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# ANALYSIS OF POSTAL TRAFFIC AS THE BASIS FOR REDESIGNING POSTAL NETWORK

*ABSTRACT*

*Analysis of the traffic flows of postal items is an important prerequisite in improving the technology and/or redesigning postal network.*

*The basic modelling sequence is to optimise the traffic (postal) network structure for the identified traffic demand and the determined traffic flow matrix, respecting relevant requirements and limitations.*

*The paper provides elements of a general approach to solving the problem and develops a concrete traffic matrix with the data on postal-item flows. Elements are indicated for redesigning of postal network, which include the positioning of nodes equipped by systems of automatic handling of postal items.*

*KEYWORDS*

*postal items, postal-item flows, redesigning postal network, postal items sorting centre, transport capacities*

## 1. INTRODUCTION

Like in any other traffic system, in postal traffic as well, the traffic network follows the traffic logistics. The basic rule of traffic logistics conditions the traffic network whose structure and capacity are set by the size and the dynamics of the traffic, but bearing in mind its oscillations. The main course of modelling the traffic network for identified traffic demand, that is for matrix of traffic flow, is to optimise the structure of the traffic network respecting all the relevant requirements and limitations.

According to the referent literature [1] [2] [3] [4] the types of problems for optimisation of postal network have been set, which include the topology of the network, the schemes and the capacity of the nodes and branches, flow on the branches and the limitations regarding the obligatory deadlines and transport safety and processing of postal-items.

In the concrete research, the data have been gathered about traffic flow of letter items recorded over the period from 24th February till 2nd March 1998 with the method of statistic observation. These particular data were used to define the traffic matrix as a necessary but not sufficient input for designing the postal traffic network.

The problem of redesigning includes determining the number and capacity of postal sorting centres and also the rules for concentration of postal-items according to the criteria that will satisfy the standards of quality of services at minimum cost.

Starting from a general model and by introducing some real factors, we can reach some operatively feasible solutions. In this sense, the main contribution of this article is expected.

## 2. REVIEW OF THE EXISTING POSTAL NETWORK STRUCTURE IN CROATIA, AND TRANSPORT RELATIONS

Croatian post office (further in the text HP) is organised in 20 postal centres (further in the text PC) which are identical with the district areas in Republic of Croatia.

Each postal centre is given a postal code. The first two numbers are used for marking the postal centres as follows:

| | |
|---|---|
| 10 PC Zagreb | 40 PC Čakovec |
| 20 PC Dubrovnik | 42 PC Varaždin |
| 21 PC Split | 43 PC Bjelovar |
| 22 PC Šibenik | 44 PC Sisak |
| 23 PC Zadar | 47 PC Karlovac |
| 31 PC Osijek | 48 PC Koprivnica |
| 32 PC Vukovar | 49 PC Krapina |
| 33 PC Virovitica | 51 PC Rijeka |
| 34 PC Požega | 52 PC Pazin |
| 35 PC Slavonski Brod | 53 PC Gospić |

The structure of the Croatian postal traffic can be represented as a traffic network to which postal cen-

tres (with the accompanying number of postal offices) are connected by two-way links. The technological structure of the postal system is interconnected by the phases of acceptance, delivery, transport, processing, arrival and handing in of the postal items.

All the postal offices accept postal items, and the delivery is done only by some of them. Fifteen postal centres perform concentration and diffusion of postal items, and thirteen postal centres are involved in sorting of the postal items. Some postal centres perform the sorting and transport of postal items also for the neighbouring postal centres.

The transport of postal items in inland traffic is organised at two transport levels. The first level includes regular lines inside the area of a certain PC, and the second level includes PCs for sorting and preparation, and that one is organised in a radial structure. The third transport level through PC Zagreb establishes the links in the international postal traffic.

The traffic structure of the second transport level is presented in Figure 1. Our national postal network and transport capacities are presented in Table 1. The existing number of postal lines, their length and passed distance per line (given in kilometres per year) are presented in Table 2.

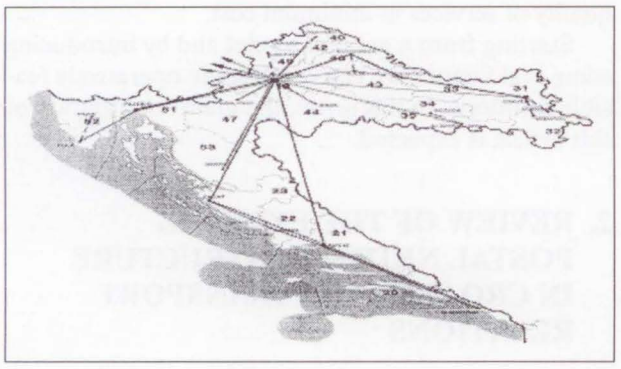


Figure 1

## 3. POSTAL TRAFFIC MATRIX

Postal traffic matrix follows as a presentation of input-output data recorded over the period from 24th February to 2nd March 1998 which were processed as the basis of redesigning the postal network. The given data are those of average daily flow of standard letters and postcards and large letter items. The postal traffic matrix also presents the international PC 10003 Zagreb (further in the text IPC).

From the traffic matrix it is clear that:

- most of the letter traffic is realised in PC Zagreb,
- all PCs realise the largest letter traffic in local traffic (in their area), and
- a considerable flow of letter items is realised on the relation between PC Zagreb and other PCs.

**Table 1 - Postal network and transport capacity of HP in 1998**

| No | Postal network | ∑ | 43 | 40 | 20 | 53 | 47 | 48 | 49 | 31 | 52 | 34 | 51 | 44 | 35 | 21 | 22 | 42 | 33 | 32 | 23 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Post office | 1144 | 38 | 24 | 73 | 39 | 45 | 34 | 38 | 78 | 78 | 19 | 107 | 39 | 39 | 143 | 39 | 32 | 21 | 56 | 56 | 146 |
| 1.1. | Sorting PC | 13 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| 1.2. | Preparation PC | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.3. | Concentration PC | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1.4. | IPC | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2. | Means of transport | | | | | | | | | | | | | | | | | | | | | |
| 2.1. | Post-wagon | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 2.2. | Truck | 21 | 4 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 2 | 2 | 1 | 0 | 0 | 2 | 4 |
| 2.3. | Luggage-car | 258 | 3 | 0 | 4 | 14 | 11 | 0 | 2 | 18 | 0 | 1 | 40 | 9 | 13 | 25 | 13 | 2 | 1 | 1 | 10 | 91 |
| 2.4. | Van | 85 | 6 | 3 | 14 | 0 | 0 | 5 | 0 | 2 | 9 | 3 | 2 | 0 | 2 | 6 | 0 | 11 | 0 | 13 | 2 | 7 |
| 3. | Postal line | 536 | 39 | 0 | 31 | 24 | 50 | 0 | 0 | 40 | 42 | 0 | 58 | 16 | 27 | 45 | 19 | 54 | 0 | 0 | 26 | 67 |
| 3.1. | Rail transport | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 8 |
| 3.2. | Road transport | 486 | 39 | 0 | 25 | 24 | 50 | 0 | 0 | 39 | 41 | 0 | 54 | 16 | 25 | 35 | 15 | 54 | 0 | 0 | 14 | 55 |
| 3.3. | Sea transport | 33 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 8 | 4 | 0 | 0 | 0 | 12 | 0 |
| 3.4. | Air transport | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |

**Table 2 - Postal lines of HP in 1998**

| No. | PC | No. of postal lines | | | | Length ot postal lines (km) | | | | Passed distance (km/year) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R | H | S | A | R | H | S | A | R* | H** | S*** | A**** |
| 1 | 43 | | 39 | | | | 2 363 | | | | 715 989 | | |
| 2 | 40 | | | | | | | | | | | | |
| 3 | 20 | | 25 | 6 | | | 1 924 | 202 | | | 646 372 | 61 206 | |
| 4 | 53 | | 24 | | | | 1 711 | | | | 521 184 | | |
| 5 | 47 | | 50 | | | | 1 293 | | | | 391 779 | | |
| 6 | 48 | | | | | | | | | | | | |
| 7 | 49 | | | | | | | | | | | | |
| 8 | 31 | 1 | 39 | | | 275 | 3 224 | | | 16 500 | 997 176 | | |
| 9 | 52 | 1 | 41 | | | 25 | 1 521 | | | 7 575 | 316 998 | | |
| 10 | 34 | | | | | | | | | | | | |
| 11 | 51 | 1 | 54 | 3 | | 60 | 4 753 | 70 | | 15 000 | 1 414 090 | 21 350 | |
| 12 | 44 | | 16 | | | | 1 353 | | | | 400 916 | | |
| 13 | 35 | 2 | 25 | | | 20 | 1 869 | | | 3 530 | 597 612 | | |
| 14 | 21 | 2 | 35 | 8 | | 84 | 2 595 | 228 | | 25 620 | 791 475 | 69 540 | |
| 15 | 22 | | 15 | 4 | | | 867 | 62 | | | 276 000 | 18 600 | |
| 16 | 42 | | 54 | | | | 2 315 | | | | 695 500 | | |
| 17 | 33 | | | | | | | | | | | | |
| 18 | 32 | | | | | | | | | | | | |
| 19 | 23 | | 14 | 12 | | | 1 598 | 554 | 1 150 | 609 436 | 479 400 | 163 200 | |
| 20 | 10 | 8 | 55 | | 2 | 2 018 | 6 221 | | 1 150 | 661 161 | 1 878 742 | | 374 300 |
| | Total | 15 | 486 | 33 | 2 | 2 482 | 33 607 | 1 106 | 1 150 | 661 161 | 7 566 722 | 272 690 | 347 300 |
| | Total HP | | | | 536 | | | | 38 345 | | | | 8 847 873 |

**Table 3 - Postal traffic matrix for letter mail-items**

| PC/PC | 10 | 20 | 21 | 22 | 23 | 31 | 35 | 42 | 43 | 44 | 47 | 51 | 52 | 53 | MPC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 (49) | 308500 | 5000 | 15800 | 4000 | 5700 | 17500 | 10500 | 10600 | 12700 | 7800 | 7600 | 14900 | 10200 | 1900 | 14000 |
| 20 | 1400 | 7800 | 600 | 40 | 50 | 50 | 100 | 40 | 30 | 10 | 30 | 150 | 50 | 10 | 700 |
| 21 | 4800 | 1500 | 19300 | 900 | 900 | 500 | 500 | 300 | 200 | 100 | 100 | 900 | 300 | 50 | 1900 |
| 22 | 1000 | 100 | 600 | 3900 | 200 | 100 | 100 | 100 | 100 | 50 | 50 | 200 | 100 | 30 | 400 |
| 23 | 2000 | 100 | 500 | 400 | 6600 | 100 | 200 | 100 | 100 | 100 | 100 | 500 | 100 | 200 | 600 |
| 31 (32) | 5600 | 100 | 500 | 100 | 100 | 17800 | 1800 | 400 | 1100 | 200 | 200 | 600 | 300 | 100 | 1600 |
| 35 (34) | 4600 | 200 | 500 | 150 | 200 | 2200 | 5500 | 500 | 900 | 400 | 400 | 900 | 500 | 100 | 800 |
| 42 (40) | 5100 | 200 | 700 | 200 | 400 | 500 | 400 | 16400 | 1600 | 300 | 200 | 600 | 400 | 100 | 1200 |
| 43 (33, 48) | 5500 | 200 | 400 | 100 | 200 | 1400 | 800 | 1000 | 9500 | 400 | 200 | 600 | 300 | 100 | 800 |
| 44 | 2600 | 20 | 100 | 50 | 100 | 200 | 300 | 200 | 400 | 4200 | 200 | 200 | 100 | 50 | 400 |
| 47 | 2300 | 200 | 300 | 100 | 100 | 300 | 300 | 300 | 200 | 200 | 3600 | 500 | 200 | 200 | 300 |
| 51 | 7300 | 400 | 1300 | 400 | 800 | 1100 | 1100 | 700 | 1000 | 500 | 500 | 31700 | 2400 | 600 | 4000 |
| 52 | 1800 | 50 | 300 | 40 | 100 | 200 | 200 | 100 | 100 | 100 | 200 | 3400 | 6600 | 30 | 2100 |
| 53 | 2100 | 50 | 100 | 60 | 400 | 100 | 100 | 100 | 100 | 50 | 200 | 800 | 100 | 700 | 200 |
| MPC | 24300 | 1400 | 4700 | 700 | 1400 | 3300 | 1500 | 2400 | 1700 | 1000 | 1000 | 8200 | 1200 | 300 | |

**Table 4 - Flow of letter mail-items between PC Zagreb and other PCs (average daily traffic)**

| No | Postal centres | Dispatched into PC Zagreb | Dispatched out of PC Zagreb |
|---|---|---|---|
| 1 | 10 Zagreb (i 49) | 308500 | 308500 |
| 2 | 20 Dubrovnik | 1400 | 5000 |
| 3 | 21 Split | 4800 | 15800 |
| 4 | 22 Šibenik | 1000 | 4000 |
| 5 | 23 Zadar | 2000 | 5700 |
| 6 | 31 Osijek (i 32) | 5600 | 17500 |
| 7 | 35 Slavonski Brod (i 34) | 4600 | 10500 |
| 8 | 42 Varaždin (i 40) | 5100 | 10600 |
| 9 | 43 Bjelovar (i 33 i 48) | 5500 | 12700 |
| 10 | 44 Sisak | 2600 | 7800 |
| 11 | 47 Karlovac | 2300 | 7600 |
| 12 | 51 Rijeka | 7300 | 14900 |
| 13 | 52 Pula | 1800 | 10200 |
| 14 | 53 Gospić | 2100 | 1900 |
| 15 | 10003 Zagreb (MPS) | 24300 | 14000 |
| | Total | 378900 | 446700 |

**Table 5 - Average daily flow of letter mail-items in PC Zagreb**

| No | PC Zagreb | PC Zagreb | Other PC | 10003 IPC | Total |
|---|---|---|---|---|---|
| 1 | Dispatched into PC Zagreb | 308 500 | 46 100 | 24 300 | 378 900 |
| 2 | Dispatched out of PC Zagreb | 308 500 | 124 200 | 14 000 | 446 700 |
| | Total | 617 000 | 170 300 | 38 300 | 825 600 |

An average daily quantity of postal traffic that is realised in PC Zagreb is presented in Tables 3, 4 and 5.

## 4. TRANSPORT OF POSTAL-ITEMS

The problem of rationalisation of postal-items transport has already earlier been the topic of technological research. Optimisation of transport capacities is closely connected with the lack of symmetry in transport load on all relations.

Effective data about the flow of postal-items between PC Zagreb and PC Rijeka and vice versa collected over the period from 16th September till 15th October 1997 were recorded by a method of statistical monitoring. These data were used as the basis for choosing the most rational mode of transport. The capacities of the vehicles are dimensioned according to a greater traffic demand which in postal system is expressed by the quantity of postal items. The lack of symmetry in transport load on the observed relation is presented in Table 6. The determined traffic demand requires 2 trucks of 10 tons capacity (20 $m^3$) and 1 truck of 7 tons capacity (15 $m^3$); that is 1 post-wagon.

The choice of a more adequate variant of traffic was preceded by the analysis of the costs related to truck and post-wagon transport. Because of lower costs of annual maintenance and adequate transport capacity, post-wagon was chosen for the Zagreb-Rijeka-Zagreb relation and it is still used today.

## 5. ELEMENTS FOR REDESIGNING OF POSTAL NETWORK

The basic elements for redesigning the postal network are the centres for postal item sorting and transport means, as well as their capacities. Redesigning and rationalisation of costs need to be approached at all levels of the technological process, from acceptance to delivery of postal items.

Based on the existing postal network and performed recording, the data have been obtained, which can be subject to a discussion, but they are not completed and therefore cannot be used for considering the whole system. Optimisation of number and capacity of postal sorting centres, as well as the transport ca-

**Table 6 - Flow of dispatched mail-items and mail-conclusions from PC Zagreb to PC Rijeka and from PC Rijeka to PC Zagreb**

| % Daily | Mailbag | | | | | Parcels | Weight (kg) | | | Height of stacking ($m^3$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | PV | Rz | P | Σ | | Bag | Parcels | Σ | Parcels | Letter bags | Parcel bags | Σ |
| Zagreb - Rijeka | 25.82 | 106.09 | 148.82 | 10.63 | 291.36 | 1014.09 | 4370.45 | 8112.72 | 12483.17 | 22.20 | 12.64 | 1.10 | 35.94 |
| Rijeka - Zagreb | 38.00 | 73.77 | 150.90 | 14.22 | 276.89 | 429.45 | 4153.63 | 3435.63 | 7589.26 | 14.59 | 3.04 | 9.47 | 27.10 |

Mailbags with: V – Remittance letters
PV – Remittance parcels
Rz – Registered and ordinary letters
P – Ordinary parcels

- Average weight of mailbags = 14.7 kg;
- Average weight of parcels = 7.9 kg;
- Average pile up on 1 $m^2$ = 27 letterbags. 7 parcelbags and 68 parcels;
- Height of stacking ($m^3$) calculated for truck: quantity of mail-pieces / m2 x 1.5m height of means of transport

pacity, are connected with the setting of rules for postal items grouping.

The necessary precondition for redesigning is the establishing of the costs for all kinds and categories of postal items.

The existing manual sorting system is slow and expensive. The sorting jobs (and the sorting workers) get multiplied on the relation "post-office of receipt – PC of origin – destination PC – post-office of destination" and the employees' salaries play a significant role in the whole structure of costs. The automation of postal item sorting would mean a decrease in the cost of labour, an increase in the security of postal items and faster working process itself.

The transport costs have a significant share in the overall structure of costs. A detailed analysis of flows of all kinds of postal items should be performed prior to rationalisation of transport at all levels. Transport structure should be (re)designed so as to adjust it to a variable transport demand. The only way to achieve this is by having one's own transport.

Postal transport matrix can serve as the basis for optimisation of number (and capacity) of the PCs as well as rationalisation of transport capacity. Considering the data from the presented transport matrix, and respecting the throughput possibilities of the system for postal items sorting automation, and taking into account the regional affiliation of individual PCs, it is possible to determine the necessary number of sorting centres. Regional approach to solving the problem (PC Zagreb, Osijek, Split and Rijeka) the work regarding concentration / diffusion of postal items would be done at selected nodes, influencing in turn the change of the number and line directions of postal item transport.

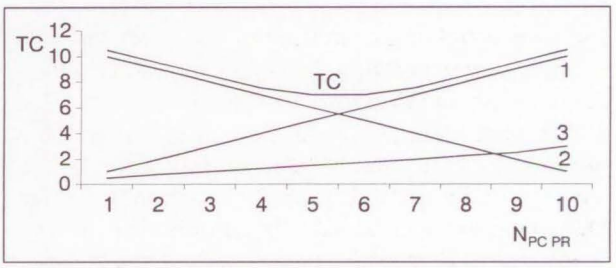
Transport logic demands a detailed analysis of the basic elements for redesigning of postal network and should give the answer to the question about how many PCs should the flow of postal-items be directed to, so as to minimise the cost of processing and transport of postal-items. The concept of optimisation of the number of PCs for processing postal items should follow the basic requirement for minimising transport costs.

$$TC_{\Sigma} = TC_{PR} + TC_{TR} + TC_{OST} \rightarrow \min$$
$$TC_{PR}, TC_{TR} = f\,(N_{PC\,PR})$$

where:

$TC_{\Sigma}$ – total costs,
$TC_{PR}$ – costs of processing postal items,
$TC_{TR}$ – costs of transport,
$TC_{OST}$ – other costs (administration, organisation, overhead expenses etc.),
$N_{PC\,PR}$ – number of processing centres.

It is to be expected that the curve of total cost will follow the pattern shown in Figure 2. The costs of processing of postal-items depending on the number of centres for processing postal-items.




Picture 2 - The costs of processing mail-items depending on the number of centres for processing

where:

- curve (1) describes the total costs of processing depending on the number of sorting centres
- curve (2) describes the total costs of transport depending on the number of sorting centres

- curve (3) describes overall other costs depending on the number of sorting centres
- curve (TC) describes total costs depending on the number of sorting centres and shows the optimal number of necessary sorting centres.

The main thesis of the concept for choosing the number and the location of the sorting centres is applicable to the traffic analysis and synthesis of optimisation of the number of nodes, their capacity and corresponding flows of postal items in postal network. For this purpose the data concerning the flow of all kinds and categories of postal items need to be gathered and a complete postal traffic matrix developed. This matrix, encumbered by the considered costs, will be used in the indicated concept for optimisation of number and capacity of sorting PCs and rationalisation of transport capacities.

The problem of rationalising postal transport requires special project analysis of concrete technological and organisational solutions regarding transport mode of postal items. This includes also the directions of items, and the choice of the best mode of transport means of the necessary capacities.

## 6. CONCLUSION

The complete proposal for redesigning of postal traffic network is an intensive traffic task in which the available statistic and economic data will be processed by feasible scientific methods.

Accomplishing of such an extensive but necessary task assumes information technology support at all levels. The main problem is the fact that technological process at HP has not been completely computerised and most of the data are still outside computers.

This paper indicates a possible approach of solving the presented problem of improving the technology and redesigning of the postal network based on the scientific basis of modern postal traffic technology and transport logistics. A detailed and concrete proposal of the new postal network structure with the introduced automated sorting of postal items should be the subject of operative project development.


### *SAŽETAK*

### *ANALIZA PROMETNIH TOKOVA POŠTANSKIH POŠILJAKA KAO PODLOGA REDIZAJNIRANJU POŠTANSKE MREŽE*

*Analiza prometnih tokova poštanskih pošiljaka važan je preduvjet za poboljšanje tehnologije i/ili redizajniranje poštanske mreže.*

*Osnovni slijed modeliranja je da se za identificiranu prometnu potražnju i utvrđenu matricu prometnih tokova optimizira struktura prometne (poštanske) mreže poštujući relevantne zahtjeve i ograničenja.*

*U članku su dati elementi općeg pristupa rješavanju naznačenog problema i razrađena je konkretna prometna matrica s podacima o tokovima poštanskih pošiljaka. Naznačeni su elementi za redizajniranje poštanske mreže koji uključuju pozicioniranje čvorova opremljenih sustavima automatske razrade poštanskih pošiljaka.*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