

# *A Decision Support System for Business Location Based on Open GIS Technology and Data*

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This article presents the architecture, features, and operating mode of a DSS (Decision Support System) aiming to assist entrepreneurs and managers in the process of location decision making. The research assembled concepts derived from theory, findings of empirical studies, together with open GIS (Geographical Information System) software and data, and modelled them into a DSS software tool, according to an original methodology and design. The users are guided step-by-step to input information on their businesses into the DSS (industry, preferences for land-use areas and facility types, weights of key location factors), and are returned two sets of results: one based on own options, and another one aggregate for the industry they operate in. The results consist in the top five locations for the user's firm, as well as for the industry, depicted both in a graphical report (map) and a text report (explanation of results).

*Key Words:* decision support system for business location, open-source GIS software, metropolitan areas

*JEL Classification:* C88, D80

## **Introduction**

Nowadays, a variety of geographical information systems are available; among them the most notorious are the electronic maps provided by Internet search services, such as Google, Yahoo!, Bing, etc. Their aim is to find locations, addresses, and provide information for navigation from point A to point B.

The opportunity of the DSS for business location is based on the fact that there are sufficient GIS data and software, some free of charge and open, that can also be used for purposes other than searching places and browsing, namely in management specialized fields. At the same time, GIS technologies are rarely involved in the crucial decision of business site selection. This article offers a new perspective on the strategic decision of business location, by taking advantage of the power of GIS technology, which has rapidly developed in the recent years.

This paper subscribes to the global trend of evolving to knowledge economy and knowledge management systems (Galandere-Zile and Vinogradova 2005, 179–196). The advances of computer and communication technology bring a massive amount of information and knowledge, just a few clicks away. Accordingly, there is a huge amount of open GIS data and open-source GIS software available to be turned into valuable business information. While extensively used in other fields, GIS data are underused in business management.

The DSS currently applies to metropolitan areas. It is restricted only by the territory included in its geographical database. This means it can easily be extended to other metropolitan areas by adding the appropriate geographical information in the system. The DSS software tool is targeted to metropolitan areas and builds upon empirical findings (Ghiță, Scarlat, and Magano 2013; Ghiță et al. 2013), obtained in two European metropolitan areas, respectively Bucharest – Romania, and Porto – Portugal. This paper is dedicated to moving forward from the empirical findings, previously published, to unfolding the architecture, features and operating mode of the DSS, in the form of a software tool built upon this knowledge.

The goal of the research was to create a DSS for business location, which could be rapidly implemented. Accordingly, it was empirically tested and implemented in the author's residential region – Bucharest, belonging to a transitional economy – Romania, where such a tool would be beneficial for the business environment. In the same time, the DSS was conceived as relevant and extendable to metropolitan areas in general, so it had to be empirically tested in another metropolitan area, such as Porto – Portugal, which was the host of the author's doctoral internship.

The DSS was conceived as an open system, i. e. to attract real estate owners or agencies, and cluster-organization, interested in advertising their offer and identity, to input information into the DSS, information that could add value for the users. For example, a user might be interested not only in receiving top five locations, but also in finding available facilities in the areas and being able to contact owners, or adhering to cluster organisations.

The article is organised in sections. The next section presents the concepts derived from literature to be integrated and developed into the DSS. The methodology section refers to the DSS framing in literature and adopted by this research, the basic logic of the DSS and the approach to the business location problem, and the steps undertaken to conduct the

research. Then, the following section is dedicated to a thorough description of the DSS, reinforced by the results obtained by an IT-Software firm using the DSS. The article concludes with the discussion of results, highlighting the main features of the DSS, the benefits brought to business environment, including the DSS limitations, and development perspectives.

### **Business Location Concepts Derived from Literature**

The DSS developed upon several relevant concepts derived from literature, in relation to places: land-use, attractiveness (appeal), accessibility, cost of space, and agglomerations of enterprises.

The father of location theory, von Thünen has developed a still-standing theory of *land use* (Thünen and Hall 1966). According to him, homogenous economic activities coagulate in concentric circles around the town centre (market). Depending on the maximum cost they afford to pay for land (rent, price) and the cost of transport to the market, they chose to locate closer or farther from the town centre. Nowadays, land-use is more than a design shaped by economic factors; it is reinforced by institutional factors (land became object of urban and landscaping planning).

Raicu and Popa highlighted two interrelated concepts in relation to places – *attractiveness* and *accessibility* (Raicu and Popa 2009, 7–13). According to them, the transport action from the initial area (origin) is induced by the attraction exerted by a utility located in another area (destination), and the attractiveness increases proportionally with the number of convergent utilities. Conversely, accessibility is a constraint to attractiveness, as attraction cannot trigger transport without the existence of a proper infrastructure. Although the two concepts are interrelated, they must be measured separately, as *accessibility is a feature of the transport system* (the infrastructure's role is crucial) and not directly related to the dynamic of commuting needs, while attractiveness is the motivation for commuting. Another consequence of the interplay between the two concepts is the *number of potential visitors*, in terms of pedestrian or road traffic in a given area.

Cost minimisation is the key concept of the (neo) classical approach of the location theory. The total cost involves various components such as transport, labour, and *cost of business space*. Dealing with metropolitan areas, we may assume that mobility is reasonably assured in terms of materials and employees, at rather equal costs across the area. While

transport cost is covered by the previous-mentioned concept of accessibility, according to the real estate websites surveyed, there is a lot of variability in the cost of space. This variability can have three main components: distance to the central business district (Alonso 1964), the quality of endowments (utility), and the image and representativeness of the area (prestige) (Reijmer and van Noort 1999).

Another key concept used in the research is the *agglomerations* of industry-related enterprises. While Alfred Marshall was the pioneer of the concept of positive externalities within industrial districts (Marshall 1920), Michael Porter has the merit of a deeper insight into the cluster phenomenon, capturing both the *cooperation* and *competitive* nature of relations between enterprises located within the cluster (Porter 1998, 197–287).

### Research Methodology

The goal of the research was to provide not merely a web-based GIS software tool, but a full *decision support system (DSS)* designed to help start-ups or relocating enterprises to find suitable operating sites, according to their needs. Thus, the software tool embedded the theoretical and empirical knowledge gained in a research undertaken between 2010 and 2013, including data inputs from users, accumulated with every location simulation cycle stored in the DSS database.

In a broad perspective, the DSS integrates four components:

1. Own approach to the location problem of enterprises;
2. Results of a questionnaire-driven study performed to track the location behaviour of enterprises (Ghiță et al. 2013);
3. Participants (entrepreneurs, real estate bidders, cluster organizations, and software tool administrators);
4. The GIS software tool itself.

In a strict sense, according to Daniel J. Power, decision support systems constitute a distinct class of information systems, consisting in computer-based interactive systems or subsystems, designed to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, in order to complete decision making process (Power 2004, 2015–31).

In this context, the DSS concept presented further, integrates communication technologies (internet, web application), data (geospatial database, and user information input), documents (web forms, maps),

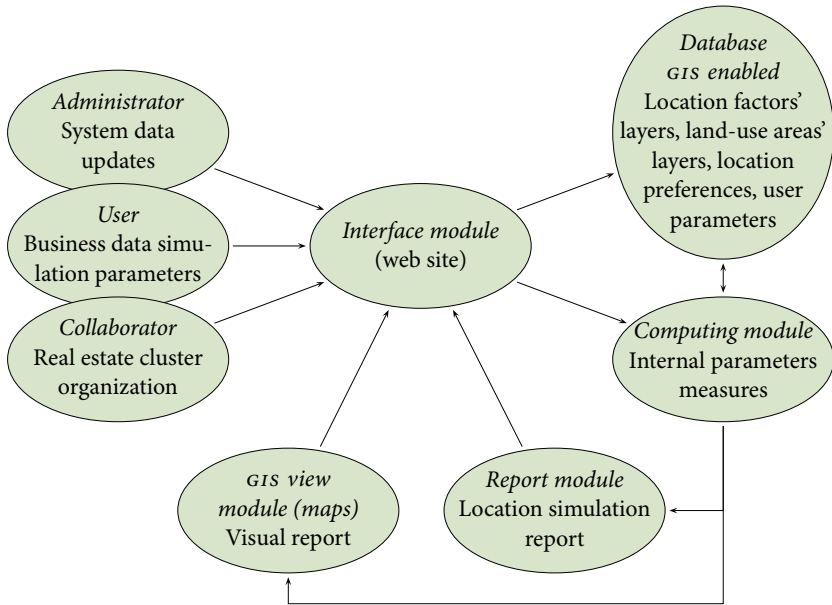


FIGURE 1 Web GIS Software Tool: Basic Concept

knowledge gained in all stages of research (theoretical research, empirical studies, own study based on questionnaires), and models (by simulating the possible options, indicators measuring variants, calibration, and selecting the best option).

Moreover, the DSS operates on an infrastructure consisting of hardware and software, including a GIS-enabled database.

The research uses the concept of *micro-location* to describe own approach, namely the precise identification of suitable operating sites, in small and dense business territories, such as metropolitan areas.

The conceptual design of the GIS software tool is depicted in Figure 1.

The core of the location decision process is identifying the required features of the location, namely the *key location factors*, in order to fulfil business's needs. The mix and weights of location factors is *industry-specific*, and, in consequence, enterprises are grouped by industries. The key location factors, selected in accordance with the concepts derived from literature, the empirical findings, and the logic of the DSS, can be grouped into the following categories: *accessibility*, *attractiveness* (measured by the number of potential visitors), *cost of space* (price or rent), *clustering* behaviour, and *competition* level.

The chosen assessment method of location factors is the *factor rating method*, which is the most used method for valuing location options (Heizer and Render 2013), thanks to its versatility that makes possible to include a wide variety of factors. This method is actually a location adoption of the mathematical weighted sum method.

If required by user, the DSS offers the possibility to render separate results for the *back-office* location, defined as the place in which the company operates manufacturing, services and/or storage, and *front-office* location, defined as the place where the commercial operations are performed (including contact with customers) and also, in most cases, top management. This differentiation is based on the fact that earlier empirical findings in the metropolitan areas, referenced above, reveal a difference between back-office and front-office, in terms of location behaviour.

The site identification process is performed at two zoom levels: *land-use area*, that refers to a functionally compact territory assigned to a certain land-use (e. g. residential area, industrial area, business park, etc.), and *facility type*, that refers to a specific site in the area (e. g. office building, individual commercial space, villa, etc.).

The questionnaire-driven study investigated the *location behaviour of enterprises* in two metropolitan areas – Greater Porto Metropolitan Area (Portugal) and Bucharest-Ilfov Region (Romania). The questionnaire was designed to be applicable to metropolitan areas in general. The results of this study served as a starting point in determination of location factors matrix, weighted by industry, which was embedded afterwards into the DSS software tool.

*Participants* include people who contribute to the decision support system by information inputs. DSS is designed as an open system, by attracting partners interested in promoting their offers and brands (e. g. real estate agents or facility owners, who lease business sites). There are four types of DSS software access accounts with different privileges and interfaces, corresponding to the categories of participants who can input data: administrator account, user account (entrepreneur), real estate collaborator and cluster organisation collaborator.

The basic geographic information (streets, buildings, administrative boundaries, land-uses, public services, etc.) that forms the underlying layer of the GIS database were downloaded from *OpenStreetMap* (<http://www.openstreetmap.org>) open-licensed under ODBL – *Open Data Commons Open Database License*, briefly stating that data and results obtained from the use or processing of these data must be made available

publicly under the same license (i. e. open and free of charge). The base map data were extracted from the free repository and rebuild inside the DSS database.

Own contribution to the GIS database consisted in adding data to the system, obtained primarily through remote sensing method, or initial data analysis and processing. An example of remote sensing was the identification of the real estate web sites that offered business accommodation. Then, by using the Street View function in Google Maps, most of the business parks in the area were identified (as their precise location was hidden to the public on the real estate web site), and then were drawn as polygons and introduced into geospatial database. An alternative way that has not been used at this stage of investigation is the digital footprint of the population, which can be a source for estimating potential visitors flow.

The basic GIS objects were further refined into layers according to the DSS software tool logic, by appropriate database queries: geometric intersections, joins, splits, and mixed queries. *OpenStreetMap* database was enriched by new defined data (over 300 polygons) saved in 20 new tables. Also, for data processing and extraction were created 7 functions, 187 views (SQL templates, saved as independent entities into the database) and a procedure for updating basic GIS data.

### **The Architecture of the DSS**

The result of this research – the DSS – was modelled into a GIS software tool, designed to assist entrepreneurs and managers in the location decision making. The logic and functionalities of the DSS software tool are described thoroughly in this section, according to the modular structure depicted in Figure 1.

#### **WEB INTERFACE MODULE**

The integration between GIS components and internet is accomplished by means of a website, built on a Content Management System platform, namely *Joomla 3.0* (see <http://www.joomla.org>). This CMS platform offers support for *PostgreSQL* (*PostgreSQL 2012*) database system and its GIS extension *PostGIS* (*PostGIS Project 2012*), which, in tandem, store the geographical data, and supply the tools for processing GIS data. Maps are rendered by GIS Server software, namely *GeoServer* (<http://docs.geoserver.org>) (*GIS Tutor 2013*) and displayed on the website with the aid of *OpenLayers* (see <http://trac.osgeo.org/openlayers/browser/trunk/openlayers/examples/proxy.cgi>) software library.

This information is very technical and supplying even more details is beyond the scope of this paper. However, the main point is that several software components are involved in the process of rendering interactive maps on the website, and all the components are open-source and free of charge.

#### USER DATA FORM

The user data input process consists of the following phases:

1. Edit previous simulation/new simulation – the user can either review one of her/his existing location simulation or launch a new one;
2. Fill in user's input data form:
  - Stage 1 – fill in: a name for the simulation, industry, and number of employees (estimate for first year after location);
  - Stage 2 – specify which activities are subject to the location decision (back-office, front-office, or both). Only if the answer is 'both' an additional section is automatically activated, respectively a question whether back-office and front-office would be located on the same site or in different sites. Depending on the answer to this question, the form resumes with a single column of responses or two (one for the back-office and one for front-office);
  - Stage 3 – choose land-use area, and facility type (multiple checks allowed);
  - Stage 4 – choose type of the real estate offer: building vs. land, rent vs. sell. Also, in this stage, location factors are given weights according to user's needs (total must be 100%);
3. Rendering two sets of results (one set based on user's own simulation, and one set based on the other users' simulations in the same industry).

#### LAND-USE AREAS' GIS LAYERS

Land-use areas are polygons delineating an area with a specific functionality. The types of areas used in the software are:

- *Industrial/Warehouse Area*: an area for industrial and/or warehouse use;
- *Business Park*: compact area with several modern office buildings;
- *Traditional Trade Area*: high streets and avenues renowned for commercial activities (shops, restaurants, cafes, etc.);



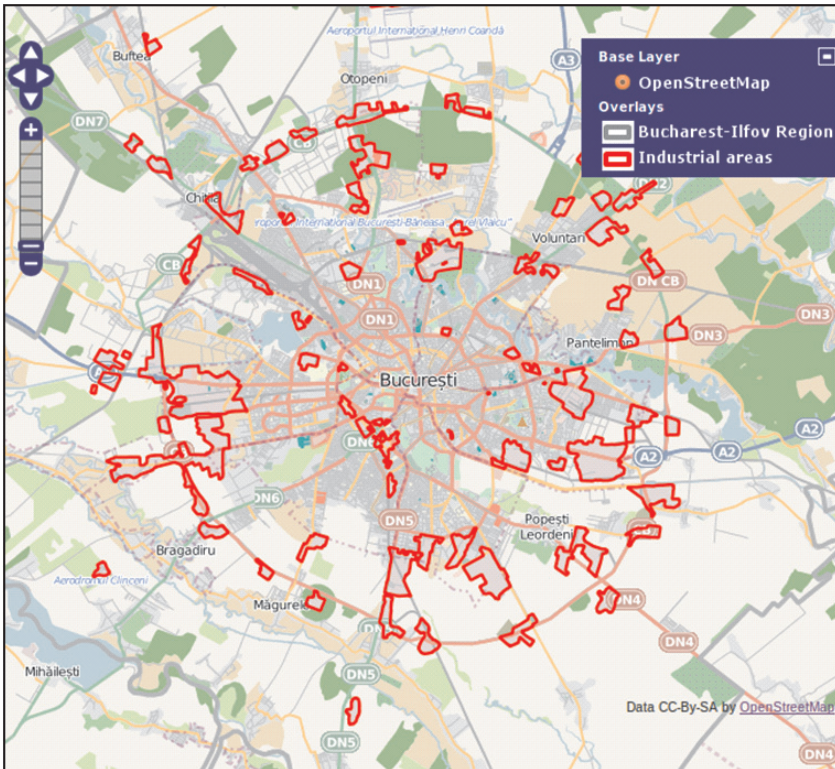


FIGURE 2 Land-Use Layer: Industrial Areas

- *Science and Technology Park*: area specializing in high technology fields (IT, research, electronics, telecommunications, etc.);
- *Urban Residential*: e. g. residential zone within the city of Bucharest and the eight surrounding towns in Ilfov county (excluding land-use areas specified above);
- *Rural Residential*: within villages, having residential use;
- *Rural Non-Residential*: rural – outside localities – excluding special areas that businesses are not allowed in: forests, public infrastructure etc.

An example of such an area layer is depicted in Figure 2. Areas are delineated according to the *principle of covering the entire region of study, with no overlaps*.

#### LOCATION FACTORS' GIS LAYERS

In order to point out different intensity levels of location factors measured across the map, a set of GIS layers were applied to each factor. These

layers correspond to real ground objects, such as a highway or a public transportation node, surrounded by a buffer (proximity) area. Layers are ordered hierarchically by a scoring scale of 1 to 10 points.

The software uses the following location factors:

1. *Freight accessibility – road*: measured in terms of availability and access speed. This factor takes into account the constraints to the access of trucks over 5 tones capacity (e. g. heavy trucks are restricted to drive in the inner city of Bucharest unless a prohibitive tax is paid), the category of road (affecting the speed and direction of travel), and type of locality – urban/rural (affecting access to markets). As an example to explain how factor scoring works, this factor's set of layers, with the corresponding scores, are presented below:
  - 10 points layer – Main access route (highway access, express road – outside truck restricted area);
  - 8 points layer – Urban – main road (outside truck restricted area);
  - 7 points layer – Rural – secondary road (county road);
  - 5 points layer – Urban – secondary street (outside truck restricted area);
  - 4 points layer – Urban – main street (inside truck restricted area);
  - 3 points layer – Rural – peripheral road;
  - 2 points layer – Urban – secondary street (inside restricted area);
2. *Freight accessibility – railway*: measures the possibility of access to the rail network, given that access can be done only at stations and platforms (industrial and warehouse areas with access to rail transport);
3. *Passenger accessibility – individual vehicle*: quantifies possibility and access speed of the population by own means of transport (car, motorcycle, etc.). This factor considers three concentric polygons, called the 15 minutes, 30 minutes, and 45 minutes isochrones, i. e. limits reached by car in 15, 30 and 45 minutes from ground zero in Bucharest (O'Sullivan, Morrison and Shearer 2000; Paganotti n. d.);
4. *Passenger accessibility – public transport*: access to means (modes) of transport, within maximum distance of 350 m from the station/stop (5 minute walk). This factor takes into account access to various modes of transport and transport capacity. In capacity terms, means (modes) of transport are divided into large capacity means (train, plane, subway, tram) and low capacity (bus, trolley, bus, minibus);

5. *Potential visitors – road traffic*: relates to access and speed to areas, taking into account population density, road class and crossroad rank in relation to the road network;
6. *Potential visitors – footfall traffic*: covers pedestrian traffic areas. It considers proximity to traffic generators, such as public transport stations/stops, leisure areas, main urban-residential crossroads, pedestrian crossings, commercial network concentration areas;
7. *Cost of space*: price/rent level, which follow similar spatial trends. Polygon boundaries were made according to reports from the real estate market, and hierarchy of administrative units in Ilfov county (administrative territory of towns and villages);
8. *Cluster-like behaviour*: targets areas with a high density of companies in the same industry or connected industries;
9. *Lower competition level*: targets areas with a low density of companies in the same industry (applies only to industries with spatial competition behaviour, such as retail, hotels and restaurants, financial services, personal services, etc.).

Similar to the defined land-use areas, the layers belonging to the same factor are bounded by the same principles: to cover the entire territory, but not overlap, with a single exception, that is for the factor ‘potential visitors – footfall traffic’ where overlaps are allowed (stacking of layers adds to the factor intensity).

Figure 3 serves as a graphical representation of factors’ different intensity levels, depicted by the three GIS layers belonging to the factor ‘Passenger accessibility – individual vehicle.’

#### COMPUTING MODULE

As described in the above section, each factor selected by user in the data input form (so called key factor) has a set of layers, each layer consisting of multiple polygons. Also, the user fills in a relative weight for the selected factors, in a way that she/he considers appropriate for the business. The rule is that all weights must totalize 100%.

Calculations module identifies all possible combinations between selected land-use layers and selected factor’s layers. Combinations are ranked descendent by an aggregate score, summing up for every key factor, each GIS layer score belonging to that certain key factor times the weight given by user to the certain key factor.



FIGURE 3 Isochrones Layers: Assessing Factor ‘Passenger Accessibility-Individual Vehicle’

Mathematically, this module iterates all *multiple array combinations*, where each array is a factor and the elements of the array are factor’s GIS layers (except for GIS layers of the factor ‘potential visitors – footfall traffic’ which are allowed to overlap and thus each layer is considered independently). Not all the key factors are included, but only those that meet the following two conditions:

- Factor is *selected (weighted) by user* in the input data form;
- Factor’s GIS layers *intersect land-use GIS layers* selected by user in the input data form.

In other words, the algorithm calculates all combinations between arrays  $F_{1a}, F_{2b}, F_{3c}, \dots$ , where  $F_1, F_2, F_3, \dots$ , are the factors, having a number of  $a, b, c, \dots$ , elements (GIS layers) intersecting selected land-use areas. At the end of each array is added a null value, so as combinations with missing (null) elements from one or more arrays to be taken into account

as well, that is, embodiments combining a number of elements less than the number of arrays. This model is repeated for each selected land-use area.

Calculation of the score for each combination variant is made by the following relation:

$$W = \frac{\sum_{i=1}^n p_i}{\sum_{i=1}^n P_{\max_i}} \times 100 \quad (1)$$

Where  $n$  is the number of arrays (selected factors),  $p_i$  is the score of the layer of factor  $i$  included in the combination, and  $P_{\max_i}$  is the maximum score for factor  $i$  (i. e. score of the highest score layer of the factor  $i$ ).

If there is no intersection between the land-use layer and the factor layers included in the combination, the combination is not feasible, so model skips to the following possible combination. When first feasible combination is identified, it becomes the first (best) location result. The algorithm is continued until it finds the top five location results (having the highest score, and feasible).

#### LOCATION REPORTS MODULE

This module handles the location results computed after completing user input phase. The results are displayed both in a graphical display (GIS map) and a text display (report), including map's legend. The report includes information on the top five location results, and how their scores are calculated.

The software tool offers two sets of results. The *first set of results* is based on user own options. The *second set of results* is based on the aggregate simulations of the other users in the same industry. The only difference is that for the second set the land-use layers are also weighted by users' choices. In the first set of results, even if multiple land-use layers are selected they are considered equal, because there is only one location simulation. As an example, Figure 4 and the text report below, depicts the first set of results obtained by an *IT-Software Firm* for the location of *back-office*.

If the user has chosen to have distinct locations for back-office and front-office, the first set of results would include separate reports for back-office and front-office. Else, it receives a common set of results for both. On the other hand, the second set of results (the industry set) always includes distinct back-office and front office reports, because it aggregates a large number of location simulations that are unlikely to be identical for





FIGURE 4 Graphical Report Example for an IT Software Firm – Back Office

both back-office and front office. Alongside the graphical report, the DSS provides the text report, which contains a review of the selections made by the user, the scores of the top five location results, as well as the calculations of these scores. For the same example of the *IT Software Firm – Back Office*, the text report has the following structure:

#### *User Options Summary*

1. Industry: IT-Software
2. Selected land-use areas:
  - Industrial/Warehouse Area
  - Business Park
  - Science and Technology Park
  - Urban-Residential
  - Rural-Residential
3. Selected location factors and weights:

- 10%: Passenger accessibility – individual vehicle
  - 20%: Passenger accessibility – public transport
  - 20%: Potential visitors – road traffic
  - 30%: Cost of space
  - 20%: Cluster-like area
4. Distinct locations for back-office and front-office

### *Top 5 Location Results*

Out of a hypothetical total of 100 points (if all factors overlap at highest intensity) the following scores were calculated:

1. Area 1: 62 points
  - Land-use area: Industrial/Warehouse Area
  - Factors:
    - Passenger accessibility – individual vehicle: 10 points
    - Passenger accessibility – public transport: 20 points
    - Potential visitors – road traffic: 20 points
    - Cost of space: 12 points
2. Area 2: 61 points
  - Land-use area: Urban-Residential
  - Factors:
    - Passenger accessibility – individual vehicle: 10 points
    - Passenger accessibility – public transport: 20 points
    - Potential visitors – road traffic: 16 points
    - Cost of space: 15 points
3. Area 3: 61 points
  - Land-use area: Urban-Residential
  - Factors:
    - Passenger accessibility – individual vehicle: 7 points
    - Passenger accessibility – public transport: 20 points
    - Potential visitors – road traffic: 16 points
    - Cost of space: 18 points
4. Area 4: 59 points
  - Land-use area: Industrial/Warehouse Area
  - Factors:
    - Passenger accessibility – individual vehicle: 10 points
    - Passenger accessibility – public transport: 14 points
    - Potential visitors – road traffic: 20 points

- Cost of space: 15 points
- 5. Area 5: 59 points
  - Land-use area: Industrial/Warehouse Area
  - Factors:
    - Passenger accessibility – individual vehicle: 7 points
    - Passenger accessibility – public transport: 10 points
    - Potential visitors – road traffic: 16 points
    - Cost of space: 6 points
    - Cluster-like area: 20 points

The maximum score that can be obtained by a location result is 100 points (100%), but this is an ideal score that may be achieved only if all factors were selected, and they all stack at their maximum intensity over the selected land-use layer.

### Discussion of Results

GIS software tools cover many fields (weather, transport, land-use development plans, etc.). Though, business management field has little support based on GIS technologies. The research presented in this paper aims to cover that gap.

The decision support system (DSS) for the location of enterprises is intended to be applicable to all metropolitan areas. The geographical coverage can be extended by including GIS data from other areas.

The DSS integrates state-of-the-art GIS technologies, i. e. latest versions of GIS open-source software and data. The basic GIS data were obtained from *OpenStreetMap*. The results of the DSS are open to public and free of charge, having the obligation of being rendered under the same conditions as the basic data obtained from *OpenStreetMap*.

The research addresses the issue of location by building a decision support system that integrates four broad components: an approach to the business location of SMEs derived from theory and applied studies; a questionnaire-based study on the location behaviour and related results; participants (software administrator, users and interested partners to popularize their offer or identity, from real estate or cluster bodies); a software tool for business location (the decision support system itself).

The research approach falls within the term *micro-location*, namely the precise identification of suitable operating sites for a certain business.

The DSS is designed to integrate business data from both user input and collaborators (real estate owners/agents, and cluster organizations).



The DSS provides the user with three lists of options: *key location factors* that may be selected and weighted (totalizing 100%), *land-use areas*, and *facility types*. At current stage, the DSS does not offer information on facilities within the top location areas rendered, as it has not yet included real estate collaborators, whose role would be to detail facility offers. The prospective real estate collaborators are supposed to supply geo-tagged information on facilities by filling in their real estate offer forms. At that point those data will be embedded into the DSS, thus location results will provide links to the real estate offers falling within the result areas.

The DSS provides *two sets of results* – one based on user's own options, and another one (aggregate) based on all other users in the same industry. This offers users a means of comparing her/his options and results to other relevant ones. The DSS can provide distinct results for *back-office* and *front-office*, according to user's option. The results are rendered directly into the web browser (the software is web-based), including a GIS report (map) and a text report with thorough explanations on options and results, as well as a map legend.

Users can enter a new simulation or revise an existing one. With each new simulation or review, the DSS database is updated, so the industry results become more relevant. Moreover, the software includes an executable procedure for updating basic GIS data contained in the DSS, to new *OpenStreetMap* database updates.

The problem of measuring the intensity of location factors in the different areas of the study region is very complex. For example, for calculating accessibility or attractiveness intensity, neither the origin nor the destination points are known. Theoretically, any user can place the business anywhere, according to available options. Therefore, factor's intensity is a relative measure, paying the maximum score to polygons where the intensity is the highest and lowering scores for polygons which have lower factor intensity.

In geometric delineation of the land-use areas, the principle used was that *areas do not overlap but cover the entire territory*. The same principle was applied to the layers belonging to the same factor.

In respect of the limitations of the elaborated model, it is important to mention a few aspects. Regarding the extension of the findings of the questionnaire-driven study to all metropolitan areas, in order to quantify firms' location behaviour, it should be mentioned that the results are based on a number of 388 questionnaires in only two metropolitan areas (Porto and Bucharest). Leading metropolitan areas such as London,

Paris, Amsterdam, Rotterdam, Moscow, and Istanbul, or from other continents than Europe were not included. Also, each country or metropolis has its specificity in terms of economy, demography, culture, etc.

This research analysed the behaviour of firms and not the needs or expectations of customers or employees about the business location. It started from the premise that the location of economic activity is a consequence of the reaction of firms to the needs of potential customers. As such subjective factors both from the customer perspective – buyers' behaviour, preferences (Borgers and Timmermans 1986, 25–31), (Naumann 1995) and from the entrepreneur's perspective – attachment to his native place, aspirations, social life (Figueiredo, Guimaraes, and Woodward 2002, 341–61), (Stam 2007, 27–50), were only indirectly addressed.

The set of key location factors used, combined with the specific features of land-use areas, offer a great flexibility in handling users' preferences. However, depending on the characteristics of each business, there may be factors which are not addressed individually, but could decisively influence the location decision.

Regarding further development of the DSS, there is a *quantitative direction* – geographical expansion and a *qualitative direction* – evaluation and treatment, where appropriate, of basic geospatial data, adding new data and involving real estate and cluster collaborators.

The DSS provides benefits to users (entrepreneurs and managers), such as reducing search time, site assessment, connecting with real estate bidders, structuring and prioritizing their location key factors and preferences, increasing their business awareness, quantifying their needs, and providing comparison with other users in the same industry (receive feedback from industry trends).

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