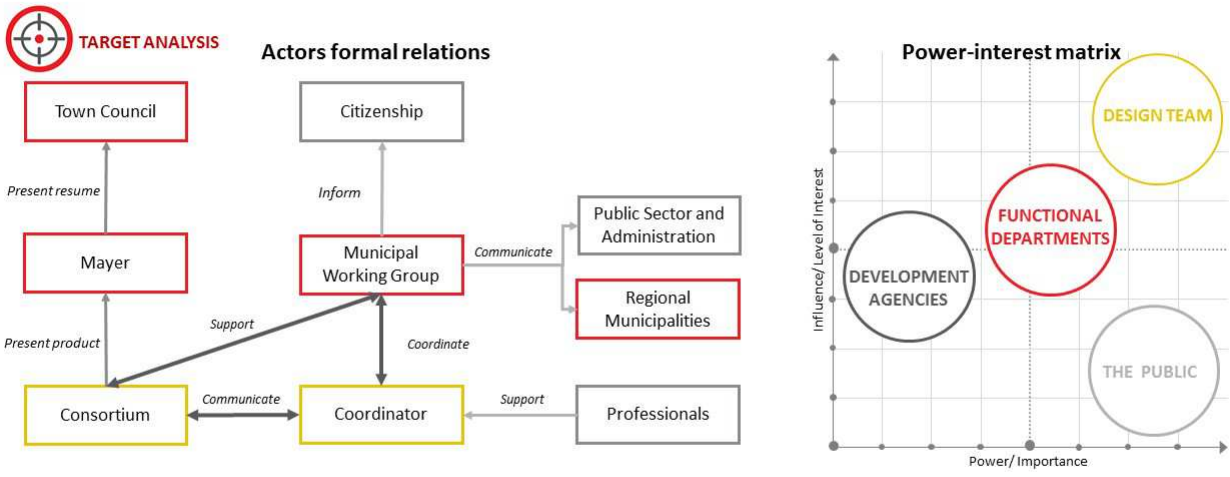

Fig. 5: Stakeholder analysis for the first stage of the planning process

Identifying the key actors and decisions to take in each stage is essential for reaching adequate form of collaboration. Inventory of the resources of the key actors showed the similarities and differences, common

objectives, interests and conflicts among them. Every path of actors was positioned on power-interest matrix estimating its resources: knowledge and skills, man power, financial, authority and organisation (fig. 5). Under this circumstances the functionality of actor network was investigated in decision-making context of overall planning process. Depending on the actors' positions and tasks they perform decision-making operation is separated in four types: discovering and understanding problems, identifying various solutions, choosing among solution alternatives and monitoring how the selected alternatives are working. In the modeling of the network and its context actors communication was estimated through graphic display materials and information management. Analysing actors in the planning process, their relations in a network and used information is crucial for creating functuonality of an integrated system for collaboration.

5 INFORMATION REPRESENTATION

Presently, the Platform of urban information systems displays results from the planning process in the form of digitalized maps providing knowledge about concrete geographic areas. This form of presentation in graphical form cannot always help users to see patterns and relationships in large datascape standing behind. Representation of the information provides clues that affect the amount of effort to explore the information for solving the problem, so that effect on the people's information recognition, implementation, and satisfaction (Adnan et al., 2008). Consequently, information representation will take more and more critical place in planning process for sustainable urban regeneration and diverse ways of visualization need to be explored for helping actors to make decisions more effectively.

There are various techniques for information representation. The complehension depends on the knowledge of the recipient, the intended use of the information, individual inclination and etc. In this paper, diverse methods for information representation are explored in accordance with the type and magnitude of information for different stages. Current research consider three elements as most important in terms of organizing information presentation for the selected planning process: level of detail (LoD), type of visualization and interaction. According to the planning stage, required information is provided in the most appropriate way as a result of combination of these three elements and can help different actors to participate more activily.

5.1 Level of displayed model

Urban planners investigate from overall status of a city to a particular building in the planning process. According to the context, the required information can concern neighbourhood structure or detail building façade. Therefore, each planning stage needs different model representation. Commonly, CityGML's LOD is the most used and accepted worldwide. There are five phases from level 0 to level 4. LOD 0 is a digital terrain model that include an aerial image or a map and covers the city territory together with the metropolitan area. LOD 1 is well known as a block model with flat appearance of roof and prismatic buildings. LOD 2 provides more detailed information on level to the roof structure and buildings' surfaces. LOD 3 represents the architectural model. LOD 4 is up to interior level (Open Geospatial Consortium, 2006). The model used in this research for the purposes of the planning process does not use the last LOD (fig. 6).

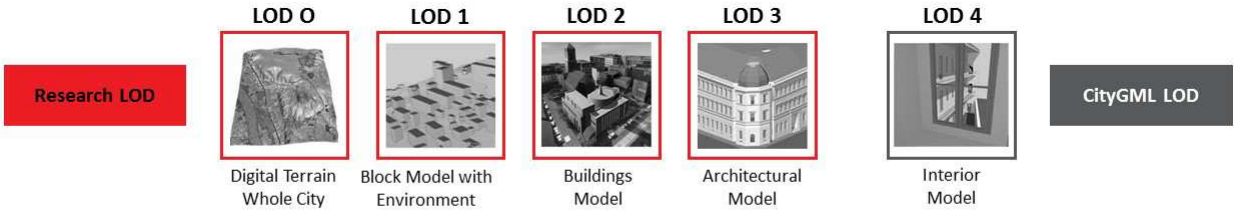

Fig. 6: Setting the range of LOD for urban planning.

5.2 Type of visualisation and interaction

The information can be represented in visual, acoustic, osmatic, tactual or other way. Among them, the visual which people are most experienced in, has the biggest effect and can be provided in any suitable manner. Furthermore, it is the most used technique that helps quickly analyse the large data set (Keim et al., 2002). In this paper, the methods of visual information representation are classified in analog and digital

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model on whole. The digital visualization is divided on text, 2D image, 3D model, 4D model and multi-dimensional model (fig. 7)

Text as the most basic way to represent information has the advantage to give detail descriptions, but it can also deliver key messages. Here, this classification proposes five different ways of use: simply a list of words, sentence, table, tree and net. The first three ways give possibilities to provide detailed information. Tree structure can be used to present words in a one-way relation, whereas the net structure presents complex connections of words. These five types of text representation can be diversely combined with other means of information in different stages of planning process.

Depending on the type of expressed information, the 2D image exposes much better methods to deliver information than text, and it is easier to understand. Here are included map, symbol, graph, net and mixed form and all of them provide static information. A more powerful way to transfer dynamic visualisation is by using 3D model. In the same way as 2D image, the 3D model uses the same techniques as map, symbol, graph, net and mixed form. 4D model combines 3D model with the time and creates simulations of urban data in different time periods.

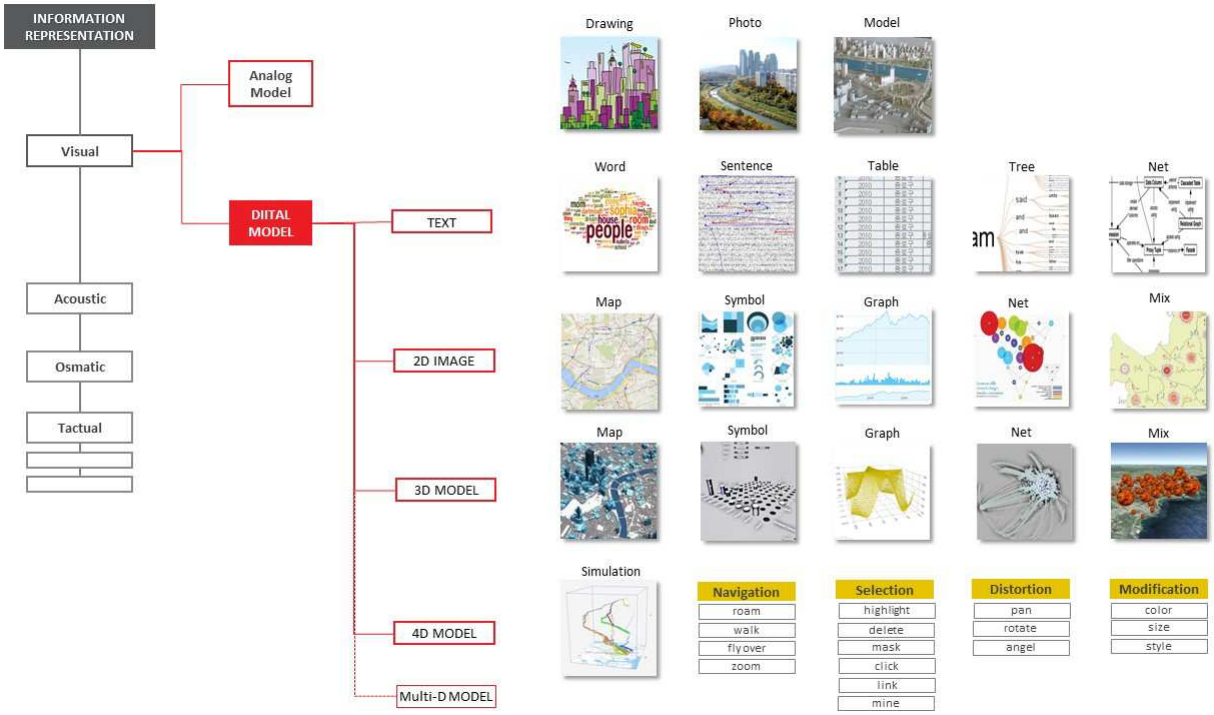

Fig. 7: Means of information representation: visualization type and interaction

Mixed visualization method creates many abounding combinations using techniques from one dimension, or brings together different visual representation forms from more dimensions. The result is presenting the content in a more specific way unifying different techniques. In the planning process for sustainable urban regeneration, the examples of mixed forms in 2D image and 3D model express summarized results additing maps with symbol, graph and net.

According to the Ward and Yang interaction is the mechanism that modifies the information visualization in what and how users see it. If there is no function of interaction, the information visualization becomes a static image or autonomously animated images (Yi et al., 2007). Main factors that influence the use of interaction are express the data, the type of data and location of the representation. Although information technologies providing different forms of interaction are developing rapidly, the main functions used in urban planning models are divided into four groups depending on their characteristics: navigation, selection, distortion and modification.

Navigation (roam, walk, fly over, zoom) allows the user go around the 3D model stimulating free movement anywhere or leading to a particular area. Concrete information singles out or emphasizes by selection functions like highlight, delete, mask, click or mine. Moreover, link automatically makes connection to another information. Distortion functions (pan, rotate, angel) provide various change to the viewpoint using multi-rotation axis. It is used for more detailed and deeper exploration of the 3D model. Modification for

interaction finds application in all forms of digital model. Changing the size, colour or style of the represented information can help users discover the necessary information more quickly among huge amounts available at the same time. Simulation indicates the passage of time. In urban planning process, 4D models present 3D spatial information changing in a concrete period.

Information visualization helps to understand the complex raw data easily even by non-experts. As interaction is the method to control the information space (Adnan et al., 2008), the interaction functions make dynamic exploration and acquisition more efficient than static information visualization. That emphasizes on the necessity for automatically and relevant information presentation. In addition, the level of information is adjusted in accordance with the level of detail of the models. Therefore, it will be able to help the decision makers involved in urban planning process who are necessary to confirm a lot of information.

5.3 Matching with urban planning process

Combining the three elements LOD, type of visualization and interaction, proper information representation is connected to the different stages of the planning process and urban monitoring system.

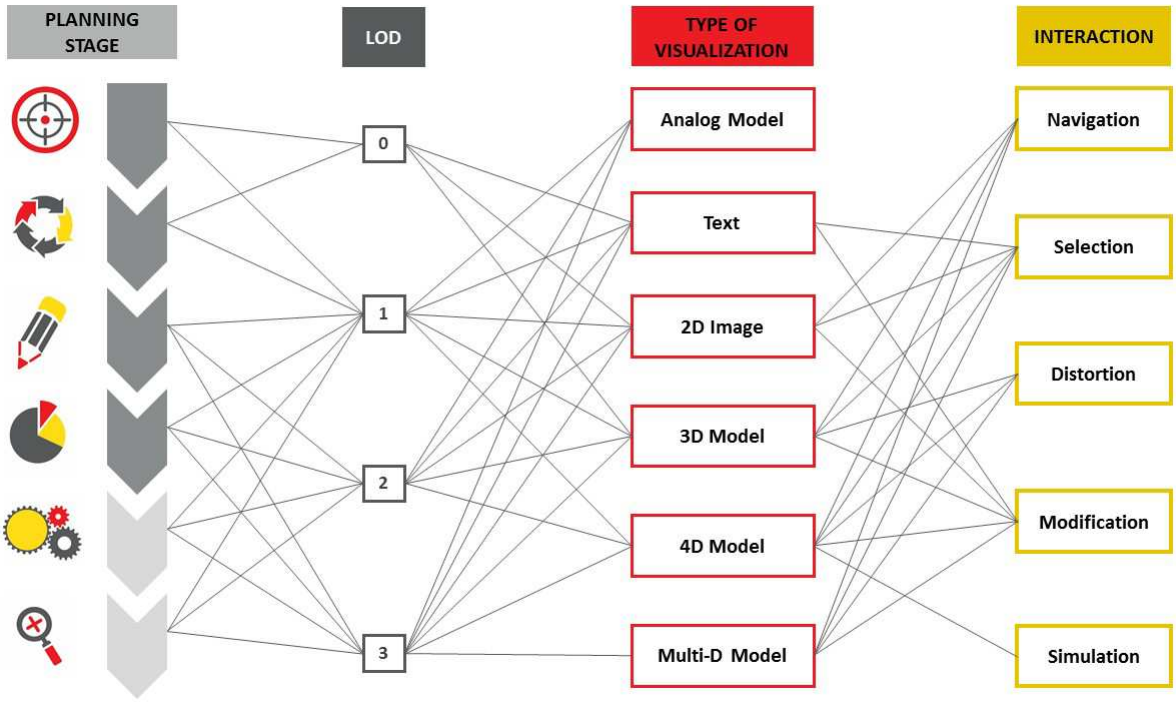

Fig. 8: Matching urban planning process with three elements: LOD, Visualization type and Interaction

In the early stages of the planning process, the actors' purpose is to grasp the situation of the whole city and select concrete targets. Therefore, detailed representation is not required and LOD is lower. As the planning process progresses, the city model needs higher LOD and more information is necessary. In the stages of urban monitoring system, the LOD depends on the detail planning and design stage. For instance, it is possible to use model with LOD 1 for checking the improvements in the environment of a neighborhood or use model with LOD 3 when it concerns a building renovation project.

Using the model with different LOD is limiting the possible types of visualization. Higher LOD allows wider range of visualization types and gives more freedom to express the required information. As much as analog model provides only static form of visualization, it cannot represent detailed shape or change in time. So in the case of planning process for sure the use range of analog model is severely limited. The dynamic information representation is more effective providing bound interaction for different side actors. Digital model covers all kinds of interaction functions. Models from three to multi-dimensions are able to connect with all interaction functions and provide various use of the model representation.

6 FRAMEWORK FOR INFORMATION DELIVERY TO DECISION-MAKING

This research aims to outline a framework for an interactive model for decision making in a collaborative environment. The proposed strategy implements information representation through a suitable screen basis

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for different actors. The system encourages collaboration between urban planners and decision makers improving mutual trust, respect, participation and commitment.

Successful collaboration between different actors should relay on both working together in a common space and doing it separately anywhere. Digital model has no constraints of on the location and has the greatest advantage to be shared with infinite number of people. Based on its potential, this framework is targeting the two main parts of decision making procedure in the planning process – functional departments and design team.

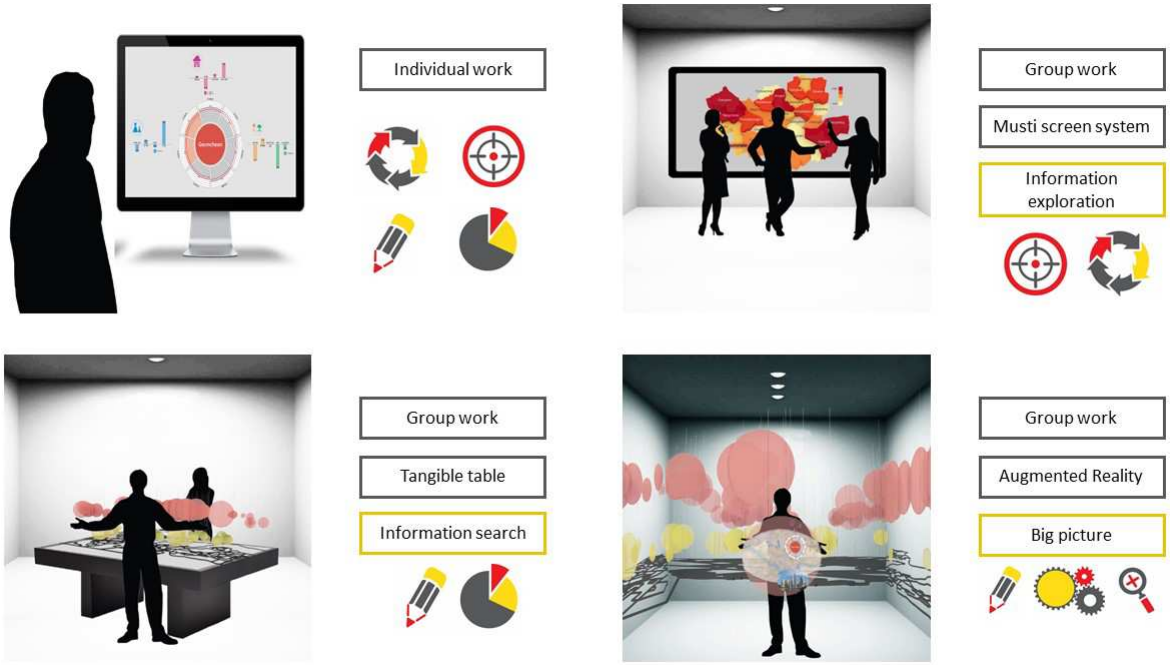

Fig. 9: Level of operation of the integrated information system s

Suggested digital model for information representation supports individual and group work. First level of the framework includes computers and portable devices typically used from urban planners in their individual work. Next levels propose digital environment for group work during all stages of the planning process. Second level includes multiscreen system which gives opportunity to explore plurality of information at at the same time and share understanding between actors. Its main application is found during the first two stages target analysis and strategic planning when most decisions concerning discovering and understanding problems about the city are made. Third level provokes actors' interest in information search using tangible table. The unified GIS based map is positioned on the basic and different layers of information are presented using multiple spheres. This way of representation presents diverse options for easy comparison between different elements or exploring details for a particular area supporting decisons concerning chose among solution alternatives or identification of various solutions, typical for detail planning and design, and programming and budgeting. This two stages of the planning process demand more detail understanding and the digital model in tangible table is the main instrument inducing interest in actors' information search and serves as a pillar for co-operative dialog. Last level, using augmented reality, is strengthened by most interaction functions and creates full comprehension of the situation. An actor can take the sphere which contains information about a concrete area surrondinng him and look at it. This form of interaction transform the actor into a real participant in the process.

7 CONCLUSION

The proposed framework for integrated information system aims to support the Bulgarian urban planning process and consider an underresearched area. The model for interactive collaborative environment contributes to the curren process and aims to transform the group work from one way to multiple ways. The main potential comes from the system's scope and used information technology. During model construction main actors of the process were organised in a network using snapshots of the different process stages. Their

relations helped to understand the decision-making operation and serve as a basis for proposing solutions. In the design of the framework the means of visual information representation were matched to the planning process depending on three variables: LOD, type of visualisation and interaction. The project is targeting the decision makers and urban planners at planning scale and the goal is to promote the generation of better collaborative environment for the early planning stages. Future development and implementation of this model would make discussions during plan preparation more constructive and decision-making process more transperant.

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