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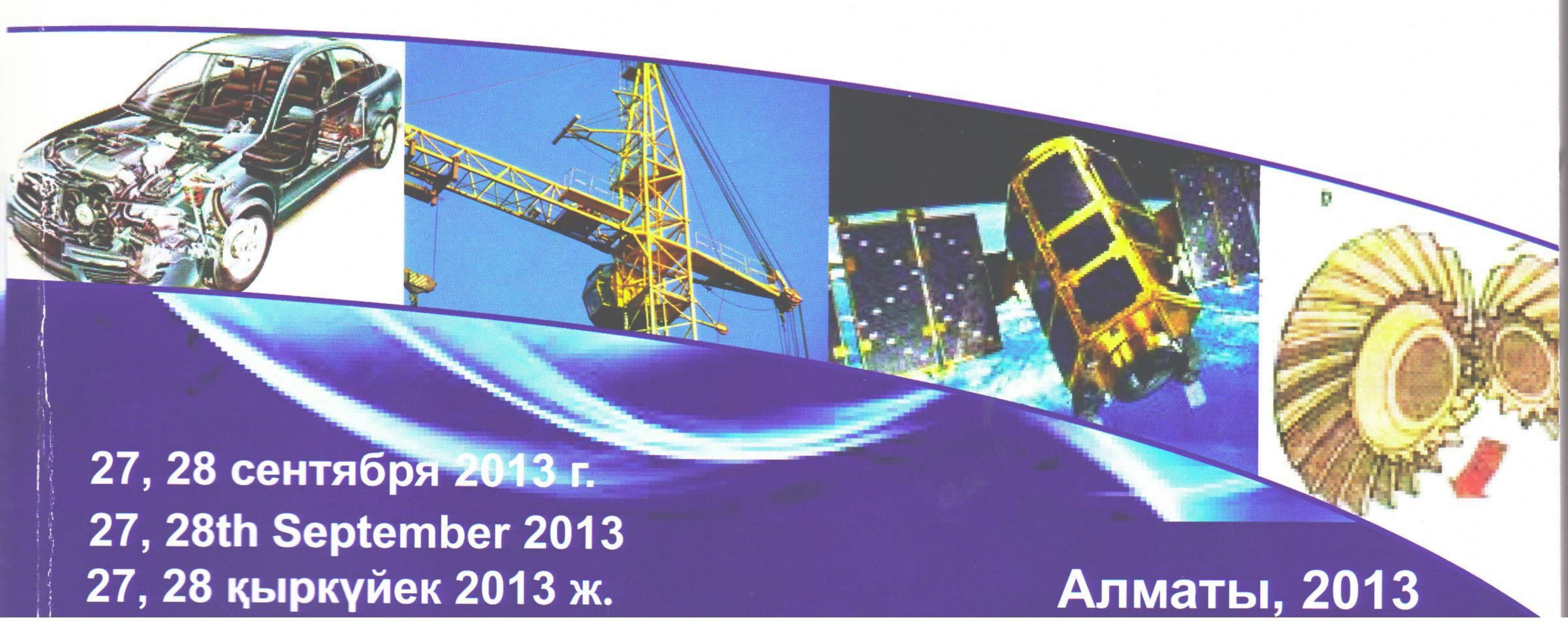

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DETERMINATION OF LOGISTICS FACILITY LOCATION WITH GRID METHOD

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1. INTRODUCTION

Enterprises through the logistics facilities (for example: distribution centres, warehouses etc.) are looking for ways to reduce costs associated with complete logistics chain within the company and want to increase their attractiveness in terms of customer service. The new location allows them to reduce the time of delivery of products to customers and enables to improve the physical flow of goods.

With the methods of optimization the company is able to find an acceptable quality solution. Very important are the financial and organizational issues, which are often crucial in order for the expansion of their potential. In order to create appropriate solutions, it is necessary to carry out their ability to recognize and define the necessary data processing operations that are essential for proper decision.

New locations and strategic analysis for the distribution centre is one of the most important elements of a successful investment, and the success of the business enterprise. What is important is an appropriate choice of the analytical method to be able to use the acquired information and data necessary for its application. For example, the team involved in the choice of location, it can be concluded that the optimal location for a new distribution centre should be close to the market, which has the greatest willingness to buy. Using the data that the company can exploit and by geographical methods, it is possible to easily determine the optimal location of the new facility with the lowest cost.

2. GRID METHOD AS AN EXAMPLE OF HEURISTIC-BASED MODEL OF LOCALIZATION

Heuristic models generally deal with very defined problems, but do not provide the optimal solution. Heuristic methods may assist in converting the size of the problems allowing for their examination and automatic analysis of the differences to obtain variants favourable solution. These models can also give a good approximation of the location of the lowest cost in the decision process. In order to reduce the number of potential sites for the location should be made to model the desired characteristics of an optimal business location [1].

Generally speaking, a combination of heuristic models of simulation study of the optimal solution which allows for the solution of such problems as:

- choosing the location of warehouses in the middle or on the edge of the largest centres of demand,
- making decisions on supply customers directly with regional warehouses or manufacturing cells,
- setting the number of nodes or points of transport,
- determination of a location of a new distribution centre that is characterized with the lowest cost,
- deliveries of the ordered products within 24 hours from the time of order (for example in Just-in Time strategy conditions) [2].

Grid method is known heuristic method that can be used by businesses that support multiple markets and has several sources of supply. This method allows to specify the location of a fixed

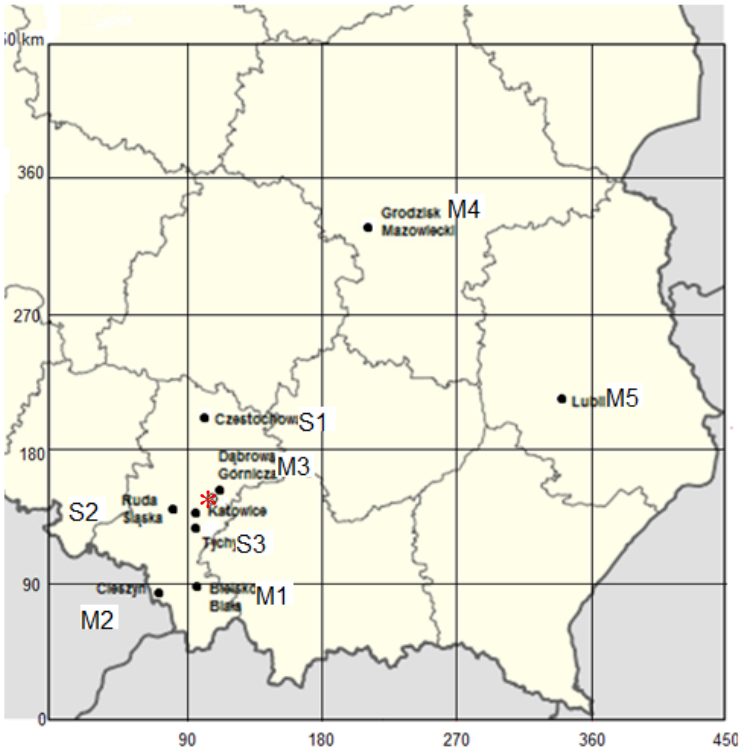
object (e.g., a distribution centre or manufacturing plant) with the lowest cost of transportation of raw materials to the facility and leaving the finished products. It is all provided in the geographical area to which was applied a grid of horizontal and vertical lines. This allows you to find the "centre of gravity" of the lowest cost transport of the one and finished on the other hand [1].

Grid method assumes that the sources of raw materials and markets for finished products are given and the company knows the size of the consumption and sale of any product. Given these assumptions, is applied to the grid lines on the geographic area encompassing all sources of supply and markets. The zero point and the remaining points correspond exactly to its geographical position on the map. In this way, you can identify each source and each market by reading the coordinates of the grid.

3. EXAMPLE OF DISTRIBUTION CENTER LOCALIZATION

The subject of a research analysed in this article is the firm located in Silesia (Poland), prospering for a long time and has a number of markets, supply and sales. It is the large, well-functioning company that is growing rapidly and is seeking to larger profits. One way to increase the level of performance will set up a new distribution centre, which can help in the further development and in gaining new customers.

The aim of the analysis was the location of the distribution centre design of plastic parts using the grid method. For this purpose a grid was prepared. Figure 1 (based on [3]) illustrates an example of an area (southeast of Poland) showing the sources of supply and markets on which the company must appoint a new facility. Their exact location can be read by the applied grid on the map. The company buys raw materials from suppliers in Czestochowa, Ruda Śląska and Tychy - marked as S1, S2 and S3. The new distribution centre will include five sales markets located in Bielsko-Biala, Cieszyn, Dąbrowa Górnicza, Grodzisk Mazowiecki, Katowice and Lublin - appropriately labelled as M1, M2, M3, M4, M5, M6.



	Grid coordinates	
	H	V
Sources of supply:		
Częstochowa (S1)	105,0	198,8
Ruda Śląska (S2)	82,5	142,5
Tychy (S3)	92,5	127,5
Sales markets:		
Bielsko-Biała (M1)	97,5	90,0
Cieszyn (M2)	75,0	87,5
Dąbrowa Górnicza (M3)	112,5	153,8
Grodzisk Mazowiecki (M4)	213,8	326,3
Katowice (M5)	92,5	151,4
Lublin (M6)	341,3	213,8

Figure 1. Sources of supplies and sales markets identified using the methods of the grid (H-horizontal, V-vertical grid coordinate)

Grid method allows you to define the position of each location using the coordinates of the grid. In Figure 1 there are also companies listed with the coordinates of the individual.

In order to find the "centre of mass" or as it's also called: "centre of gravity" of the material flows, the following equation should be used:

$$C = \frac{\sum_l^m r_i d_i S_i + \sum_l^n R_i D_i M_i}{\sum_l^m r_i S_i + \sum_l^n R_i M_i} \quad (1)$$

where:
C - the center of mass (km)
Di - the distance from the 0 point of grid to the i-th sales market,
di - the distance from the 0 point of grid
Mi - the weight (volume) of finished products sold in the i-th market,
Si - the weight of raw materials purchased in the i-sourcing.
R - the rate for the carriage of the i-th final product per unit distance,
ri - the rate for the carriage of the i-th material per unit distance.

Table 1 (based on [3]) shows the relevant data for the location of examples of a distribution center and a solution to this example by grid method, using a computer spreadsheet. For simplicity, it was assumed that the firm produces only one type of finished product which means that the shipping rate for each time the same.

Table 1

Example of location of the distribution centre - analysis by the grid method

Supply sources/ sales markets	Carriage rate [PLN/km] (A)	Tones (B)	Grid coordinates		Calculations	
			H	V	H (A) · (B)	V (A) · (B)
Częstochowa	5,1	300	105	198,8	160 650	304 164
Ruda Śląska	4,8	400	82,5	142,5	158 400	273 600
Tychy	4,5	750	92,5	127,5	312 188	430 313
TOTAL		1 450			631 238	1 008 077
Bielsko- Biała	5,2	370	97,5	90,0	187 590	173 160
Cieszyn	5,2	105	75,0	87,5	40 950	47 775
Dąbrowa Górnicza	5,2	814	112,5	153,8	476 190	651 005
Grodzisk Mazowiecki	5,2	146	213,8	326,3	162 317	247 727
Katowice	5,2	177	92,5	151,4	85 137	139 349
Lublin	5,2	9	341,3	213,8	15 973	10 006
TOTAL		1 621			968 157	1 269 021

	Localization coordinates	
	H	V
Counter: Σ(r·d·S)=	631 238	1 008 077
+ Σ(R·D·S)=	968 157	1 269 021
Total	1 599 394	2 277 098
Denominator : Σ(r·S)=	6 825	6 825
+ Σ(R·M)=	8 429	8 429
Total	15 254	15 254
"Centre of gravity" (centre of mass)	**105**	**149**

Table 1 shows sample calculations. The last two columns on the right side of the board include the estimated partial needed to determine the center of mass. The penultimate column shows the calculations for the horizontal coordinate counter, which is the sum of the products of freight rates, horizontal coordinates on the grid and trading volume in tonnes for each source of raw material and market. The calculation of the bottom of table are the numerator and denominator of the equation for the center of mass.

As can be seen from Table 1, the coordinates for the new distribution center at the lowest cost are as follows: 105 - horizontal position, 149 - vertical coordinate at the grid. Distances are measured from the zero point on the grid. In Figure 1 the position of the center point marked with ∗ (star) symbol is located in the central-eastern part of Silesia in Sosnowiec area between Katowice and Dąbrowa Górnicza on the map).

The grid method is the starting point for making decisions related to location. It has to be remembered that the cost of transport is not the only determinant of location. This method allows to focus on the regions that are most favorable from the point of logistics by eliminating certain areas. For more accurate and further characterization of determinants of the new location requires consideration of many more criteria.

Despite the high facility of calculation shall also bear in mind that grid method also has limitations. First of all, it is a static tool and the solution is optimal only in the moment. Any change in the rates, the quantity of products purchased or sold by the company or changes in arrangements sales markets and sources of supply will affect the location of the center of mass (the "center of gravity") and of course we're not able to change the position of a facility built. In addition, the grid method does not account for topographic conditions in the optimal location, so it may be that a point will be located in the middle of the lake.

4. CONCLUSIONS

a) Grid method is a known heuristic method that can be used by businesses that support multiple markets and has several sources of supply.
b) Grid method is a good solution of many problems among which is choosing the location of warehouses in the middle or on the edge of the largest centres of demand.
c) Grid method allows for more accurate positioning of the sources of supply and sales markets by taking into account the quantitative relationship between the distances and the freight rates.
d) Basing on the data on the number of purchases, sales volume, cost of transport provided by the company, the new distribution center has been appointed with grid method. Its location in the region accounted for Sosnowiec.
e) Selection of Sosnowiec on location for of the new logistics facility from the beginning could have been easily predicted because of its location close to a market located in Dąbrowa Górnicza, for which there was the highest annual sales.

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