# A POSSIBLE APPROACH TO TRANSPORTATION SYSTEMS MODELLING IN THE SILISTRA REGION

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## INTRODUCTION

The present investigation is made due to the lack of a general concept for the system of models for the integrated regional development of the Silistra region. Nevertheless, it is not only possible, but is necessary that guidelines for the transportation system modelling be sketched out. Furthermore, the transportation system has many different components and it represents in itself a large-scale system. For this reason the solving of the problem concerning the modelling of the internal transportation links within a unified transportation system will not only help to solve an unsolved (to date) problem, but will also give us the possibility to incorporate the transportation in the system of models for integrated regional development. That is why the pursued goal here at this stage is limited and has as its subject the internal components of the transportation system model. After the general concept has been elaborated, this approach may be supplemented and improved.

The proposed approach is based on two accepted conditions:

- the initial prospective value of the transportation system components and their interrelations within the region are balanced but not optimized. This value is determined by the assigned parameters on the side of the other subsystems and of the central planning body; and
- the optimization of the transportation system has to be realized at the subsequent stages of an optimization cycle and this depends on the accepted approach for transportation system modelling.

## I. MAIN STAGES OF THE TRANSPORTATION SYSTEM OPTIMIZATION CYCLE

Depending on the internal link formation of the basic transportation system components and on the possible interrelations with other subsystems in the region, we can formulate the following main stages of the optimization of the transportation system:

1st stage: *Determination of the initial prospective state of the transportation system.*

The following transportation system components referring to the prospective period may be balanced at the initial stage:

$$X^1 = \sum_i \sum_j \sum_k \sum_l \sum_t X^1_{ijklt} \, , \qquad (1)$$

where:

X = total volume of the transported commodities differentiated by commodities of type k from i to j sections of the road from i to j consumer by transportation of type l for t years of the planning period;

$$C^1 = \sum_i \sum_j \sum_k \sum_l \sum_t C^1_{ijklt} \, , \qquad (2)$$

where:

C = volume of the current transportation costs differentiated by the same conditions;

$$\Phi^1 = \sum_i \sum_j \sum_k \sum_l \sum_t \Phi^1_{ijklt} \, , \qquad (3)$$

where:

Φ = value of the productive funds installed differentiated by the same conditions.

Of great significance for the above quantity of the main components of the transportation system is the necessity to define the productivity of each element referring to the concrete volume of the transportation production X, i.e. to derive the intensity coefficients q expressing the necessity of this element for unit of transportation production X:

$$q = \frac{N}{X} \quad , \tag{4}$$

where:

N = quantity of the productive element whence the quantity of the relative elements for the transportation production needed at the initial stage will be:

$$N^1 = q \cdot X^1 \quad . \tag{5}$$

Since the separate elements must be comparable (viewed as current consumption elements in the transportation process) their value by prices $N^1 \cdot P = S^1$ will express the value of the transportation costs:

$$\sum C^1_{ijklt} = S^1_{ijklt} \cdot \sum X^1_{ijklt} \quad . \tag{6}$$

Respectively on the basis of the productive funds needs, one may derive the capital investement needed:

$$\sum K^1_{ijklt} = b^1_{ijklt} \cdot \sum X^1_{ijklt} \quad . \tag{7}$$

In order to be commensurable the current transportation costs with the capital investments the latter have to be reduced to the first, using the coefficient α, reversed to the life of the productive funds (in the case that the productive funds life is 15 years, $\alpha = \frac{1}{15} = 0,15$). In this sense the annual transportation costs $F^1$ at the intitial stage will appear as follows:

$$F^1 = C^1 + \alpha \cdot K^1 \quad . \tag{8}$$

Using the productive funds life-term instead of the in practice applied effectiveness coefficients which are a priori assigned, we approach this component to the required goal: the effectiveness has to be argued but not a priori assigned. The above accepted statement enables us to implement distributing type of model as a basic model for prospective planning of the different kinds of transportation development in an unified transportation system.

2nd stage: *Optimal distribution of the total transportation production volume among the different kinds of transports.*

The distribution of the total transportation production is made depending on the efficiency of the different kinds of transports at their initial state using the following model:

$$\sum_{i}\sum_{j}\sum_{k}\sum_{l}\sum_{t} F^2_{ijklt} \cdot X^2_{ijklt} \rightarrow \min \quad , \qquad (9)$$

where:

$F^2$ = transformed annual costs at the second stage.

By means of the model one looks for such distribution of transportation production k among l transportation modes in t years of the planning period in order to obtain the minimum value of the annual transformed costs. The model is subject to:

$$\sum_{i}\sum_{k}\sum_{l}\sum_{t} X_{ijklt} = a_{ik} \quad , \quad \begin{matrix} i = 1,\dots,m; & k = 1,\dots,n; \\ l = 5; & t = 1,\dots,n; \end{matrix} \qquad (10)$$

i.e. the total transportation production volume should be equal to the total production of the producers;

$$\sum_{j}\sum_{k}\sum_{l}\sum_{t} X_{ijklt} = r_{jk} \quad , \quad \begin{matrix} j = 1,\dots,m; & k = 1,\dots,n; \\ l = 5; & t = 1,\dots,n; \end{matrix} \qquad (11)$$

i.e. the total transportation production volume should be equal to the total production consumer needs;

$$\sum X_{ijklt} \geq 0 \quad , \tag{12}$$

- non-negative conditions.

It is necessary to stress that obtaining the new structure of the different kinds of transport means that the new transportation production volume is detached from the financial resources because of the new needed elements (N). This necessitates a new value of the annual transformed costs to be derived using the same coefficients:

$$\sum C^2_{ijklt} = S^1_{ijklt} \cdot \sum X^2_{ijklt} \quad . \tag{13}$$

$$\sum K^2_{ijklt} = b^1_{ijklt} \cdot \sum X^2_{ijklt} \quad , \tag{14}$$

$$\sum F^2_{ijklt} = \sum C^2_{ijklt} + \alpha \cdot \sum K^2_{ijklt} \quad , \tag{15}$$

The total gain is the difference between the cost for the initial and optimal plan:

$$\sum G^2_{ijklt} = (\sum C^1_{ijklt} + \alpha \sum K^1_{ijklt}) - (\sum C^2_{ijklt} + \alpha \sum K^2_{ijklt}) \quad . \tag{16}$$

3rd stage: *Optimization of the separate kinds of transports.*

The functioning of the separate transports has such features that different activities and subdivision work in it in a complex way. The link of these activities and subdivisions with the final transportation production is an indirect one. This necessitates separate tasks for each mode of transport to be solved. These tasks express different aspects of the given transport functioning and they have to be interlinked.

The classification of tasks may be as follows:

1. The first type of task is connected with different transport technology choice (for instance, diesel or electric traction in the railway transport, different types of engine in the motor transport, etc.). The result of this task solving is a new quantity of material, labor resources and productive capacities and respectively new transportation costs. In this respect the tasks can be linked with tasks of other classes.
   In outline the first type tasks may be expressed as follows:

$$\hat{T} = \min \sum F^{31}_{ijklt} \quad , \tag{17}$$

where:

where: 31 is the number of the third stage of the optimization cycle and first type task.

2. The second type of tasks is connected with the optimal size capacities of the separate transports and their relative speeds (for instance, gross weight of the train, ship loading capacity, etc.). The outline of these tasks is:

$$\hat{Q} = \min \sum F^{32}_{ijklt} \quad . \tag{18}$$

3. The third type of tasks refers to the optimal spatial distribution of the transport capacities and resources among the different sections. The determining factors for this distribution are the different transport conditions which cause different expenditures:

$$\hat{D} = \min \sum F^{33}_{ijklt} \quad . \tag{19}$$

4. The fourth type of tasks have a markedly dynamic character and determine the development strategy over time and more concretely define the rational time to embed the possible actions. If $t_i$ is the year of the action implementation $\Delta A$ = capital investments since the beginning of the period

under analysis, T = final term, E = annual current costs gain, $P_n^t$ = rate of the action productivity, the maximum total gain of cost will be:

$$G = \left(\Delta A - \Delta A \frac{1}{P_n^{t_i}}\right) + \sum_{t1}^{T} \Delta E \frac{1}{P_n^t} - \sum_{0}^{t_i} \Delta E \frac{1}{P_n^t} \rightarrow \max \quad , \qquad (20)$$

and the most rational time for embedding the action will be:

$$t_i = \frac{\Delta A_0 \cdot \lg Pn - (\Delta E_0 + \Delta A)}{\Delta E - \Delta A \lg Pn} \quad , \qquad (21)$$

or in outline, the fourth type of tasks are:

$$\hat{t} = \min \sum F_{ijklt}^{34} \quad . \qquad (22)$$

The task arrangement within each transport permits their iterative linking. Therefore, in a direct line (depending on the task rank) for each subsequent task, the need for transport elements is calculated on the basis of thier optimization in the previous task. In a reverse line an iterative link exists between the last and the first ranking task. The right and reverse links between the different type of tasks will appear as follows:

$$\hat{T} = \min \sum F_{ijklt}^{31}; \quad \hat{Q} = \min \sum F_{ijklt}^{32}; \quad \hat{D} = \min \sum F_{ijklt}^{33}; \quad \hat{t} = \min \sum F_{ijklt}^{34} \qquad (23)$$

4th stage: *Reflection of the total gain of transformed costs on the initial optimal distribution of the total transportation production volume among different kinds of transports.*

The result of the separate transports optimization will be the total gain of transformed costs. The total gain is the difference between costs of the initial and optimal plans:

$$\sum G^{4}_{ijklt} = (\sum C^{1}_{ijklt} + \alpha \sum K^{1}_{ijklt}) - (\sum C^{3}_{ijklt} + \alpha \sum K^{3}_{ijklt}) \quad . \tag{24}$$

The total gain will influence in reverse line on the optimal distrubtion of the total transportation production volume in the following directions:

- by means of changing the coefficients q and b and hence the annual transformed costs changing;
- by means of changing of the total transportation production volume $\sum X_{ijklt}$ which is possible to be linked with the other subsystem models in the region;
- by means of changing the external material, labor and productive resource funds reflecting on the interdependencies with the other subsytem models.

The closed optimization cycle may be repeated until the final solution is obtained. The full optimization cycle may be described in Figure 1.

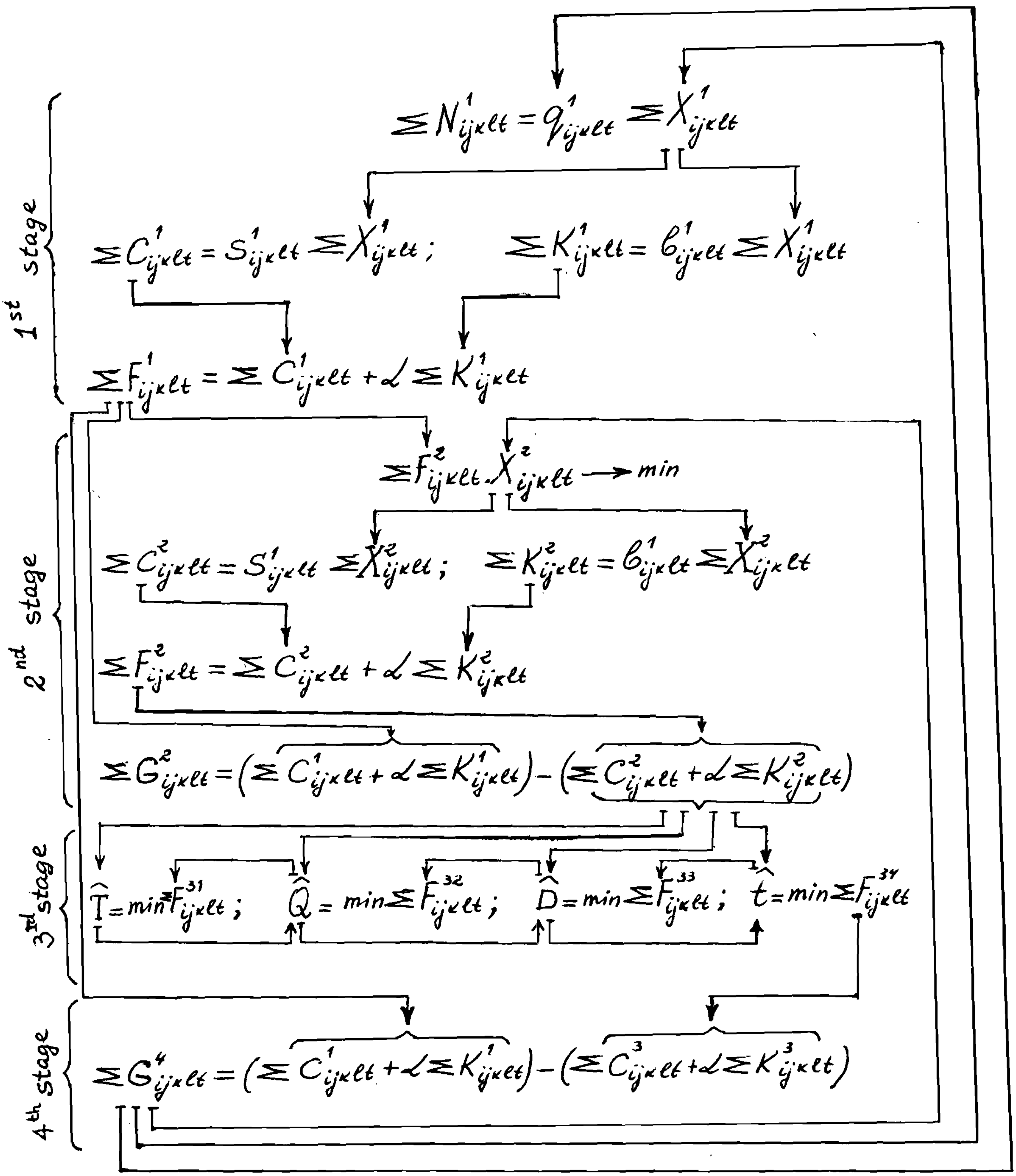
1st stage
$\sum N^1_{ijklt} = q^1_{ijklt} \sum X^1_{ijklt}$
$\sum C^1_{ijklt} = S^1_{ijklt} \sum X^1_{ijklt}$;
$\sum K^1_{ijklt} = b^1_{ijklt} \sum X^1_{ijklt}$
$\sum F^1_{ijklt} = \sum C^1_{ijklt} + \alpha \sum K^1_{ijklt}$
2nd stage
$\sum F^2_{ijklt} \cdot X^2_{ijklt} \longrightarrow min$
$\sum C^2_{ijklt} = S^1_{ijklt} \sum X^2_{ijklt}$;
$\sum K^2_{ijklt} = b^1_{ijklt} \sum X^2_{ijklt}$
$\sum F^2_{ijklt} = \sum C^2_{ijklt} + \alpha \sum K^2_{ijklt}$
$\sum G^2_{ijklt} = (\sum C^1_{ijklt} + \alpha \sum K^1_{ijklt}) - (\sum C^2_{ijklt} + \alpha \sum K^2_{ijklt})$
3rd stage
$\hat{T} = min \sum F^{31}_{ijklt}$;
$\hat{Q} = min \sum F^{32}_{ijklt}$;
$\hat{D} = min \sum F^{33}_{ijklt}$;
$\hat{t} = min \sum F^{34}_{ijklt}$
4th stage
$\sum G^4_{ijklt} = (\sum C^1_{ijklt} + \alpha \sum K^1_{ijklt}) - (\sum C^3_{ijklt} + \alpha \sum K^3_{ijklt})$

Figure 1

## II. GENERAL CONCLUSIONS

The following general conclusions could be made on the basis of the proposed approach.

1. The differentiation of the transport system optimization cycle and the usage of costs coefficients of the transport components have a great importance both for the transportation system optimization and its linking with the other subsystem models within the region.
2. The convergence between the separate tasks within an unified system is realized by means of similar criteria, the task arrangement and right and reverse relations used.
3. This appraoch enables traditional techniques for transportation indicies calculation to be used as auxiliary ones and some of the tasks solved in practice as well, but submitted to the proposed optimization cycle.
4. The described optimization cycle shows that the transportation system is a large-scale system and may be optimized on at least two levels: on the uniform transportation system level and on separate kinds of transport level. The general concept for the system of models for integrated regional development has to be conform with this circumstance.
5. The transportation system modelled with regional aspects is a centralized system as well as with national aspects. But this does not mean the regional management body can directly controle the transportation system. This body may offer their concepts to the central planning body without the certainty that they will be accepted.