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TOPOLOGY AND SEMAPHORICAL REGULATION OF DURRES AND ELBASAN CITIES IN ALBANIA

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Abstract

Intelligent Transport Systems are today a tangible reality even in Albania. In a road network where motorways are almost missing, their application is mainly focused on urban roads. Being a developing country, in the last ten years Albania was affected by the phenomenon of migration, ie urbanization of large industrial cities. This certainly condition not only the existing road infrastructure improvements, but also the design of new transportation systems. This paper, based on the experience of European countries, tends to address not only theoretically but also virtually real-world systems, topology problems, and traffic light regulation. By studying two cities from the country's most important "industrial triangle" (DurrësR4 and ElbasanR5, with about 56/34 thousand inhabitants), we tried to analyze some of the most used algorithms for optimal solution of the problem. Given the fact that the parameters affecting the topology variables are several, different values were experimented to enable their calibration. Subsequently, the selected algorithms and the respective calibrated parameters will then be used to calculate traffic flows and propose interventions in the infrastructure network of the largest city in the area.

Keywords: Urbanization, Algorithm, Optimum, Calibration, Traffic Control

INTRODUCTION

The Traffic Control Project

The first stage is the choice of an algorithm. Then it is necessary to verify the results that he is able to guarantee. To this end, experimentation was carried out with a test transport system with defined dimensions [number of branches from 5 ÷ 24, nodes 4 ÷ 9 and origin / destination couples from 1 ÷ 12], in which they were considered by 1 ÷ 3 crossings in the project.

In the case of a general cross-project in the project are considered two stages. The green times of this junction linked to node ***n***, given by $y_{C,n}$ *and* $y_{C,n'}$, may be related to the relation

$$\sum_{i \in J_n} y_{C,i} = t_n - t'_n \qquad for \ \mathrm{n} \in \mathrm{N_C} \qquad (1)$$

and, expressing them in function of each other

$$y_{C,n'} = t_n + t'_n - y_{C,n}$$

The relationship (1) also serves to reduce the defining variables, considering only one for each junction in the project.

The algorithm converges towards a solution approaching the optimum, so the results from the experiment are positive.

To illustrate results are derived from a test system [24 branches, 9 nodes and 12 origin / destination pairs], with two project intersections, that is, with two determining variables (Figure 1). The presence of two variables allows us to present the function level curves in a graph, having the ratio between green time and cycle time to the time difference $t_n - t'_n$. This representation is given in the figure, showing schematically the trajectories that are taken starting from nine points different from A to H. Let's look at two cases:

- Trajectories that start from very low green (F to I) time points, reduce even more this time, worsening the value of the objective function;
- Trajectories starting from the point where green times are not small (from A to E) converge all at a point near the optimum point, always improving the value of the objective function. These trajectories in the area around the optimum (convergence) point, where the level curves are more diluted, are characterized by a portion of the adhesion, ie the part where the objective function deteriorates.

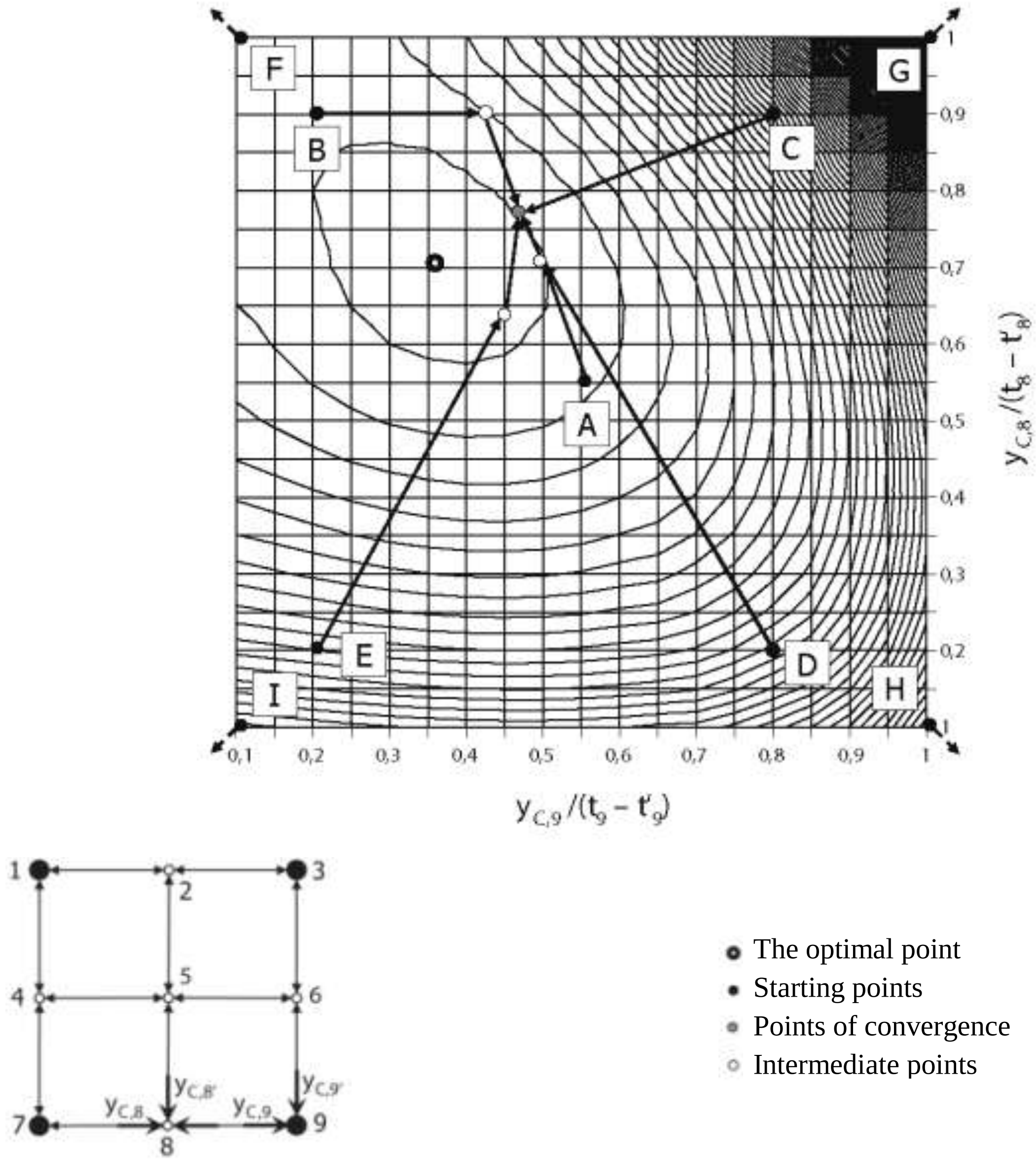

Figure 1. Results of algorithm application in the test system

Some of these trajectories can be analyzed to show the continuity of the objective function, or rather the percentage difference to the optimum value, denoted by Δw^{+}, and the continuity of determining variables during the repeat changes.

The traceability of the objective function for trajectories starting from points D and E is given in Figures 2 and 3. It is noted that the trajectory part of the trajectory gives a negligible deterioration of the objective function. The trajectories that depart from A and B are not considered, since at the starting point the percentage difference of the objective function, respectively the optimal value, is very small (less than 2%) and therefore the reduction is insensitive.

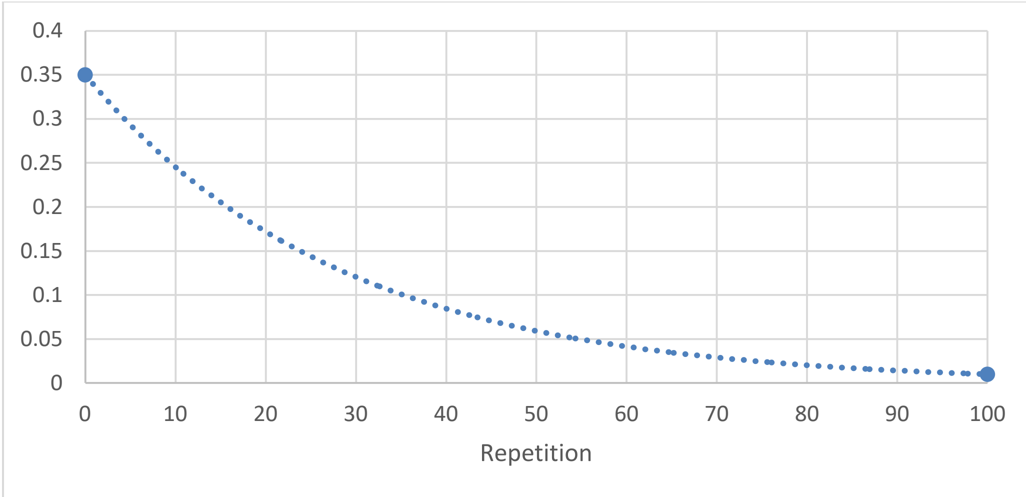

Figure 2. The traceability of the objective function for the trajectory starting from point D.

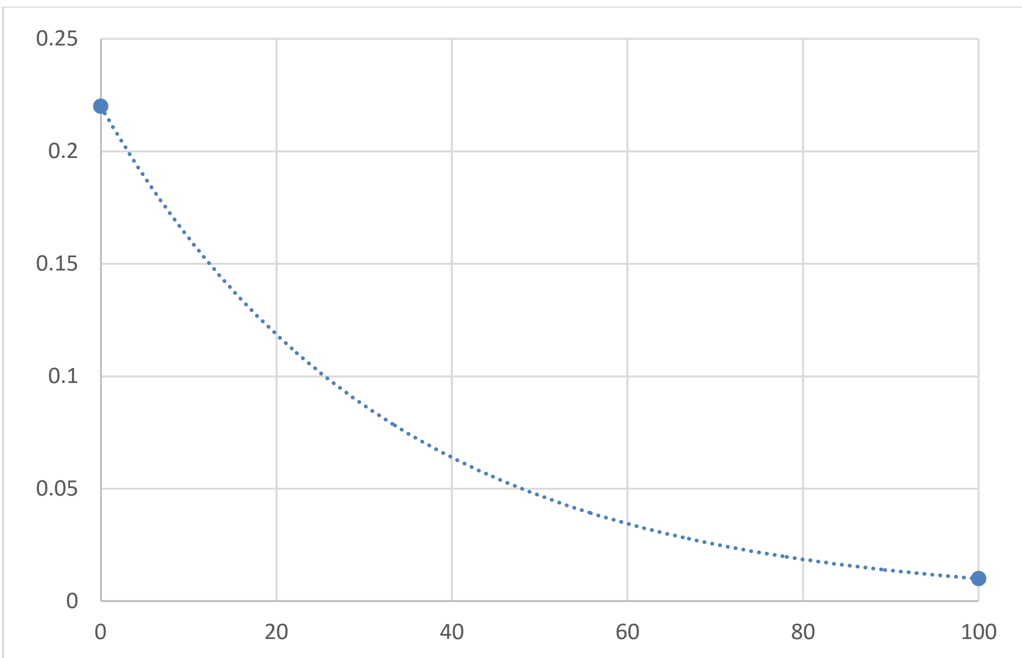

Figure 3. Continuity of determining variables for trajectory starting from point D.

The attuability of determining variables for trajectories starting from points D and E is given in Figures 4 and 5. It is noted that variations of these variables are almost invariable during repetitions. This makes us think that the same results can be achieved with a much smaller number of repeats, if in the algorithm we had a more accurate technique in choosing the downward direction shift step.

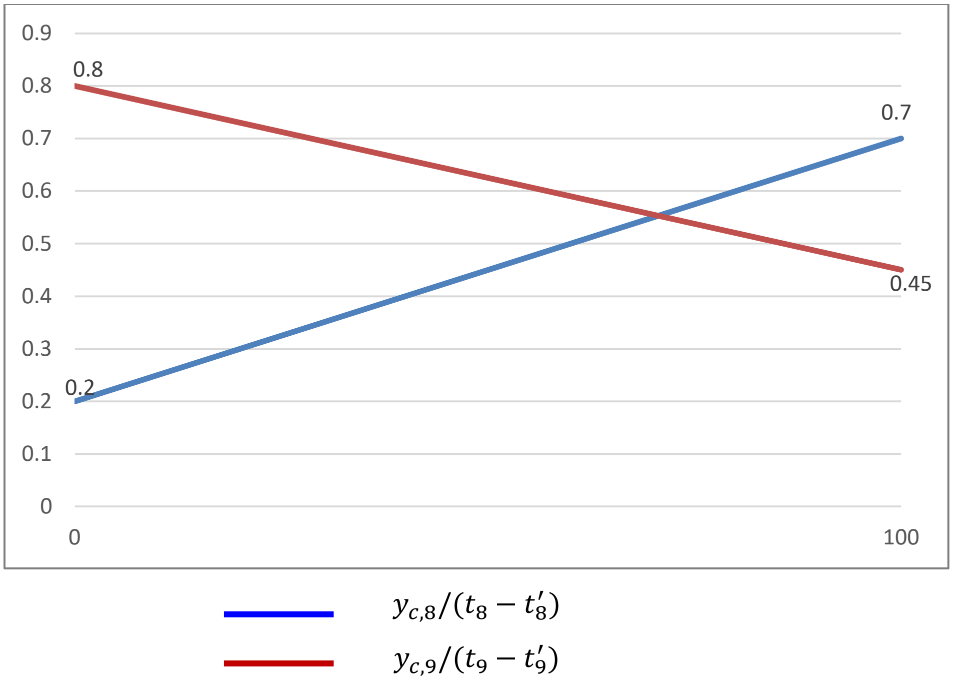

Figure 4. The traceability of the objective function for the trajectory starting from point D.

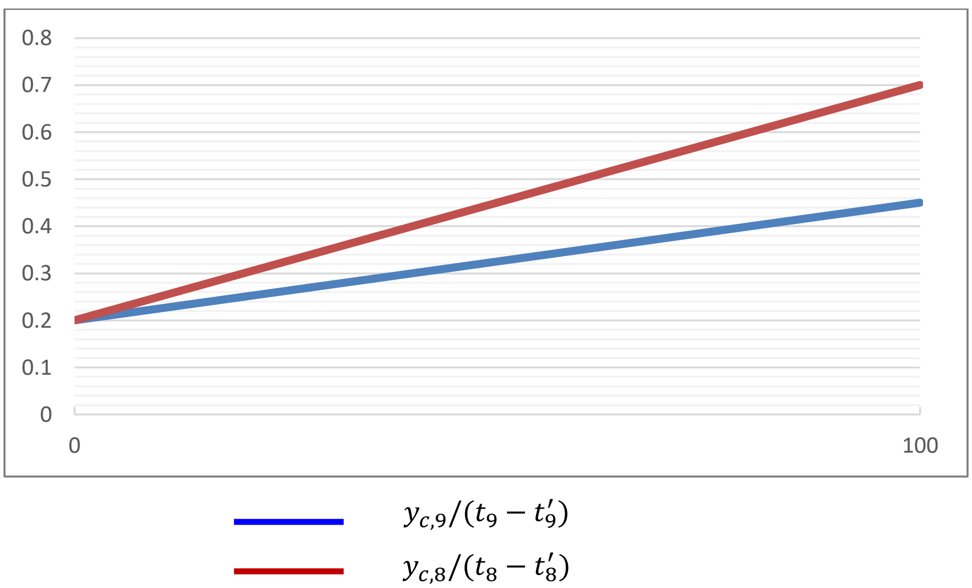

Figure 5. Continuity of determining variables for trajectory starting from point E

Following the experimentation, the algorithm applied to the analytical approximation for calculating the direction of displacement was compared with an algorithm in which the downward direction calculation was performed with a numerical equivalent approximation. In this latter, the total element of the approximate gradient is calculated by the finite difference method. It is proved that the approximation is equivalent to the application of this method, considering the value of the objective function at that point, calculated accurately. So with the Stochastic User Equilibrium (SUE), while the value of the objective function in the adjacent points is calculated roughly by determining the Stochastic Network Loading (SNL).

TOPOLOGY AND SEMAPHORICAL REGULATION PROJECT

In designing transport networks for the two important cities of Albania, DurresR4 and ElbasanR5, with about 56/34 thousand inhabitants, the proposed algorithms for the joint project of topology and semaphorical regulation were tested. This practice had three objectives:

- Calibrate the control parameters used in the approximations of the topology project phase;
- Analysis of characteristics obtained from different approximations;
- Comparison of topology and configuration indicators that deal with proposed "what to" methods, with those of “what if” methods used in practice.

For each transport system, 2 origin / destination matrices are considered:

- First matrix, referring to the morning peak hour (estimated with a demand model);
- Another matrix, referring to the afternoon peak hour (approximated with the transposed matrix of the previous matrix).

In order to avoid that project configurations are unbalanced (favoring, for example, access to areas with the highest concentration of activities, to the detriment of the outflow, if only the morning peak matrix would be used), they were used both matrices. The objective function takes into account both the simulations performed, so it is given by the amount of time travels at midday and afternoon.

All edits start from the solution that represents the actual configuration and, with the exception of the Hill Climbing method, stop after exploring a predetermined number of topological configurations.

According to the literature recommendations, it is best to use this symbolology in obtaining the results of the applications:

- w_0 - is the value of the objective function calculated using the initial topological configuration, ie the actual factor with optimized regulation;
- w* - is the best value of the objective function, obtained during the execution of a processing;
- $\Delta w^{\%}$ - is the percentage reduction of the objective function obtained during a processing, so

$$\Delta w^{\%} = \frac{w_0 - w^*}{w_0}$$

PARAMETERS CALIBRATION

This section describes and analyzes the experiments performed to calibrate parameters that govern hypotheses at the topology project stage. These experiments allow preliminary comparisons between the performance of different algorithms.

For the calibration, the transport systems of the cities of Durres and Elbasan were used. In the case of Durres, the study area corresponds to the historical area that is about 30% of the branches of the entire urban area (Fig.6). While in the city of Elbasan, the study area and the project area coincide with the entire urban area (Fig. 7). However, in both cases there are 26 parts of the project; crossings in the project match the parts (so are those joints for which at least one entry or exit branch belongs to a part of the project). The main characteristics of the two transport systems are given in Table 1.

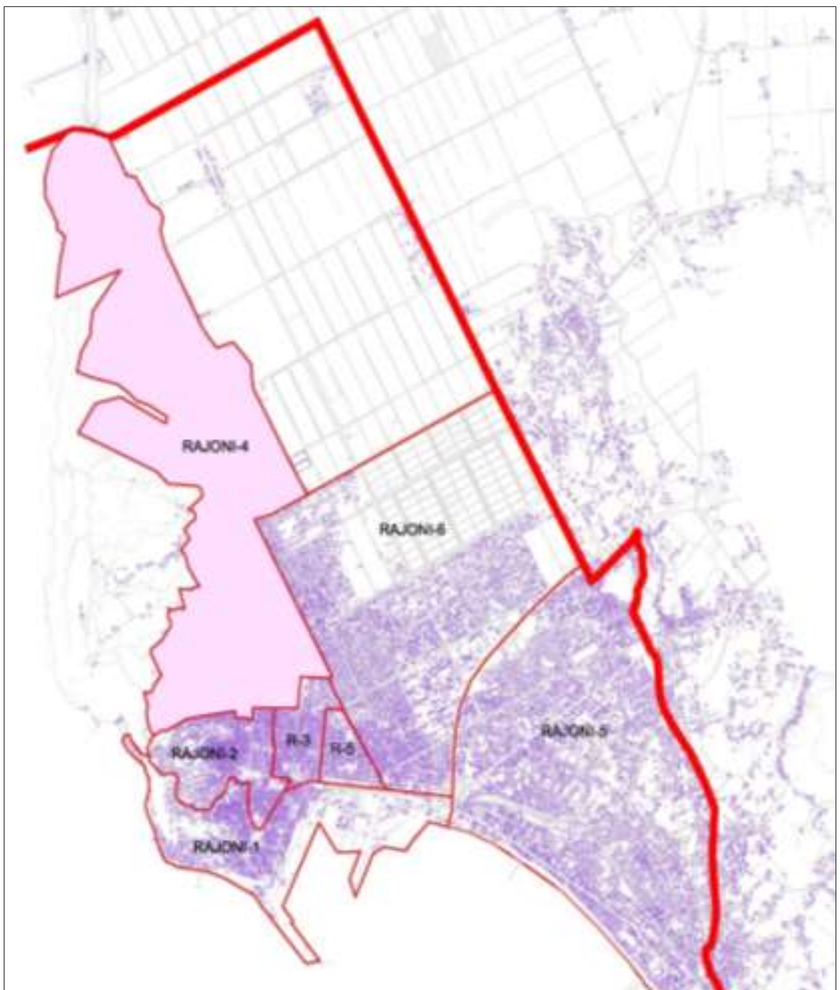

Figure 6. Study area and design area for the Durres transport system

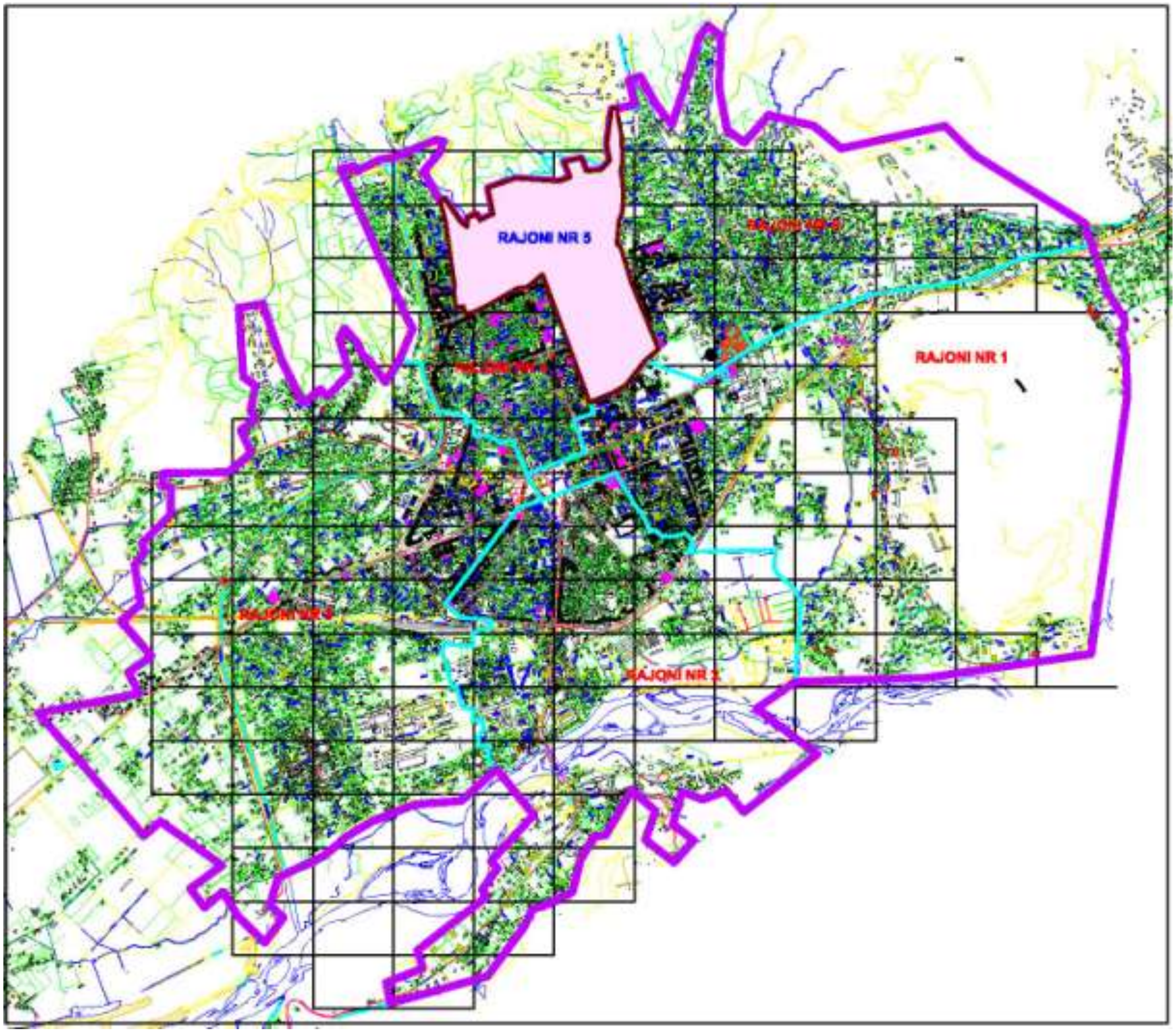

Figure 7. Study area and design area for the Elbasan transport system

Table 1. Characteristics of transport systems for EL and DR cities

		Elbasan	Durrës
	People	34.000	56.000
	Moving by car (peak time)	4650 car / hour	6408 car / hour
Study area	Origin-destination pairs	240	430
	Nodes	56	84
	Branch	165	225
	Network length	31 km	48 km
Project area	Parts	26	26
	Intersections	32	44

Below are given the processing results with different parameters for each algorithm. The detention criterion foresees the processing of $2x10^4$ topological configurations.

Method with Hill Climbing (HC) algorithm

This algorithm does not need calibration because it is not controlled by any parameter. The values of the processing results are given in Table 2. In both cases, respectively, 413 and 1250 topological configurations were processed before the minimum was found (however, attempts smaller than the $2x10^4$ limit).

Table 2. The result of processing with HC algorithm

City	Processed configurations	The best value, w* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	413	845,3	15,14 %	975,4 [h]
Durrës	1250	2014,6	2,15 %	2057,91 [h]

Method with Simulated Annealing (SA) algorithm

The control parameters are:

- initial temperature $\boldsymbol{\tau_0}$;
- final temperature $\boldsymbol{\tau_p}$.

The length of the field step is accepted $\boldsymbol{\lambda_p}$ =100 and the degree of cooling $\boldsymbol{\alpha_c}$ is taken in function of initial and final temperatures. Based on the recommendations in the literature (Webster, 1958) for similar cases, they are accepted $\boldsymbol{\tau_0} \cong w_0$ and $\boldsymbol{\tau_p} \cong 10^{-4}\, w_0$.

Table 3 shows the results of the processing performed to change the calibration parameters for both cities.

Table 3. The result of processing with SA algorithm

City	τ_0 [h]	τ_p [h]	α_c	λ_p	The best value, w* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	1000	100	0,989	100	954,2	2,17%	975,4 [h]
	100	10			938,1	3,82%	
	10	1			905,7	7,14%	
	1	0,1			916,7	6,01%	
Durrës	1000	100	0,989	100	2034,6	1,13%	2057,91 [h]
	100	10			1987,4	3.42%	
	10	1			1895,7	7,88%	
	1	0,1			1943,3	5,56%	

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Method with Tabu Search (TS) algorithm

There is only one parameter that controls the specification proposed by TS (Wardrop, 1952): tabu list size $\boldsymbol{\lambda_l}$. The processing results with the change of the parameter being calibrated are given in Table 4.

Table 4. The result of processing with TS algorithm

City	$\boldsymbol{\lambda_l}$	The best value, w* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	0	882,3	9,54%	975,4 [h]
	5	854,2	12,34%	
	10	846,7	13,19%	
	20	831,6	14,74%	
	30	843,6	13,51%	
	35	874,3	10,36%	
	40	878,2	9,96%	
	50	877,4	10,04%	
	55	874,3	10,36%	
	60	879,5	9,83%	
	70	874,9	10,30%	
Durrës	0	2048,6	0,45%	2057,91 [h]
	5	2032,8	1,22%	
	10	2024,7	1,61%	
	20	2020,2	1,83%	
	30	2005,9	2,52%	
	35	2024,3	1,63%	
	40	2018,6	1,91%	
	50	2026,2	1,54%	
	55	2028,3	1,43%	
	60	2019,8	1,85%	
	70	2019,8	1,85%	

Method with Genetic Algorithms (GA)

The parameters that control the specificity of Genetic Algorithms are four:

- the total population coefficient, $\boldsymbol{v_p}$;
- selectivity parameter, $\boldsymbol{\alpha_r}$;
- crossover frequency, $\boldsymbol{\varphi_c}$;
- frequency of change, $\boldsymbol{\varphi_n}$.

Cantarella & Vitetta (1994) provides a set of calibrated parameters ($\mathbf{v_p}$ = 40, $\boldsymbol{\alpha_r}$ = 70, $\boldsymbol{\varphi_c}$ = 0,40, $\boldsymbol{\varphi_n}$ = 0,20). Calibration results are given in Table 5.

Table 5. GA Process Algorithm Output

City	v_p	α_r	φ_c	φ_n	The best value, w* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	40	70	0,40	0,20	905,3	7,18%	975,4 [h]
	20	70	0,40	0,20	890,6	8,69%	
	80	70	0,40	0,20	888,7	8.88%	
	40	30	0,40	0,20	895,7	8,17%	
	40	140	0,40	0,20	903,2	7,40%	
	40	70	0,20	0,20	919,2	5,76%	
	40	70	0,80	0,20	774,5	20,59%	
	40	70	0,40	0,10	840,3	13,85%	
	40	70	0,40	0,40	912,7	6,42%	
Durrës	40	70	0,40	0,20	2006,3	2,50%	2057,91 [h]
	20	70	0,40	0,20	2015,6	2,05%	
	80	70	0,40	0,20	2005,8	2,53%	
	40	30	0,40	0,20	2019,8	1,85%	
	40	140	0,40	0,20	2004,7	2,58%	
	40	70	0,20	0,20	1999,4	2,84%	
	40	70	0,80	0,20	2001,3	2,75%	
	40	70	0,40	0,10	1960,6	4,72%	
	40	70	0,40	0,40	2017,3	1,97%	

Hybrid Method 1 (TS + GA)

The parameters that control the hybrid method are six:

- Tabu Search parameter - $\boldsymbol{\lambda_l}$.
- Genetic Algorithms Parameters - $\mathbf{v_p}$; $\boldsymbol{\alpha_r}$; $\boldsymbol{\varphi_c}$; $\boldsymbol{\varphi_n}$.
- Parameter that determines the part of the solutions reviewed with TS, which is marked by $\boldsymbol{\tau_{\%}}$.

Since many parameters are being calibrated, the best values obtained from calibrations with the special methods are accepted. The part of the solutions reviewed with TS is accepted $\tau_{\%}$ = 75% and that with GA: 1- $\tau_{\%}$ = 25%. The processing results are given in Table 6.

Table 6. Result by hybrid method 1 (TS + GA)

City	Hybrid Method 1	The best value, w* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	TS→GA	823,64	15,56	975,4 [h]
	GA→TS	837,25	14,17	
Durrës	TS→GA	1988,32	3,38	2057,91 [h]
	GA→TS	2009,71	2,34	

Hybrid Method 2 (TS + PR)

The only parameter that controls the specificity of this hybrid method is the tabu list size $\boldsymbol{\lambda_l}$. From the literature recommendations, it is good to get a value that is close to the values of the parts of the project. The processing results are given in Table 7.

Table 7. Result by hybrid method 2 (TS + PR)

City	$\boldsymbol{\lambda_l}$	The best value, w* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	0	870,3	10,77	975,4 [h]
	5	852,6	12,58	
	10	850,3	12,82	
	20	841,6	13,71	
	30	844,5	13,42	
	35	865,5	11,26	
	40	832,2	14,68	
	50	868,3	10,98	
	55	859,8	11,85	
	60	864,5	11,37	
	70	861,2	11,70	
Durrës	0	2021,7	1,75	2057,91 [h]
	5	2012,2	2.22	
	10	2006,3	2,50	
	20	1996,7	2,97	
	30	1992,7	3,16	
	35	2011,4	2,26	
	40	1984,5	3,56	
	50	2008,4	2,40	
	55	2004,7	2,58	
	60	2009,2	2,36	
	70	2010,8	2,13	

Hill Climbing Method with double circle method (HC2)

This method is not regulated by any parameter and therefore there is no need to calibrate. Table 8 gives the results for both areas in the study. In the case of EL, 1.021 topological configurations were processed before locating the local minimum, while in the case of DR, 6.870. In both cases, less than the recommended limit $2 \cdot 10^4$.

Table 8. Processing result by Hill Climbing with double circle method (HC2)

City	Processed configurations	The best value, w^* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	1.021	812,3	16,72 %	975,4 [h]
Durrës	6.870	2018,6	1,91 %	2057,91 [h]

In conclusion let's look at the analysis of the comparison of the results obtained with each of the methods. For this purpose, Table 9 lists the best recorded values.

Table 9. Comparison of best results obtained with all algorithms

City	Algorithm	The best value, w^* [h]	Decrease, $\Delta w^{\%}$	Initial value, w_0
Elbasan	HC	845,3	15,14 %	975,4 [h]
	SA	905,7	7,14%	
	TS	831,6	14,74%	
	GA	774,5	20,59%	
	TS+GA	823,64	15,56%	
	TS+PR	832,2	14,68%	
	HC2	812,3	16,72 %	
Durrës	HC	2014,6	2,15 %	2057,91 [h]
	SA	1895,7	7.88%	
	TS	2005,9	2,52%	
	GA	1960,6	4,72%	
	TS+GA	1988,32	3,38%	
	TS+PR	1984,5	3,56%	
	HC2	2018,6	1,91 %	

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CONCLUSIONS

These results are considered preliminary, due to the fact that for different methods a number of applications were not used, as well as different parameter sets for each method. The results show that the percentage reduction of the objective function is included in the interval (2,17% -

20,59%) for EL and (0,45%-7,88%) for DR. These intervals are extensive and highlight the need to use the best algorithms with optimal parameters. The target function reduction intervals, for each method and the change in the parameters used, are given in Figure 8 for EL and in Figure 9 for DR.

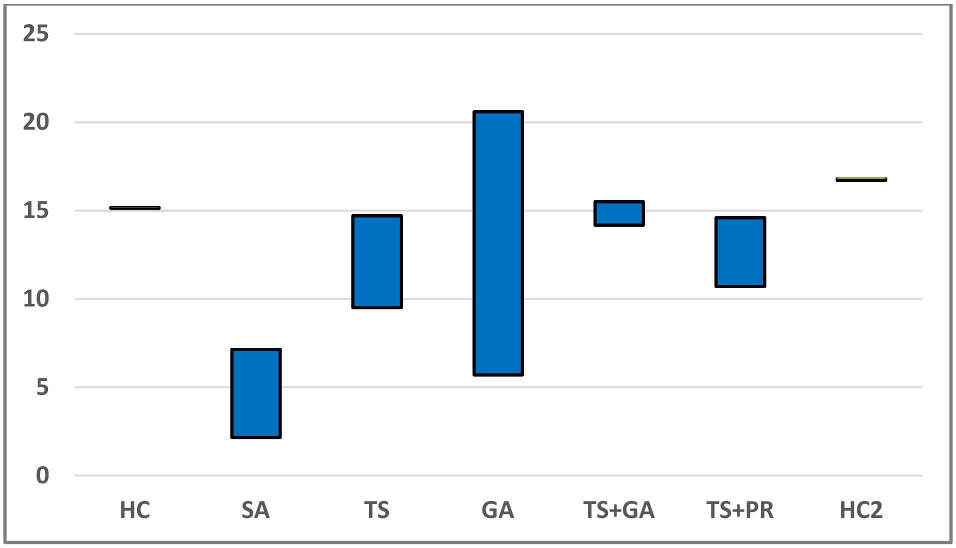

Figure 8. Target function reduction intervals, for each method and the change in the parameters used for EL

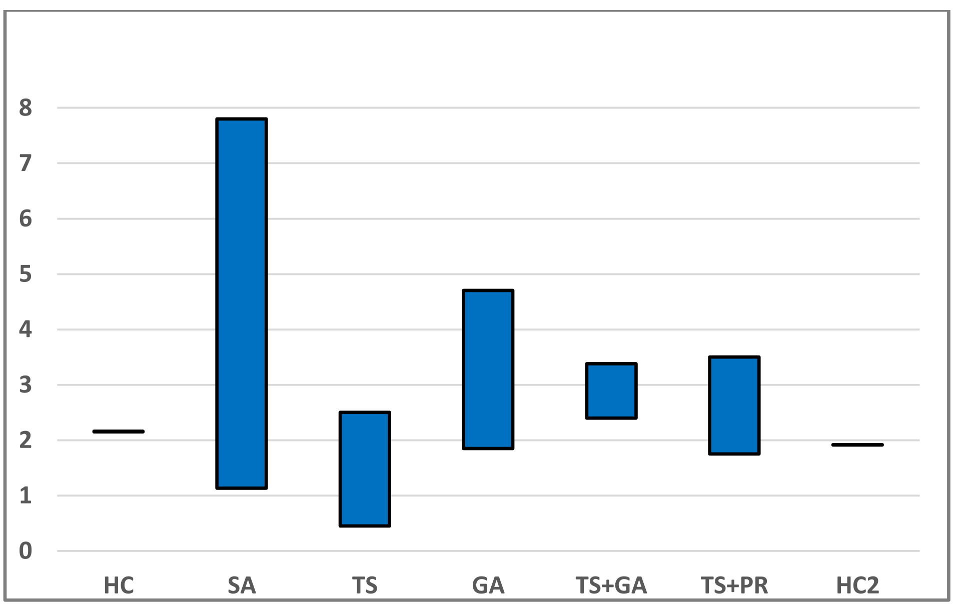

Figure 9. Target function reduction intervals, for each method and the change in the parameters used for EL

By interpreting the graphs, the best algorithm is the Tabu Search.

This paper analyzes the algorithms that serve to calibrate parameters for the topology project phase. To make a comparison as close to reality, a transport system different from the two used to calibrate the parameters will need to be used. For further studies, this is a treatment that shall be carried out in another paper.

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