ŽELJKO IVANOVIĆ, M.Sc.
E-mail: clt@t-com.me, ivanovic.zeljo@gmail.com
Center for Logistics and Transport "Z-Logistics"
Ilino 69, 85000 Bar, Montenegro
SANJA BAUK, Ph.D.
E-mail: bsanjaster@gmail.com
University of Montenegro
Faculty of Maritime Studies
Dobrota 36, 85330 Kotor, Montenegro

Transport Logistics
Preliminary Communication
Submitted: Feb. 10, 2014
Approved: Sep. 23, 2014

MULTIPHASE APPROACH TO DEVELOPING MODEL OF LOGISTICS FOR COASTAL TOURIST DESTINATIONS

ABSTRACT

The process of urbanization of coastal tourist destinations (CTDs) is taking place at high speed and at the same time creating a lot of complex problems. The positive trend of urbanization has resulted in increased volume of freight transport which leads to burdening the traffic network, time losses and causes traffic congestion problems on the streets with increased environmental pollution due to emissions, noise and vibration. These findings brought to some research being started on the EU level, aiming to develop new logistic solutions, so these areas could be developed on a sustainable basis. With this in mind, the paper proposes a method of developing a novel model of logistics (MoL) for CTDs through several stages. The point of proposed MoL lies in achieving optimal connectivity of transportation, warehousing and physical distribution of goods, and making it a single functional model, so as to allow simultaneous optimization of logistic processes in a CTD, and to incorporate logistics in tourist offer.

KEY WORDS

logistics; coastal tourist destination (CTD); model of logistics (MoL); simulation modelling;

1. INTRODUCTION

In their evolutionary development path coastal tourist destinations (CTDs) have dominantly incorporated physical and historical components, with all the features in terms of close association with water surface, dense urban cores with a concentration of generators of logistic activities within them, narrow one-way streets burdened with the implementation of freight transport, congestion on access roads at certain intervals, predominance of road transport mode in shipping goods, etc. Therefore, the desire to find an adequate model of supplying the CTDs without undermining the quality of tourist offer and the environment is permanently present. A holistic approach in developing MoL which is the base of research work presented in this article employs several phases and methods in order to comprehensively and simultaneously optimizes logistic processes in a CTD.

Contemporary models of sustainable development of CTDs promote horizontal and vertical integration logistics and tourist activities. They are focused on technical vision, combined distribution, and the concept of environmental sustainability. This approach is fundamentally opposed to pro-road freight transport strategy that has been present for a long time and brought to the increase in number of vehicles on roads, which in turn brought to a series of negative impacts on CTDs.

The model of sustainability is closely connected to total logistic integration (TLI) of processes in a CTD (*Figure 1*). In accordance with Tinen's theory [1], it can be stated that within a CTD, the location factor, in respect to water surface, represents the key element of the development of the model. On this basis, the geographic area in a CTD which is the closest to water surface is the one with the highest density, rents, and traffic intensity. As a rule, these areas are reserved for the most expensive tourist facilities, while the most distant areas, in geographical terms, with the lowest rents, are used for industrial or agricultural production. In the last mentioned areas the transportation costs are lower, and the intensity of transport is considerably weaker. Being that TLI creates sustainable, competitive and strategic advantage, the physical aspect of a CTD must be reaffirmed, in accordance with Tinen's model.

The descriptive approach to the research of relations between tourist destination and associated generators of logistic requirements, logistic centers (LCs), location problem, and optimization of tourist facilities supply, represents the basis of the research and development of a novel model of logistics (MoL). Quality management of TLI system, as a key moment in developing MoL [2], should essentially search for an optimum among the following four processes: (1) research and forecasting of customer needs and expectations, (2) cooperation, coordination and consolidation of material, energy, transport and information flows, (3) network and physical planning, and (4) environmental planning.

Model of logistics (MoL) as a term, along with its significance in the development process and redefinition of logistic-transport system of a certain geographic area, represents a construction based on a set of principles. It optimally connects *primary logistic elements* (system structure, organization, logistic chains, logistic flows and telematic technologies) and *secondary logistic elements* (public, private, and public-private logistic measures) into a systematic and sustainable solution of logistics for CTD.

Active development of CTD affects the existing logistic solutions and causes higher costs and greater number of complex requirements related to the processes of distribution of goods. Therefore, the development of new methodological approaches for creating sustainable solutions in logistics is imposed as an inspiration. In other words, the approach aimed to simultaneously and comprehensively optimize logistic processes, and above all minimize transportation costs, along with providing development of cooperative model of physical distribution.

Development of CTDs contains four phases (*Figure 1*): *initialization* (initial development of fishing ports), *urbanization* (urban development and trade around the fishing port), *industrialization* (development of related industrial facilities), and *expansion* (development of tourism and tourism-related facilities). According to the level of economic development of a society, each phase has some logistic solution. The last phase of development is characterized by certain concentration of different regional functions present on a rather small area that mutually coincide and create a set of negative effects which are harming sustainable development of the region.

Physical and infrastructural restrictions on one side, and increased frequency of vehicles on the other, create gaps in the implementation of cargo flows. Former areas of concentration of cargo flows such as ports, docks and town squares, have now become significant tourist and catering facilities in which there has been a change in the characteristics of cargo flows in terms of size, intensity and structure. The key problem is that there has been an increase of road transport and it is the result of: (1) elimination of holding stock in facilities, (2) desire to deliver goods in accordance to JIT (Just in Time) strategy, (3) rapid increase in e-shopping, and (4) tendency to independently solve transport problems of separate entities by not taking into account the overall efficiency.

2. PROBLEM FORMULATION AND PROPOSED METHODOLOGY

Coastal tourist destinations (CTDs) are special and unique geographical areas with emphasized logistic needs during specific period of time throughout the year (150-165 days). It is necessary to come up with a new MoL that will allow better cooperation, coordination and consolidation of logistic flows, which are implemented in these areas. Therefore, the basis for developing MoL being proposed in this paper relies on

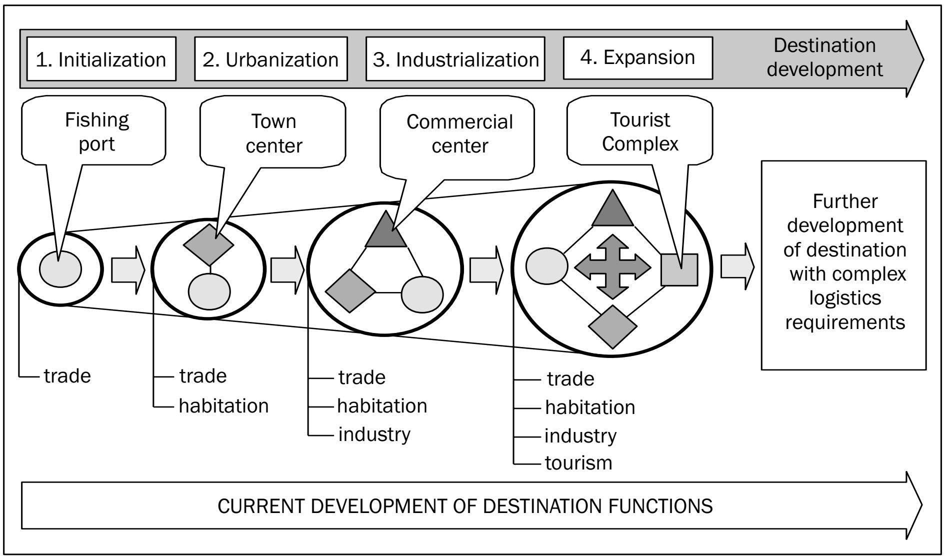


Figure 1 - Scheme of CTDs' evolution

the relations between: geographic area and the existing generators of logistic requirements, LC and terminals, location problems and optimization of tourist destination supply. The newly proposed MoL is developed by using a holistic approach, the one that allows simultaneous optimization of all parts of logistic chain within CTD. This model allows the development of a higher level of logistic service, as well as development of a combined distribution system between land and water mode of transport. The key features in developing an optimal MoL are realized through four phases referring to: (1) clustering problem in logistics, (2) location problem, (3) vehicle starts optimization, and (4) vehicle routing problem. These four phases are described in the following sub-sections of the paper (2.1-2.4).

2.1 First phase - clustering in logistics

Within the first phase of the development of MoL, it is necessary to cluster generators that are located in a CTD. Clustering can be done by using k-means (greedy) method of clustering. At this stage, on the basis of number, structure and physical distribution of generators of logistic requirements, it is necessary to determine the physical concentration of generators based on the principle of similarities of characteristics of logistic requirements and by using the method of clustering that will enable defining optimal locations for hub and LC, and in later stages, cross docking terminals. The clustering process consists of the following phases: initialization, aimed to define the number and physical distribution of generators, variable selection for clustering (characteristic for logistic applications), selection of distance measure, selection of clustering algorithm, determination of the number of clusters, and validation of the analysis [3-6]. Distances within clusters are being determined as Euclidean ones from the center (centroid).

K-means clustering is based on two components: (a) input a set X on n points $x_i, i = \overline{1,n}$, and (b) output calculated as a set C consisting of k points (cluster centres) $\overline{x}_j, j = \overline{1,k}$ that minimizes the square error distortion $d(X,C)$ over all possible choices of C:

$$d(X,C) = \min \sum_{j=1}^{k} \sum_{i=1}^{n} | x_i - \overline{x}_j |^2 . \quad (1)$$

It is possible to achieve this goal (1) by applying the following heuristics: place k points into the space representing generators, assign each generator to the group that has the closest centroid, when all objects have been assigned relocate the positions of k centroids, repeat the second and the third steps until the centroids no longer move.

Greedy method should be applied in initial clustering and/or in determining the optimal connections later on between the established centroids.

2.2 Second phase - solving hub location problem

The second phase means determining the network of LC based on the results of the clustering phase. The basis of this sub-model is to determine the optimal structure of two echeloned systems of distribution: hubs-satellites as the first echelon, and satellites-users as the second one. The scheme of this phase is given in *Figure 2*, and it is described in more detail further on.

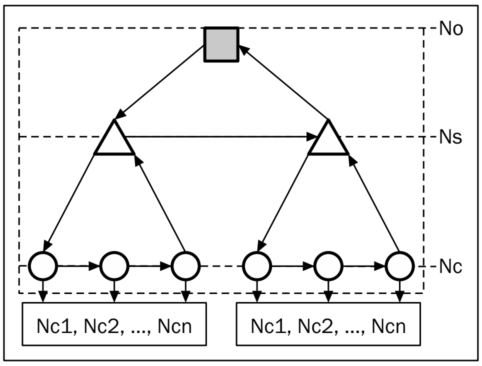


Figure 2 - Set of nodes arrangement for two-echelon routing problem

Procedure of identifying hubs should be summarized as follows: let us observe graph $G = (N, A)$ where N is the set of all terminal nodes, and the set of potential hub notes is $H \subset N$. The set of arcs is defined as A, where each arc is weighted by travel time (distance, or costs). Paths in the graph are identified as a sequence of the nodes traversed, where this number is limited to at most two hub nodes per path by the definition of the path variables. The standard incapacitated location model [7] is given as a model (2-6):

$$\min_{x,z} F(x,z) = \sum_{i\in N} \sum_{j\in H} \sum_{k\in H} \sum_{l\in N} c_{ijkl} x_{ijkl} + \sum_{j\in N} f_j z_j \cdots \quad (2)$$

subject to:

$$\sum_{j\in H} \sum_{k\in H} x_{ijkl} = d_{il}, \forall (i,1) \in W \cdots \quad (3)$$

$$\sum_{j\in N} x_{ijkl} < Q_{il} z_k, \forall k \in H, (i,1) \in W \quad (4)$$

$$\sum_{k\in N} x_{ijkl} < Q_{il} z_j, \forall j \in H, (i,1) \in W \quad (5)$$

$$z_j = 0 \vee z_j = 1, \forall j \in N \quad (6)$$

where $d \in R_+^{|W|}$ is the vector of demands over the set $W \subset N^2$ of origin-destination pairs. The flow variables are given by $x \in R_+^{|N|^2 \times |H|^2}$, and $z \in \{0,1\}^{|H|}$ is the vector of discrete decision variables indicating whether a hub is to be opened or not. The constant Q_{il} is defined as $Q_{il} > d_{il}, (i,1) \in W$, in which case equations (4) and (5) ensure that hub terminal is open for the flow. Costs of the path (i,j,k,l) are given by c_{ijkl}, while f_j is the cost associated with converting the terminal j into the hub node.

2.3 Third phase – setting fuzzy logic conditions for vehicle starts

In this model, vehicles and LCs have predefined capacity [8-9]. Demands arriving from more customers should be met by engaging only one vehicle. The moment when vehicle departs from its starting point is very important and it is determined by fuzzy logic. Its route starts and ends within the same LC, and the total load must be less than or equal to the capacity of LC. The objective is to minimize the total costs of the system, including storage costs and routing costs.

Since customer demand is described by fuzzy logic, after the first customer has been served, the capacity of each vehicle is also described by fuzzy logic, due to the rules of fuzzy arithmetic. The capacity of LC is also described by triangular fuzzy number, and it has all the conditions not to exceed the remaining capacity of LC with the next customer demand.

Greater difference between available capacity of vehicles and customer demand puts dispatcher in the position to send the next vehicle. The preference index herewith means magnitude of preferences to send the vehicle to the next customer. Details of mathematical notation of this model can be found in [8]. However, limitations of this model are robust fuzzy calculus and unpredictable customer demands.

2.4 Fourth phase - two-echelon vehicle optimal routing

In order to describe two-echelon vehicle model [10-23], let us consider a transportation carrier that has to deliver goods to a set of N_C destinations, called customers. A quantity of freight q_i to be delivered, called demand, is associated to each customer i. The carrier has one depot N_O (hub) and N_S (terminal) intermediate facilities, or satellites where cross-docking operators can take place. Let us assume that the transportation company has two fleets of homogenous vehicles, m_1 and m_2, assigned respectively to the first and the second echelon. These vehicles have maximum capacities C^1 and C^2, respectively. Two types of routes are then defined, one per each echelon. The first echelon route starts and finishes in a depot and visits the satellites. At the satellites, the freight is transhipped into the second echelon vehicles. Each of them makes a round trip to deliver goods to one or more customers.

The objective function seeks to minimize the overall transportation costs. Constraints include: maximum number of routes, balancing the number of vehicles entering and exiting each node; achieving that each route returns to its starting point and each node receives its corresponding demand; limitations to the vehicle capacities; existence of connection between the two echelons, and assigning each customer to one and only one satellite. Detailed mathematical model of herewith presented verbal formulation of the problem is given in Gonzales-Feliu (2012). The limitation of this model is its computational complexity [24-27].

In this paper, for the purposes of vehicle routing, instead of several well-known methods, such as genetic algorithms, bee colonies and similar, an object-oriented computer simulation is used.

2.5 General algorithm scheme

Concerning all above described phases, an algorithm for a novel CTD MoL is created and given in *Figure 3*. It consists of the following key processes: (1) determination of destination size, (2) clustering of generators of logistic requirements, (3) determination of system structure, (4) determination of cooperation models, and (5) simulation modelling of a real system.

The size of destination (small, medium or large) depends on the number and physical distribution of generators of logistic requirements. This problem corresponds in a manner to the clustering problem being described in (2.1) sub-section. The number and nature of generators and their initial values are usually set on the basis of extensive empiric observations on the spot.

When it comes to defining LC's network, it corresponds to the second phase of MoL (see 2.2). Here are identified possible LCs and their interconnectivity within two-echelon structure of distribution, including seasonal characteristics of logistic flows as very important elements.

The model of cooperation is presented in the following segment where key conditions are described with fuzzy logics. The process management of goods distribution is closely connected to conditioned vehicle departures caused by key attributes, i.e. vehicle capacity and freight space being used. This segment of proposed algorithm directly corresponds to the third described methodological approach in (2.3) sub-section. The vehicle routing problems are solved by the process of simulation modelling (2.4). For the last phase, input data are the results of the resolved problems encountered in the previous three phases (2.1-2.3).

Direct and strict application of integrated MoL which includes particular combination of analytic, probabilistic and fuzzy methods is too complex and it is hard to have it entirely realized. The appropriate simulation modelling represents the key phase in models like this one. The role of the simulation is double. On the one hand it should describe and simulate very complex processes with several dimensions: analytic, probabilistic and fuzzy. On the other, it should provide a database which offers important indicators like: capacities used of available vehicles, LCs' locations, mileage, number of stops, time consumed during unloading, etc., for further analysis.

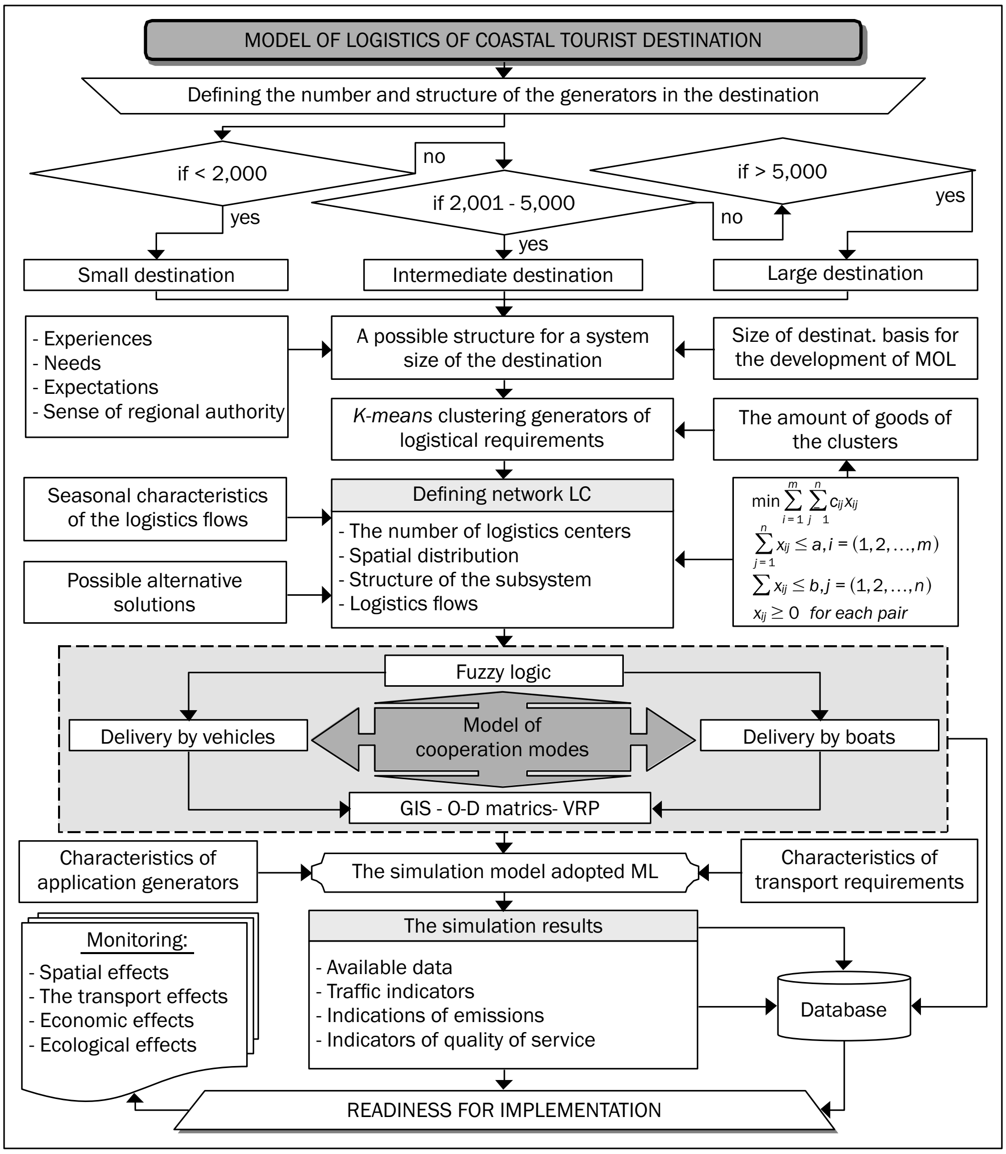


Figure 3 - Proposed algorithm for development of MoL for CTDs

By taking into account the previously described phases (2.1-2.4), along with the proposed holistic approach to the development of MoL in CTDs, it needs to be emphasized that there are many difficulties when it comes to the realization of the process of connecting separate sub-models into one integrated model. Consequently, some phases can be separately realized, and their results can be used as independent input data for future development of similar models.

The developed multiphase MoL is tested on a concrete example, i.e. Montenegrin CTD (MCTD) as a medium developed tourist destination. The goal is to obtain relevant data for a complete optimization of logistic processes within this CTD in the time period to come. The simulation results over newly developed MoL for MCTD, which has three different scenarios, are presented in the next section of the paper, along with all relevant indicators.

3. THE MoL APPLICATION AT MCTD

The proposed model of logistics (MoL) has been tested at MCTD, which is a unique destination composed of six towns: Herceg Novi, Kotor, Tivat, Budva, Bar and Ulcinj, and fourteen input and output gates. These towns need annually 572,271 tons of goods for the purpose of satisfying their functions (trade, tourism, etc).

The key steps in developing MoL at MCTD are briefly described below.

Step 1: Features of the existing logistic solutions at MCTD are summarised. It is a disorganized system in logistic terms. In other words, the concentration of logistic processes is not present at MCTD, and each sub-system independently organizes distribution of goods, not taking into account the general efficiency. Furthermore, insufficient coordination and

Table 1 - Presence of certain types of generators at MCTD

Groups of generators	Off-season		In-season	
	No.	%	No.	%
Food shops	539	21.53	643	18.45
Textile, shoes & boutiques	360	14.38	435	12.48
Hotels and catering	591	23.61	1,024	29.38
Technical goods	237	9.47	275	7.89
Craft shops	284	11.35	300	8.61
Furniture	21	0.84	21	0.60
Bookstores	39	1.56	46	1.32
Other	432	17.26	741	21.26
Total:	2,503	100.00	3,485	100.00

cooperation among different modes of transport is present. Consequently, regarding the presence of a number of separate and partial solutions, numerous examples of unsynchronized logistic activities are preset, like: dispersion of storage and transhipment capacities, intensive road traffic in narrow city centre areas, running vehicles with a small degree of cargo space utilization, frequent deliveries during the peak load, etc.

Step 2: Number of generators of logistic demand has been initialized. At MCTD, in total 3,485 generators are identified during the season, while 2,503 generators are identified in off-season period. Each generator presents a sub-system of marketing logistics of the region with different features of demand. In order to have better understanding of the facts, the generators are grouped (*Table 1*) according to the flows of goods similarity.

Step 3: Different types of generators are identified. In order to simplify things for the purpose of the following simulations, the generators are divided into five groups: G1 – generators for local industry, G2 - generators for civil engineering, G3 - generators for retail, G4 - generators for hotels and catering, G5 - other generators. The number of generators is analyzed for both in-season (approximately 92 days per year) and off-season (approximately 273 days per year) periods.

Step 4: Six towns at MCTD: Herceg Novi, Kotor, Tivat, Budva, Bar, and Ulcinj are defined as six clusters in the model.

Step 5: The hub-location problem is resolved within this step, i.e. the structure of three LCs is defined. One hub in Bar within the Port of Bar which should provide technical and technological support, while two satellites are in Tivat and Herceg Novi (*Figure 4*). *Figure 4* also gives the amounts of goods (Q) needed by the analysed cities and modes of transport for MCTD per year. This structure will allow effective coordination and utilization of transportation infrastructure at MCTD, including optimal distribution of macro and micro commodity flows.

Step 6: Two-echelon vehicle optimal routing is realized within this step. The first echelon is composed of the hub in Bar and the two satellites in Tivat and Herceg Novi. The second echelon consists of several satellites and end-users. At the level of the first echelon, supply is realised by using bigger transportation devices (ship, wagon, truck, etc.), while at the level of the second echelon the distribution of goods is realized by smaller transportation units (vehicles).

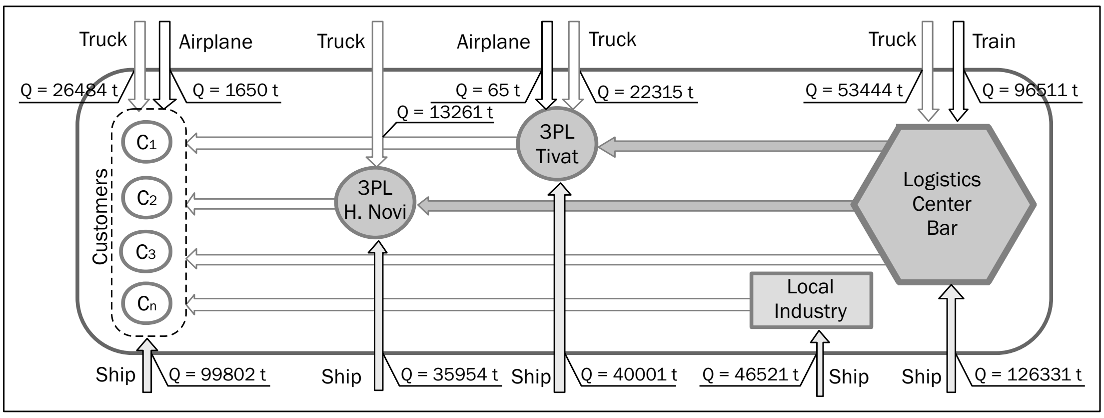


Figure 4 - Graphic presentation of implementation of logistic chains

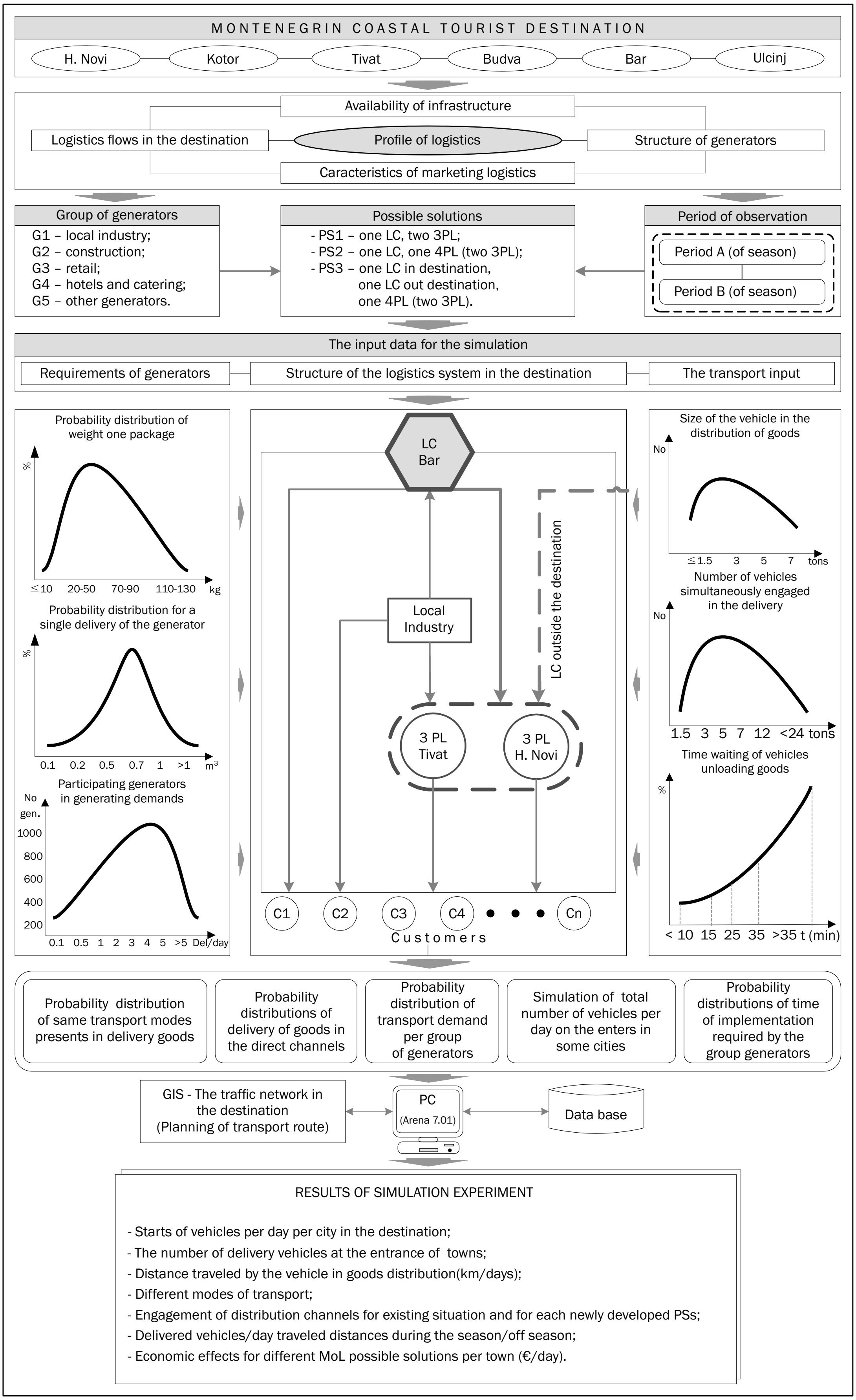


Figure 5 - General structure of the simulation model for MCTD

3.1 The structure of the simulation model

All contemporary tendencies towards optimization of logistic processes in a tourist destination basically coincide with the process of development of LCs. The main development goals of LCs are concentration and consolidation of logistic activities in one place by achieving positive economic, physical, and environmental effects. Contemporary designed and organized LCs represent central elements, or *hardware* of the MoL which, as such, are in strong connection with the development and implementation of modern logistic strategies such as: *make or buy* (MOB), JIT, 3PL, and 4PL. After solving the location problem for MCTD, the structure of three LCs is defined, i.e. one hub in Bar within the Port of Bar, which should provide technical and technological support, and two satellites, one in Tivat and the second one in Herceg Novi. This structure allows effective coordination and utilization of transportation infrastructure in the destination.

An important feature of the proposed model is to define quantitative characteristics of logistic demand which are related to: (1) establishing average number of demands per time unit and determining medium value (amount of goods) per demand, (2) defining probability distribution of time between two demands, (3) defining probability distribution of amount of goods per demand, and (4) defining random functions of events for two periods of observation.

The general scheme of simulation modelling for MCTD is given in *Figure 5*.

On the basis of a completed profile of logistics for MCTD, the following elements are defined: geo-physical features of the destination (border destination, gate layout, LC's location and road network), characteristics of macro and micro commodity flows, where the largest percentage of macro flows is directed firstly towards the Port of Bar and later on from the port to LCs. The characteristics of physical distribution are in accordance with the logistic requirements of the generators and the vehicle characteristics.

Based on the initial conditions, the system structure has been defined for three alternative solutions. Any alternative solution has a different system structure, which are modelled by the simulations.

Variant 1: It consists of one hub (cargo centre Bar) and two LCs (3PL logistic providers in Tivat and Herceg Novi). At the same time, this form presents possible solution No. 1 (*PS 1*) in the general structure of the herewith presented simulation model for MoL;

Variant 2: It consists of one hub (cargo centre Bar) within the destination and one 4PL logistic provider. In this form 4PL provider is a complete structure made of two LCs (3PL providers Tivat and Herceg Novi) and one IT provider. This form presents possible solution No. 2 (*PS 2*) in the general simulation model;

Variant 3: It consists of two hubs (one within the destination – Bar, and another outside the destination) and one 4PL provider. In this form we have the possibility of having one hub situated outside the destination with auxiliary function. This form is solution No. 3 (*PS 3*) in the general simulation model.

The main idea is that the hub in Bar should present central element of logistic structure enabling concentration, cooperation and transformation of all forms of commodity flows. The numerical and graphical results of the simulation processes are given in the next part of the paper.

3.2 Generators of logistic demand features

All input data were obtained on the basis of multi-criteria empirical analysis made by the authors during the past two years. The proposed MoL for MCTD is an open, dynamic and stochastic model determined by a set of sizes with discontinuous characteristics, which affect the system, so that it changes discretely over time. The features of generators of logistic demand for MCTD are given in the form of number of vehicles' starts per day (*Figure 6*).

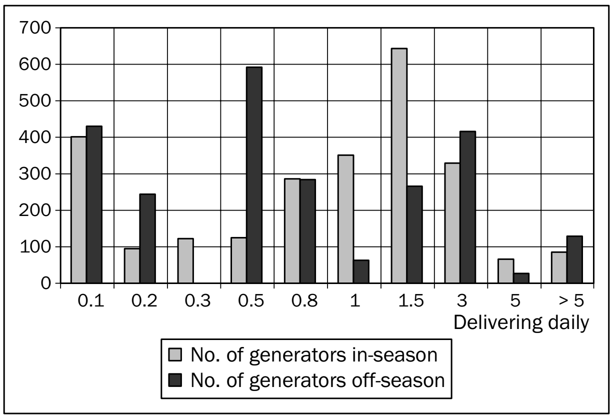


Figure 6 - Number of vehicles' starts per day

The size structure and the number of freight vehicles are given in *Table 2*, along with the starting points from which the vehicles depart on their routes within the explored MCTD. It is obvious that there are extensive data which create solid basis for the development of a simulation model.

In addition to data presented in *Figure 6* and *Table 2*, it should be pointed out that the authors have collected extensive data sets regarding the number of passenger cars, pick-ups and trucks exploited during and off season, in all MCTD clusters, i.e. in Herceg Novi, Kotor, Tivat, Budva, Bar and Ulcinj. Also, data on transport facilities structure and frequency of employing different modes of transport in delivering the goods have been collected. This kind of comprehensive research has never been done in this area so far (to the best knowledge of authors).

Table 2 - Percentage and structure of delivered vehicles of different freight capacities

Description	Structure			From own storages			Directly from the producers			From the distributors inside MCTD			From the distributors outside MCTD		
Generators	< 3.5t	3.5-7.5t	> 7.5t	< 3.5t	3.5-7.5t	> 7.5t	< 3.5t	3.5-7.5t	> 7.5t	< 3.5t	3.5-7.5t	> 7.5t	< 3.5t	3.5-7.5t	> 7.5t
Food stores	46	29	25	82	15	3	2	17	81	77	21	2	24	64	12
Textiles, shoes and boutique	68	29	4	92	7	1	5	84	11	86	13	1	87	12	1
Hotels and catering	32	38	30	71	24	5	6	23	71	29	52	19	21	53	26
Technical goods	42	29	30	74	23	3	2	9	89	67	28	5	23	54	23
Craft stores	65	32	3	82	18	0	28	61	11	72	27	1	78	21	1
Furniture	0	50	50	0	97	3	0	3	97	0	3	97	0	98	2
Bookstores	96	4	0	100	0	0	83	17	0	100	0	0	100	0	0
Other	50	36	14	76	21	3	21	61	18	57	28	15	47	34	19

4. SIMULATION RESULTS

The simulation experiment includes MCTD space as a single system with six sub-systems for each considered cluster. The process of modelling and simulation experiment based on the developed MoL for two characteristic periods *off-season* and *in-season*, is realized as a whole in programming language Rockwell Arena (ver. 7.1) on Intel processor (2.4 GHz/4 GB RAM) for the present situation at MCTD, and for three newly proposed solutions within the concept of rationalization of commodity flows. The numerical results obtained by the simulation model are given in Tables 3-5, and in Figures 7-10.

The number of vehicle starts per day is considerably reduced, depending on the variational solution and generators type (from 8% to 67%). Therefore, this results in a relief of the transportation network and achieving of greater economic and environmental effects (lower levels of CO_2, noise, etc).

The structure of distribution channels over LC Bar, 3PL points (Tivat and Herceg Novi), and local industry for each generator (G1-G5) is given in *Figure 7*.

In *Table 3*, the data on savings, i.e. effects (%) during and off-season are given for three examined logistic solutions for MCTD, concentrated in and around Herceg Novi, Kotor, Tivat, Budva, Bar and Ulcinj. These effects are calculated for the savings in the number of vehicles set in motion for different generators (G1-G5). Besides the detailed analysis per each type of generators for clusters considered within MCTD, the simulation results for the number of vehicle starts at the entrance of each analyzed cluster and effects in terms of savings in the distances travelled by the employed vehicles are given in *Table 4*.

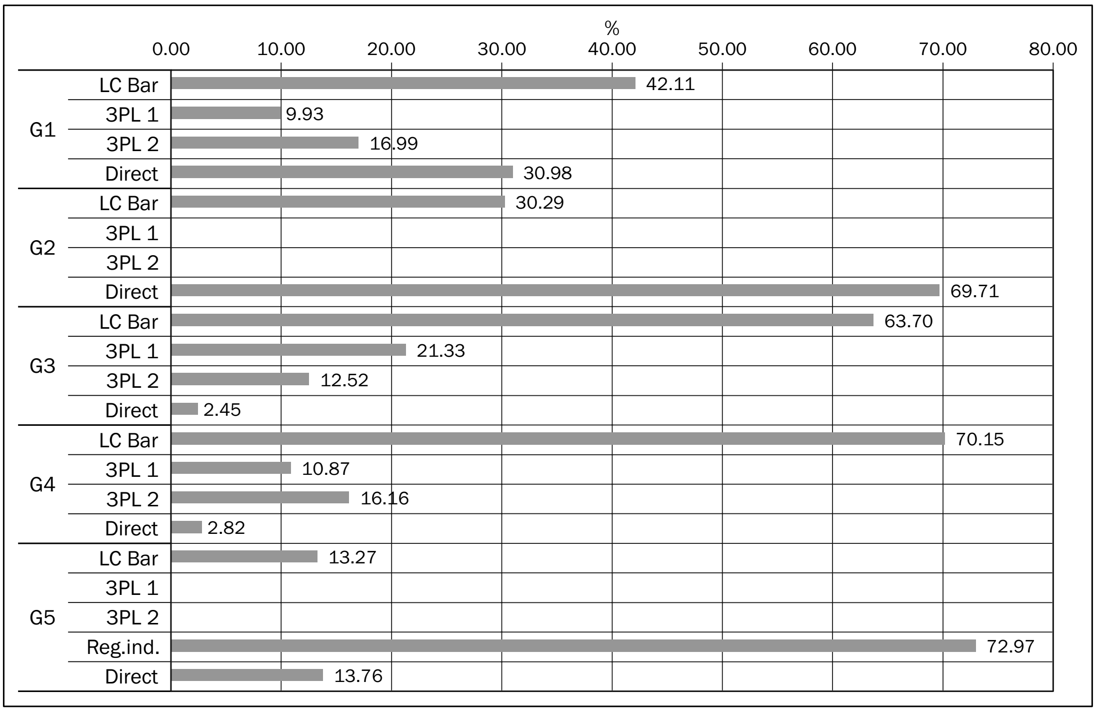


Figure 7 - The structure of distribution channels at MCTD

Table 3 - Comparative analysis of existing and three newly proposed MoL solutions for MCTD based on number of vehicle starts per analyzed clusters and generators

No.	Characteristic		MoL solutions for MCTD														
			Existing		PS 1				PS 2				PS 3				
			Off-season	Season	Off-season	Effect (%)	Season	Effect (%)	Off-season	Effect (%)	Season	Effect (%)	Off-season	Effect (%)	Season	Effect (%)
1	Goods/year (t)		572 271		572 271				572 271				572 271			
2	Period (days)		273	92	273	-	92	-	273	-	92	-	273	-	92	-
3	Starts of vehicles per day Ulcinj	G1	30.0	30.0	23.4	22.0	23.4	22.0	23.7	21.0	23.8	20.6	22.8	24.0	23.1	23.0
		G2	36.0	44.0	28.8	20.0	36.5	17.0	29.3	18.6	35.2	20.0	28.1	22.0	35.6	19.0
		G3	231.1	462.7	104.0	55.0	208.2	55.0	99.4	57.0	194.3	58.0	108.6	53.0	199.0	57.0
		G4	139.8	362.9	60.1	57.0	156.0	57.0	58.7	58.0	153.5	57.7	60.8	56.5	151.7	58.2
		G5	12.8	8.4	9.5	25.3	6.3	25.0	9.6	24.5	6.3	25.0	9.4	26.0	6.3	25.0
4	Starts of vehicles per day Bar	G1	54.0	54.0	44.8	17.0	44.8	17.0	42.7	21.0	44.3	18.0	41.0	24.0	43.9	18.7
		G2	135.0	165.0	113.4	16.0	140.3	15.0	109.9	18.6	138.6	16.0	105.3	22.0	137.0	17.0
		G3	517.3	1039.6	186.2	64.0	363.9	65.0	197.6	61.8	374.3	64.0	243.1	53.0	367.0	64.7
		G4	236.4	757.3	96.9	59.0	325.6	57.0	93.6	60.4	310.5	59.0	102.8	56.5	318.1	58.0
		G5	46.4	33.9	36.2	22.0	27.5	19.0	35.0	24.5	26.4	22.0	34.3	26.0	26.1	23.0
5	Starts of vehicles per day Budva	G1	18.0	18.0	15.7	13.0	14.8	18.0	14.2	21.0	15.7	13.0	15.5	13.7	15.5	14.0
		G2	36.0	44.0	31.0	14.0	38.3	13.0	29.3	18.6	37.8	14.0	30.5	15.3	38.1	13.3
		G3	333.0	722.0	113.2	66.0	231.0	68.0	117.5	64.7	245.5	66.0	111.2	66.6	238.3	67.0
		G4	172.4	1015.8	72.4	58.0	416.5	59.0	71.0	58.8	426.6	58.0	73.8	57.2	420.5	58.6
		G5	26.4	20.7	20.3	23.0	16.8	19.0	19.9	24.5	15.9	23.0	20.1	23.7	16.1	22.4
6	Starts of vehicles per day Tivat	G1	12.0	12.0	10.8	10.0	10.8	10.0	9.5	21.0	10.9	9.2	10.6	11.3	10.6	12.0
		G2	72.0	88.0	61.2	15.0	74.8	15.0	59.3	17.6	73.9	16.0	59.8	17.0	74.2	15.7
		G3	148.4	265.2	69.0	53.5	118.0	55.5	67.2	54.7	123.3	53.5	66.8	55.0	119.3	55.0
		G4	143.8	303.8	61.8	57.0	127.6	58.0	59.2	58.8	130.6	57.0	60.4	58.0	128.5	57.7
		G5	3.6	3.0	2.8	21.5	2.3	24.0	2.7	24.5	2.4	21.5	2.7	25.0	2.4	21.5
7	Starts of vehicles per day Kotor	G1	24.0	24.0	21.8	9.0	22.1	8.0	21.4	11.0	21.8	9.0	21.3	11.3	22.0	8.2
		G2	36.0	44.0	30.6	15.0	38.3	13.0	30.3	15.7	37.4	15.0	30.9	14.2	37.7	14.3
		G3	232.3	405.8	127.7	45.0	175.7	56.7	123.6	46.8	170.4	58.0	125.4	46.0	166.4	59.0
		G4	119.0	278.5	63.1	47.0	117.0	58.0	62.8	47.2	114.2	59.0	62.4	47.6	115.9	58.4
		G5	14.0	8.4	10.5	25.0	6.5	22.8	10.3	26.0	6.3	25.0	10.2	27.0	6.2	26.0
8	Starts of vehicles per day H.Novi	G1	12.0	12.0	11.0	8.5	9.8	18.0	9.5	21.0	11.0	8.5	9.7	19.0	11.0	8.5
		G2	63.0	77.0	54.4	13.7	67.0	13.0	51.3	18.6	66.5	13.7	52.5	16.7	66.5	13.7
		G3	332.6	615.8	110.4	66.8	198.3	67.8	117.4	64.7	204.5	66.8	108.4	67.4	204.5	66.8
		G4	145.9	431.9	62.7	57.0	178.4	58.7	60.1	58.8	185.7	57.0	61.9	57.6	185.7	57.0
		G5	9.9	6.6	8.2	17.0	5.3	19.0	7.5	24.5	5.5	17.0	8.0	19.0	5.5	17.0

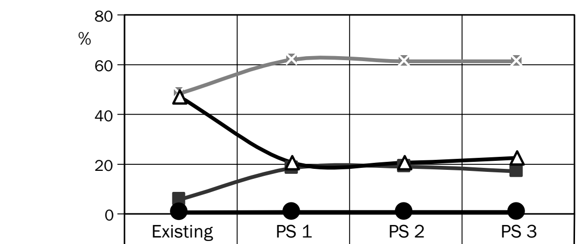
Figure 8 presents changes in the structure of the presence of different modes of transportation (ship, rail, road, and air) in MCTD during and off-season. It is evident that in the newly proposed logistic solutions (PS 1, PS 2 and PS 3) there is a significant decrease in the share of road and rail transport in comparison to sea shipping. This is of great importance in terms of relieving urban cores of analyzed cities, especially during the season. The new MoL solutions contribute to relieving the transport network in the destination from heavy trucks by increased use of sea and to slightly lower extent rail transportation modes, which is of particular importance during the summer tourist season.

The presence of much smaller scattering among engagement of direct distribution channels in delivery of goods to customers for all five groups of generators speaks in favour of the here proposed solutions PS 1, PS2, and PS 3 (*Figure 9*).

Figure 10 shows the change in the total commercial vehicle travelled distances in [km] per day during the summer tourist season in the analyzed coastal tourist destination, i.e. MCTD.

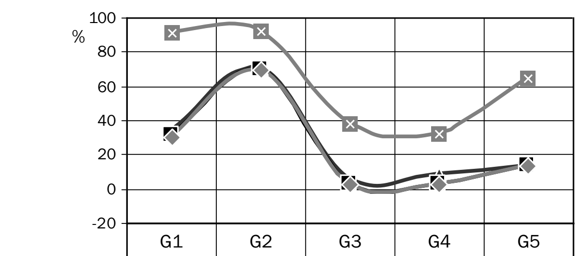
Table 4 - Comparative analysis of existing and three newly proposed MoL solutions for MCTD based on total number of delivered vehicles per clusters and the travelled distances

No.	Characteristic		MoL solutions for MCTD														
			Existing		PS 1				PS 2				PS 3				
			Off-season	Season	Off-season	Effect (%)	Season	Effect (%)	Off-season	Effect (%)	Season	Effect (%)	Off-season	Effect (%)	Season	Effect (%)
1	Goods/year (t)		572 271		572 271				572 271				572 271			
2	Period (days)		273	92	273	-	92	-	273	-	92	-	273	-	92	-
3	The number of delivery vehicles at the entrance of towns	UL	449.6	908.0	225.8	49.8	430.5	52.6	220.7	50.9	413.2	54.5	229.7	48.9	415.7	54.2
		BR	989.0	2,049.8	477.5	51.7	902.0	56.0	478.7	51.6	894.1	56.4	526.6	46.8	892.0	56.5
		BD	585.8	1,820.5	252.6	56.9	717.3	60.6	252.0	57.0	741.6	59.3	251.2	57.1	728.5	60.0
		TV	379.8	672.0	205.6	45.9	333.5	50.4	198.0	47.9	341.1	49.2	200.3	47.3	334.9	50.2
		KO	425.2	760.7	253.7	40.3	359.5	52.7	248.4	41.6	350.2	54.0	250.1	41.2	348.2	54.2
		HN	563.4	1,143.3	246.7	56.2	458.8	59.9	245.7	56.4	473.1	58.6	240.5	57.3	473.1	58.6
4	Distance traveled by the vehicle in goods distribution (km/days)	UL	47,212	104,42	13,550	71.30	26,691	74.44	13,243	71.95	25,617	75,47	13,784	70,80	25,774	75,32
		BR	90,988	274,677	5,730	93.70	12,629	95.40	5,745	93.69	12,517	95.44	6,319	93,06	12,488	95,45
		BD	55,064	163,845	21,974	60.09	64,559	60.60	21,927	60.18	66,740	59.27	2,1852	60,32	65,564	59,98
		TV	14,812	37,629	1,851	87.50	4,002	89.37	1,782	87.97	4,093	89.12	1,802	87,83	4,019	89,32
		KO	22,110	46,404	3,552	83.94	5,393	88.38	3,478	84.27	5,253	88.68	3,502	84,16	5,223	88,74
		HN	45,070	137,198	14,803	67.16	28,907	78.93	2,212	95.09	5,677	95.86	2,164	95,20	5,677	95,86



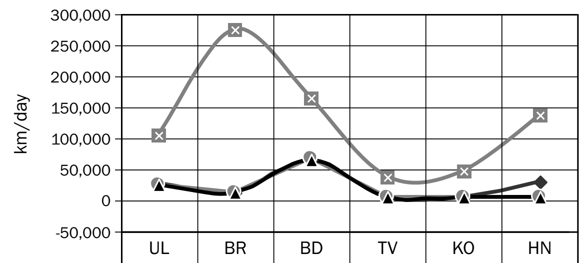
	Existing	PS 1	PS 2	PS 3
Ship	47.93	61.53	60.92	60.92
Rail	5.31	17.98	18.6	16.69
Truck	46.6	20.17	20.17	22.08
Airplane	0.16	0.31	0.31	0.31

Figure 8 - Simulation results obtained for different modes of transport



	G1	G2	G3	G4	G5
Existing	91.44	91.67	38.18	32.5	65.01
PS no 1	33.65	70.1	5.9	8.84	13.25
PS no 2	30.98	69.71	2.45	2.82	13.76
PS no 3	30.52	69.71	2.92	2.81	13.76

Figure 9 - Engagement of distribution channels for existing situation and for each newly developed MCTD solutions (PS 1, PS 2, and PS 3)



	UL	BR	BD	TV	KO	HN
Existing	104,423	274,677	163,845	37,629	46,404	137,198
PS no 1	26,691	12,629	64,559	4,002	5,393	28,907
PS no 2	25,617	12,517	66,740	4,093	5,253	5,677
PS no 3	25,774	12,488	65,564	4,019	5,223	5,677

Figure 10 - Delivered vehicle travelled distances [km] during the tourist season per day

The new structure affects the change of image of the total cost, the amount of harmful substances and the quality of logistic services. There is a much smaller share of unconsolidated delivery to users. The result of this is the relief of road transport network in the destination, which is up to 95.20% in the period outside the summer season and up to 95.86% in the peak tourist season. The economic effects of the new solutions per day for each PS are shown in *Table 5*.

In terms of direct positive economic effects per considered clusters (€/day) in the cases of a novel proposed MoL solutions, on the basis of figures presented in *Table 5*, it is obvious that certain differences are present. Namely, the greatest economic effects are noticeable for variant PS 3 in-season, while the great-

Table 5 - Economic effects for different MoL possible solutions per cluster (€/day) at MCTD

City	PS 1		PS 2		PS 3	
	Off-season	Season	Off-season	Season	Off-season	Season
Ulcinj	33,662	77,733	33,969	78,807	33,428	78,650
Bar	85,258	262,049	85,243	262,160	84,669	262,189
Budva	33,090	99,286	33,138	97,105	33,212	98,281
Tivat	12,961	33,628	13,030	33,536	13,009	33,610
Kotor	18,558	41,011	18,633	41,151	18,609	41,181
Herceg Novi	30,267	108,291	42,858	131,521	42,905	131,521
Total:	216,796	621,998	226,871	644,280	225,832	645,432

est positive financial effects, even with small variation in comparison to PS 3, are present off-season in the case of PS 2 variant. Through further analyses additional observations can be made, depending on the particular interests of the researchers, professionals and stakeholders in this domain. However, it is evident that the proposed MoL significantly improves the logistic processes in the considered MCTDs by providing time saving, congestion reductions, and money saving.

5. CONCLUSION

The growth in volume of logistic processes and services in all business segments of CTD affects the development of an approach that will enable its comprehensive and integral observation. Parallel with the process of expansion of logistics, certain logistic trends that significantly affect the processes of designing new systematic solutions can be seen. All these solutions are focused on the development of a *win-win* situation among all participants in the logistics of CTD. Their key determinant is the focus on making complete optimization and coordination of logistics - transport processes and sub-systems - in order to create situations which will result in synergy effects. Therefore, the tasks of logistics in CTD, aside from energy and regulatory aspects, also include material side of the process whose main goal is the delivery of materials and products to certain locations at a certain time with minimal resources and minimal economic expenses, where certain quality of logistic services is expected.

The starting point in the development of sustainable MoL is to identify important factors that initiate its development. A number of different factors that influence the development of logistic solutions can be differentiated into seven main groups: (1) rapid globalization processes, (2) integration of supply chains and their growing presence in CTD, (3) growth in the scope of logistic activities in CTD, (4) technical and technological innovations in all logistic sub-systems, (5) rapid development of IT technologies, techniques and equipment, (6) improvement of methodological procedures and techniques, and (7) environmental requirements for sustainable environmental solutions.

The characteristics of physical dispersion, mass, inhomogeneity, stochastic commodity and material flows have made it necessary to develop modern methods of technological design so as to have an as successful rationalization as possible. The concept of design of material flow in a meta and macro logistics system is focused on: (1) harmonized correspondence of transportation requirements and technological elements, (2) examination of reciprocal impact factors: addition, consolidation, interphase warehousing, inventory management, and physical distribution, (3) implementation of material flow in CTD within stochastic and non-stationary conditions of the logistics processes.

Logistics management and decision-making in CTD falls into the category of strategic issues. For the location problems in logistics of CTD, a set of objects appears that are associated with other interactive set of objects (LC and their satellites interact with generators of logistic requirements). The interconnectivity of these objects constitutes a logistics network of destinations. The problem of determining the optimal location of LC and its satellites in respect to the number and physical distribution of generators of the logistic requirements is one of three key problems in the development of customizable logistic system solutions of CTD. The objective function of the considered problem is usually defined by the selection of a location that will meet the transportation and physical conditions, while the transportation costs will be brought to a minimum trying to meet all logistics needs of generators.

Due to the complexity and scope of the process, the development of MoL cannot be done in a single step. It takes a holistic and multiphase approach. In this paper, in the development of MCTD MoL, we took into consideration the following constraints: number, structure and physical distribution of generators of logistic requirements at MCTD. Then, we proposed clustering, i.e. location/allocation problem along with optimization of supply processes throughout optimal available vehicles routing. Corresponding data sets were collected on the spot during and off-season and the appropriate simulations have been realized throughout a unique simulation model using programming language Rockwell Arena (ver. 7.1). On the basis of computer simulation over the developed MoL and the previously collected data on the spot, multiple positive effects have been observed:

- Reduction in the number of vehicles for newly proposed PS 1, PS 2, and PS 3 logistic solutions in MCTD is noticeable in comparison to the actual situation, that is of particular importance in the season period;
- Also, noticeable are the reductions in the number of vehicles during and off-season at the entrances of examined MCTD clusters in comparison to the present situation;
- The novel proposed logistics solutions PS 1, PS 2, and PS 3 caused the reduction of road and rail transport density in favour of sea transportation. This relieves the road (and partly the rail) transportation network. This is again of particular importance in season periods;
- Channels of distribution congestion are considerably reduced in the cases of PS 1, PS 2, and PS 3 for each generator type (G1-G5) in comparison to the present state of logistic facilities at considered MCTD;
- Delivered vehicles travelled distances per day expressed in [km], especially during summer period, are reduced for PS 1, PS 2, and PS 3 variant solutions;
- Positive economic effects of the proposed logistic solutions PS 1, PS 2, and PS 3 are obvious for each considered MCTD cluster - Herceg Novi, Kotor, Tivat, Budva, Bar, and Ulcinj, etc.

The above listed conclusions obtained as a result of conducted simulations upon the proposed MoL for MCTDs might be treated as promising facts for further experimental and more rigorous and extensive research work related to key issues for providing integral and adaptive MoL at CTDs in general. Additionally, one of the possible future directions of research is analyzing combined commodity distribution between sea and road transportation modes. This might include the development of a network of cross-docking terminals as satellite logistic centres and intensively involved speedboats in the distribution of commodities towards providing an optimal CTD logistics scenario.

mr **ŽELJKO IVANOVIĆ**
E-mail: clt@t-com.me, ivanovic.zeljo@gmail.com
Centar za Logistiku i Transport "Z-Logistics"
Ilino 69, 85000 Bar, Crna Gora
Prof. dr **SANJA BAUK**
E-mail: bsanjaster@gmail.com
Univerzitet Crne Gore
Fakultet za pomorstvo
Dobrota 36, 85 330 Kotor, Crna Gora

REZIME

VIŠEFAZNI PRISTUP RAZVIJANJU MODELA LOGISTIKE ZA PRIMORSKE TURISTIČKE DESTINACIJE

U radu je predložen postupak razvijanja modela logistike (MoL) za primorske turističke destinacije (PTD) kroz nekoliko faza. Osnova za razvoj ovog modela oslanja se na istraživanja odnosa između prostora, logističkih centara i terminala, lokacijskih problema i optimizacije procesa snabdijevanja turističkih objekata. Ovo se može tretirati kao novi MoL-a, ili kao multidimenzionalni konceptualni model za razvoj PTD u cilju postizanja većih ekonomskih, prostornih, tehničko-tehnoloških i ekoloških efekata. Smisao predloženog MoL leži u postizanju optimalne, savremene povezanosti transporta, skladištenja i city logistike u jedinstveni funkcionalni model, u koji, između ostalog treba ugraditi nove strategije u regionalnoj logistici: just in time (JIT), outsourcing, third part logistics (3PL) i fourth part logistics (4PL). Suština razvoja MoL-a jeste u primjeni logističkih načela u povezivanju privrednih, tranzitnih i snabdjevačkih funkcija u PTD.

KLJUČNE RIJEČI

logistika; primorska turistička destinacija; model logistike; simulaciono modeliranje;

REFERENCES

[1] **Krugman P**. *Development, Geography and Economic Theory*. Cambridge Mass and London: The MIT Press; 1995.

[2] **Ivanović Ž**. *One approach to the development of models of logistics of tourist coastal regions*. The 1st Logistics International Conference, LOGIC. Belgrade, Serbia; 2013.

[3] **Likas A**, **Vlassis N**, **Verbeek J**. *The global k-means clustering algorithm*. Pattern Recognition. 2003;36:451-461.

[4] **Duda R.O**. *Feature selection and clustering for HCI [Internet*, cited 2014 February 1]; 1996-2007. Available from: https://www.cs.princeton.edu/courses/archive/fall08/cos436/Duda/C/k_means.htm

[5] **Husein N**. *A fast greedy k-means algorithm* [Master's thesis]. Amsterdam, Netherlands: University of Amsterdam; 2002 [cited 2014 February 1]. Available from: www.science.uva.nl/.../NoahLaith.doc

[6] **Faber V**. *Clustering and the continuous k-means algorithm*. Los Alamos Science. 1994;22:138-144.

[7] **Racunica I**, **Wynter L**. *Optimal location of intermodal freight hubs*. Rapport de recherché n 4088. Unit´e de recherche INRIA Rocquencourt; December 2000 [cited 2014 February 8]. Available from: http://hal.archives-ouvertes.fr/docs/00/07/25/45/PDF/RR-4088.pdf

[8] **Mehrjendi YZ**, **Nadizadeh A**. *Using Greedy Clustering Method to Solve Capacitated Location Routing problem with Fuzzy Demands*. European Journal of Operational Research. 2013;299(1):75-84.

[9] **Najaf P**, **Famili S**. *Application of an Intelligent Fuzzy Regression Algorithm in Road Freight Transportation Modelling*. Promet – Traffic&Transportation. 2013;25(4):311-322.

[10] **Kratica J**, **Milanović M**, **Stanimirović Z**, **Tošić D**. *An evolutionary based approach for solving a capacitated hub location problem*. Applied Soft Computing, ASC. 2011;11(2):1858-1866.

[11] **Crainic TG**, **Mancini S**, **Perboli G**, **Tadei R**. *Multistart heuristics for the two echelon vehicle routing problem*. Lecture Notes in Computer Science. 2011;6622:179-190.

[12] **Crainic TG**, **Ricciardi N**, **Storchi G**. *Advanced freight transportation systems for congested urban areas*. Transportation Research Part C. 2004;12:119-137.

[13] **Jacobsen S**, **Madsen O**. *A comparative study of heuristics for a two level routing location problem*. European Journal of Operational Research. 1980;5:378-387.

[14] **Nagy G**, **Salhi S**. *Location routing: Issues, models and methods*. European Journal of Operational Research. 2007;177:649–672.

[15] **Nakamura Y**, **Taniguchi E**, **Yamada T**, **Ando N**. *Selecting a dynamic and stochastic path method for vehicle routing and scheduling problems*. Procedia - Social and Behavioral Sciences. 2010;2(3):6042-6052.

[16] **Perboli G**, **Tadei R**, **Vigo D**. *The two echelon capacitated vehicle routing problem: models and mathbased heuristics*. Transportation Science. 2011;45:364-380.

[17] **Perboli G**, **Pezzella F**, **Tadei R**. *EVEOPT: a hybrid algorithm for the capability vehicle routing Problem*. Mathematical Methods of Operations Research. 2008;68:361-382.

[18] **Quak H**, **De Koster R**. *The impacts of time access restrictions and vehicle weight restrictions on food retailers and the environment*. European Journal of Transport and Infrastructure Research. 2005;6(2):131-150.

[19] **Quak H**, **De Koster R**. *Delivering goods in urban areas: How to deal with urban policy restrictions and the environment*. Transportation Science. 2009;43(2):211-227.

[20] **Groer C**, **Golden B**, **Wasil E**. *A library of local search heuristics for the vehicle routing problem*. Mathematical Programming Computation. 2010;2(2):79-101.

[21] **Homberger J**, **Gehring H**. *A two phase hybrid metaheuristic for the vehicle routing problem with time windows*. European Journal of Operational Research. 2005;162:220-238.

[22] **Taniguchi E**, **Yamada T**, **Tamagawa D**. *Probabilistic vehicle routing and scheduling on variable travel times with dynamic traffic simulation*. In: **Taniguchi E**, **Thompson RG**, editors. *City Logistics I*. Kyoto: Institute for City Logistics; 1999. p. 8599.

[23] **Qureshi AG**, **Taniguchi E**, **Yamada T**. *Exact solution for the vehicle routing problem with semi soft time windows and its application*. Procedia - Social and Behavioral Sciences. 2010;2(3):5931-5943.

[24] **Gonzalez-Feliu J**. *Models and methods for the city logistics: the two echelon capacitated vehicle routing problem* [dissertation]. Torino, Italy: Politecnico di Torino; 2008.

[25] **Gonzales-Feliu J**. *Freight distribution systems with cross docking*. Journal of the Transportation Researc Forum, JTRF. 2012;51(1):93-109.

[26] **Gonzalez-Feliu J**, **Ambrosini C**, **Routhier JL**. *New trends on urban goods movement: Modelling and simulation of e-commerce distribution*. European Transport. 2012;50:6-23.

[27] **Russo F**, **Comi A**. *A modelling system to simulate goods movements at an urban scale*. Transportation. 2010;37(6):987-1009.

[28] **Ivanović Lj**, **Ivanović Ž**. *City logistics in the Montenegrin coastal region*. The 1st Logistics International Conference, LOGIC. Belgrade, Serbia; 2013.