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Identification of maritime ferry operation process including operating environment threats

Keywords

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Abstract

In the paper, the traditional semi-Markov approach to a complex technical system operation process modeling is proposed to modelling a critical infrastructure operation process including operating environment threats. Next the model is applied to real critical infrastructures such as the maritime ferry technical system.

1. Introduction

The operation process of a critical infrastructure is very complex and often it is difficult to analyze these critical infrastructure safety with respect to changing in time its operation process states and operating environment conditions that are essential in this analysis. The complexity of the critical infrastructure operation process and its influence on changing in time the critical infrastructure structure and its components' safety parameters are essential in critical infrastructure safety analysis and protection. Usually, the critical infrastructure environment have either an explicit or an implicit strong influence on the critical infrastructure operation process. As a rule, some of the environmental events together with the infrastructure operation conditions define a set of different operation states of the critical infrastructure in which the critical infrastructure change its safety structure and its components safety parameters. In this report, we propose a convenient tool for analyzing this problem applying the semi-Markov model [14]-[16], [18], [23]-[24] of the critical infrastructure operation process, both without including critical infrastructure environment threats and with including them into this model.

2. Identification of maritime ferry operation process

2.1. Maritime ferry description

The considered maritime ferry is a passenger Ro-Ro ship operating at the Baltic Sea between Gdynia and Karlskrona ports on regular everyday line. We assume that the ferry is composed of a number of main subsystems having an essential influence on its safety. These subsystems are illustrated in *Figure 1*.

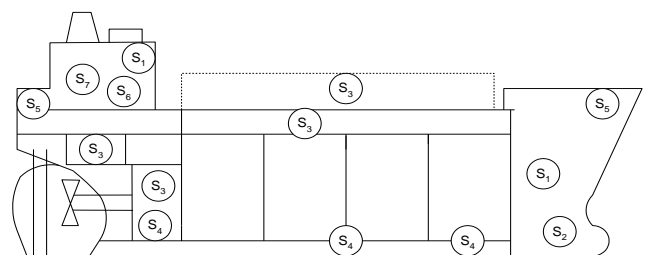


Figure 1. Subsystems having an essential influence on the ferry safety

On the scheme of the ferry presented in *Figure 1*, there are distinguished its following subsystems:

- S_1 - a navigational subsystem,
- S_2 - a propulsion and controlling subsystem,
- S_3 - a loading and unloading subsystem,
- S_4 - a stability control subsystem,
- S_5 - an anchoring and mooring subsystem,
- S_6 - a protection and rescue subsystem,
- S_7 - a social subsystem.

In the safety analysis of the ferry, we omit the protection and rescue subsystem S_6 and the social subsystem S_7 and we consider its strictly technical subsystems S_1, S_2, S_3, S_4 and S_5 only, further called the ferry technical system.

2.2. Statistical identification of maritime ferry operation process including operating environment threats identified by expert opinion – statistical and expert data

On the basis of the expert opinions concerning the operation process of the considered maritime ferry technical system, in [3] the number of the system operation process states $\nu=18$ is fixed and the operation states $z_b, b=1,2,\dots,18$, are defined. Moreover, it is fixed that there are possible only the transitions between the neighbouring system operation states, i.e., from the operation states z_b to the operation states $z_{b+1}, b=1,2,\dots,17$, and from the operation state z_{18} to the operation state z_1 .

2.3. Defining parameters of maritime ferry operation process including operating environment threats identified by expert opinion – statistical and expert data

The unknown parameters of the system operation process semi-Markov model are:

- the initial probabilities $p_b(0), b=1,2,\dots,18$, of the ferry technical system operation process staying at the particular states z_b at the moment $t=0$,
- the probabilities $p_{bb+1}, b=1,2,\dots,17$, and p_{181} of the ferry technical system operation process transitions from the operation state z_b into the operation state z_{b+1} and from the operation state z_{18} into the operation state z_1 ,
- the distributions of the ferry technical system operation process conditional sojourn times $\theta_{bb+1}, b=1,2,\dots,17$, and θ_{181} at the particular operation states and their mean values $M_{bb+1} = E[\theta_{bb+1}], b=1,2,\dots,17$, and $M_{181} = E[\theta_{181}]$.

2.4. Evaluating parameters of maritime ferry operation process including operating environment threats identified by expert opinion – statistical and expert data

On the basis of the statistical data from Section 3.2.1, [3] using the formulae (2.1)-(2.3) in [3] and respectively (2.4)-(2.6) given in Section 2.2 in [3], it is possible to evaluate the following basic parameters

of the ferry technical system operation process including operating environment threats without their separation:

- the vector

$$[p(0)]_{1 \times 18} = [1, 0, 0, \dots, 0], \quad (1)$$

of the initial probabilities $p_b(0), b=1,2,\dots,18$, of the maritime ferry operation process staying at the particular operation states z_b at the moment $t=0$,

- the matrix

$$[p_{bl}]_{18 \times 18} = \begin{bmatrix} 0 & 1 & 0 & \dots & 0 & 0 \\ 0 & 0 & 1 & \dots & 0 & 0 \\ \dots & & & & & \\ 0 & 0 & 0 & \dots & 0 & 1 \\ 1 & 0 & 0 & \dots & 0 & 0 \end{bmatrix}, \quad (2)$$

of the probabilities $p_{bl}, b,l=1,2,\dots,18$, of the maritime ferry operation process transitions from the operation state z_b into the operation state z_l , having the values

$$p_{bb+1} = 1, b=1,2,\dots,17, p_{181} = 1$$

and $p_{bl} = 0$ in the remaining cases;

- the matrix

$$[M_{bl}]_{18 \times 18} = \begin{bmatrix} 0 & 54.67 & 0 & \dots & 0 & 0 \\ 0 & 0 & 2.60 & \dots & 0 & 0 \\ \dots & & & & & \\ 0 & 0 & 0 & \dots & 0 & 7.92 \\ 18.74 & 0 & 0 & \dots & 0 & 0 \end{bmatrix}, \quad (3)$$

of the mean values $M_{bl}, b,l=1,2,\dots,18$, of the conditional sojourn times $\theta_{bl}, b,l=1,2,\dots,18$, the maritime ferry operation process at the the operation state z_b when the next operation state is z_l , having the values

$$\begin{aligned} M_{12} &= 54.67, M_{23} = 2.60, M_{34} = 37.33, \\ M_{45} &= 52.27, M_{56} = 526.43, M_{67} = 37.16, \\ M_{78} &= 7.02, M_{89} = 23.26, M_{910} = 53.69, \\ M_{1011} &= 2.86, M_{1112} = 4.38, M_{1213} = 24.12, \\ M_{1314} &= 508.60, M_{1415} = 50.14, M_{1516} = 34.43, \\ M_{1617} &= 4.59, M_{1718} = 7.92, M_{181} = 18.74. \end{aligned} \quad (4)$$

and $M_{bl} = 0$ in the remaining cases.

Considering expert opinions (MSRSG, GMU, MOG) that in all operations states of the maritime ferry operation process, at each of the operation states if $z_b(0) \neq 0, b = 1, 2, \dots, 18$, the probability of a human error can be approximately evaluated as

$$P_b(ut_1) = P(ut_1) = 17/1000h = 0.017,$$

the probability of a terrorist attack can be approximately evaluated as

$$P_b(ut_2) = P(ut_2) = 0,$$

and the probability of a heavy sea traffic can be approximately evaluated as

$$P_b(ut_3) = P(ut_3) = 5/365d = 0.0137,$$

We distribute the initial probabilities (1) according to the variant 1 procedure defined by (5.1)-(5.4) [3] as follows:

- if $p_b(0) \neq 0, b = 1, 2, \dots, 18$,

we replace it by

$$\begin{aligned} p'_{4(b-1)+1}(0) &= p_b(0) - [P(ut_1) + P(ut_2) + P(ut_3)] \\ &= p_b(0) - [0.017 + 0.0 + 0.0137] \\ &= p_b(0) - [0.0307], \\ p'_{4(b-1)+i}(0) &= P(ut_i), i = 1, 2, 3, \end{aligned}$$

for $b = 1, 2, \dots, 18$;

- if $p_b(0) = 0, b = 1, 2, \dots, 18$,

we replace it by

$$\begin{aligned} p'_{4(b-1)+1}(0) &= 0, \\ p'_{4(b-1)+i}(0) &= 0, i = 1, 2, 3 \end{aligned}$$

for $b = 1, 2, \dots, 18$.

Thus, in particular, we distribute

$$- p_1(0) = 1$$

into the initial probabilities

$$\begin{aligned} p'_{11}(0) &= 0.9693, p'_{12}(0) = 0.017, \\ p'_{13}(0) &= 0.0, p'_{14}(0) = 0.0137; \end{aligned}$$

- $p_b(0) = 0, b = 2, 3, \dots, 18$

into the initial probabilities

$p'_{4(b-1)+1}(0) = 0.0, p'_{4(b-1)+2}(0) = 0.0,$
 $p'_{4(b-1)+3}(0) = 0.0, p'_{4(b-1)+4}(0) = 0.0, b = 2, 3, \dots, 18.$
 After that, we get new vector of initial probabilities of the maritime ferry operation process including operating environment threats with their separation:

$$\begin{aligned} [p'(0)] &= [0.9693, 0.017, 0, 0.0137; 0, 0, 0, 0; \\ &0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; \\ &0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; \\ &0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; 0, 0, 0, 0; \\ &0, 0, 0, 0] \end{aligned}$$

Similarly considering expert opinion (GMU, MSRS, MOG), we distribute the probabilities of transitions between the operation states (2) according to the variant 1 procedure defined by (5.9)-(5.14) [3] as follows:

- if $p_{bl} \neq 0, b, l = 1, 2, \dots, 18$,

we replace it by

$$\begin{aligned} p'_{4(b-1)+1, 4(l-1)+1} &= p_{bl} - [P(ut_1) + P(ut_2) + P(ut_3)] \\ &= p_{bl} - [0.00086 + 0 + 0.000076] \\ &= p_{bl} - [0.000936], \\ p'_{4(b-1)+1, 4(l-1)+i} &= P(ut_i), i = 1, 2, 3, \end{aligned}$$

for $b, l = 1, 2, \dots, 18$,

and we additionally assume that

$$\begin{aligned} p'_{4(b-1)+i, 4(b-1)+1} &= 1, i = 1, 2, 3, \\ p'_{4(b-1)+i, j} &= 0, i = 1, 2, 3, j = 1, 2, \dots, 72, \end{aligned}$$

and $j \neq 4(b-1)+1$

- if $p_{bl} = 0, b, l = 1, 2, \dots, 7, b \neq l$,

we replace it by

$$\begin{aligned} p'_{4(b-1)+1, 4(l-1)+1} &= 0, \\ p'_{4(b-1)+1, 4(l-1)+i} &= 0, i = 1, 2, 3, \end{aligned}$$

for $b, l = 1, 2, \dots, 18$.

Thus, in particular, we distribute:

$$- p_{12} = 1$$

into the probabilities of transitions

$$\begin{aligned} p'_{15} &= 0.9693, p'_{16} = 0.017, \\ p'_{17} &= 0, p'_{18} = 0.0137; \end{aligned}$$

- $p_{1l} = 0, l = 1, 3, \dots, 18$,

into the probabilities of transitions

$$p'_{14(l-1)+1} = 0, p'_{14(l-1)+2} = 0, \\ p'_{14(l-1)+3} = 0, p'_{14(l-1)+4} = 0, l = 1, 3, \dots, 18;$$

and additionally we assume

$$p'_{21} = 1, p'_{2l} = 0, l = 2, 3, \dots, 72, \\ p'_{31} = 1, p'_{3l} = 0, l = 2, 3, \dots, 72, \\ p'_{41} = 1, p'_{4l} = 0, l = 2, 3, \dots, 72;$$

to replace the 1st row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0000; 0.9693\ 0.017\ 0\ 0.0137; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000] \\ [1000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000] \\ [1000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000] \\ [1000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000].$$

We distribute:

$$- p_{23} = 1$$

into the probabilities of transitions

$$p'_{59} = 0.9693, p'_{510} = 0.017, \\ p'_{511} = 0, p'_{512} = 0.0137;$$

$$- p_{2l} = 0, l = 1, 2, 4, \dots, 18,$$

into the probabilities of transitions

$$p'_{54(l-1)+1} = 0, p'_{54(l-1)+2} = 0, \\ p'_{54(l-1)+3} = 0, p'_{54(l-1)+4} = 0, l = 1, 2, 4, \dots, 18;$$

and additionally we assume

$$p'_{65} = 1, p'_{6l} = 0, l = 1, 2, \dots, 4, 6, \dots, 72, \\ p'_{75} = 1, p'_{7l} = 0, l = 1, 2, \dots, 4, 6, \dots, 72, \\ p'_{85} = 1, p'_{8l} = 0, l = 1, 2, \dots, 4, 6, \dots, 72;$$

to replace the 2nd row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0000; 0000; 0.9693\ 0.017\ 0\ 0.0137; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000] \\ [0000; 1000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000]$$

$$[0000; 1000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000] \\ [0000; 1000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000].$$

We distribute:

$$- p_{34} = 1$$

into the probabilities of transitions

$$p'_{913} = 0.9693, p'_{914} = 0.017, \\ p'_{915} = 0, p'_{916} = 0.0137;$$

$$- p_{3l} = 0, l = 1, 2, 3, 5, \dots, 18,$$

into the probabilities of transitions

$$p'_{94(l-1)+1} = 0, p'_{94(l-1)+2} = 0, \\ p'_{94(l-1)+3} = 0, p'_{94(l-1)+4} = 0, l = 1, 2, 3, 5, \dots, 18;$$

and additionally we assume

$$p'_{109} = 1, p'_{10l} = 0, l = 1, 2, \dots, 8, 10, \dots, 72, \\ p'_{119} = 1, p'_{11l} = 0, l = 1, 2, \dots, 8, 10, \dots, 72, \\ p'_{129} = 1, p'_{12l} = 0, l = 1, 2, \dots, 8, 10, \dots, 72;$$

to replace the 3rd row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0000; 0000; 0000; 0.9693\ 0.017\ 0\ 0.0137; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000] \\ [0000; 0000; 1000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000] \\ [0000; 0000; 1000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000] \\ [0000; 0000; 1000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000; \\ 0000; 0000; 0000; 0000; 0000; 0000].$$

We distribute:

$$- p_{45} = 1$$

into the probabilities of transitions

$$p'_{1317} = 0.9693, p'_{1318} = 0.017, \\ p'_{1319} = 0, p'_{1320} = 0.0137;$$

$$- p_{4l} = 0, l = 1, 2, \dots, 4, 6, \dots, 18,$$

into the probabilities of transitions

$$p'_{13\ 4(l-1)+1} = 0, p'_{13\ 4(l-1)+2} = 0,$$

$$p'_{13\ 4(l-1)+3} = 0, p'_{13\ 4(l-1)+4} = 0, l = 1, 2, \dots, 4, 6, \dots, 18;$$

and additionally we assume

$$p'_{14\ 13} = 1, p'_{14\ l} = 0, l = 1, 2, \dots, 12, 14, \dots, 72,$$

$$p'_{15\ 13} = 1, p'_{15\ l} = 0, l = 1, 2, \dots, 12, 14, \dots, 72,$$

$$p'_{16\ 13} = 1, p'_{16\ l} = 0, l = 1, 2, \dots, 12, 14, \dots, 72;$$

to replace the 4th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{5\ 6} = 1$$

into the probabilities of transitions

$$p'_{17\ 21} = 0.9693, p'_{17\ 22} = 0.017,$$

$$p'_{17\ 23} = 0, p'_{17\ 24} = 0.0137;$$

$$- p_{5\ l} = 0, l = 1, 2, \dots, 5, 7, \dots, 18,$$

into the probabilities of transitions

$$p'_{17\ 4(l-1)+1} = 0, p'_{17\ 4(l-1)+2} = 0,$$

$$p'_{17\ 4(l-1)+3} = 0, p'_{17\ 4(l-1)+4} = 0, l = 1, 2, \dots, 5, 7, \dots, 18;$$

and additionally we assume

$$p'_{18\ 17} = 1, p'_{18\ l} = 0, l = 1, 2, \dots, 16, 18, \dots, 72,$$

$$p'_{19\ 17} = 1, p'_{19\ l} = 0, l = 1, 2, \dots, 16, 18, \dots, 72,$$

$$p'_{20\ 17} = 1, p'_{20\ l} = 0, l = 1, 2, \dots, 16, 18, \dots, 72;$$

to replace the 5th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{6\ 7} = 1$$

into the probabilities of transitions

$$p'_{21\ 25} = 0.9693, p'_{21\ 26} = 0.017,$$

$$p'_{21\ 27} = 0, p'_{21\ 28} = 0.0137;$$

$$- p_{6\ l} = 0, l = 1, 2, \dots, 6, 8, \dots, 18,$$

into the probabilities of transitions

$$p'_{21\ 4(l-1)+1} = 0, p'_{21\ 4(l-1)+2} = 0,$$

$$p'_{21\ 4(l-1)+3} = 0, p'_{21\ 4(l-1)+4} = 0, l = 1, 2, \dots, 6, 8, \dots, 18;$$

and additionally we assume

$$p'_{22\ 21} = 1, p'_{22\ l} = 0, l = 1, 2, \dots, 20, 22, \dots, 72,$$

$$p'_{23\ 21} = 1, p'_{23\ l} = 0, l = 1, 2, \dots, 20, 22, \dots, 72,$$

$$p'_{24\ 21} = 1, p'_{24\ l} = 0, l = 1, 2, \dots, 20, 22, \dots, 72;$$

to replace the 6th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{7\ 8} = 1$$

into the probabilities of transitions

$$p'_{25\ 29} = 0.9693, p'_{25\ 30} = 0.017,$$

$$p'_{25\ 31} = 0, p'_{25\ 32} = 0.0137;$$

$$- p_{7\ l} = 0, l = 1, 2, \dots, 7, 9, \dots, 18,$$

into the probabilities of transitions

$$p'_{25\ 4(l-1)+1} = 0, p'_{25\ 4(l-1)+2} = 0,$$

$$p'_{25\ 4(l-1)+3} = 0, p'_{25\ 4(l-1)+4} = 0, l = 1,2,\dots,7,9, \dots, 18;$$

and additionally we assume

$$p'_{26\ 25} = 1, p'_{26\ l} = 0, l = 1,2, \dots, 24,26, \dots, 72,$$

$$p'_{27\ 25} = 1, p'_{26\ l} = 0, l = 1,2, \dots, 24,26, \dots, 72,$$

$$p'_{28\ 25} = 1, p'_{28\ l} = 0, l = 1,2, \dots, 24,26, \dots, 72;$$

to replace the 7th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

We distribute:

$$-p_{8\ 9} = 1$$

into the probabilities of transitions

$$p'_{29\ 33} = 0.9693, p'_{29\ 34} = 0.017,$$

$$p'_{29\ 35} = 0, p'_{29\ 36} = 0.0137;$$

$$-p_{8\ l} = 0, l = 1,2,\dots, 8,10, \dots, 18,$$

into the probabilities of transitions

$$p'_{29\ 4(l-1)+1} = 0, p'_{29\ 4(l-1)+2} = 0,$$

$$p'_{29\ 4(l-1)+3} = 0, p'_{29\ 4(l-1)+4} = 0, l = 1,2,\dots,8,10, \dots, 18;$$

and additionally we assume

$$p'_{30\ 29} = 1, p'_{30\ l} = 0, l = 1,2, \dots, 28,30, \dots, 72,$$

$$p'_{31\ 29} = 1, p'_{31\ l} = 0, l = 1,2, \dots, 28,30, \dots, 72,$$

$$p'_{32\ 29} = 1, p'_{32\ l} = 0, l = 1,2, \dots, 28,30, \dots, 72;$$

to replace the 8th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

We distribute:

$$-p_{9\ 10} = 1$$

into the probabilities of transitions

$$p'_{33\ 37} = 0.9693, p'_{33\ 38} = 0.017,$$

$$p'_{33\ 39} = 0, p'_{33\ 40} = 0.0137;$$

$$-p_{9\ l} = 0, l = 1,2,\dots, 9,11, \dots, 18,$$

into the probabilities of transitions

$$p'_{33\ 4(l-1)+1} = 0, p'_{33\ 4(l-1)+2} = 0,$$

$$p'_{33\ 4(l-1)+3} = 0, p'_{33\ 4(l-1)+4} = 0, l = 1,2,\dots,9,11, \dots, 18;$$

and additionally we assume

$$p'_{34\ 33} = 1, p'_{34\ l} = 0, l = 1,2, \dots, 32,34, \dots, 72,$$

$$p'_{35\ 33} = 1, p'_{35\ l} = 0, l = 1,2, \dots, 32,34, \dots, 72,$$

$$p'_{36\ 33} = 1, p'_{36\ l} = 0, l = 1,2, \dots, 32,34, \dots, 72;$$

to replace the 9th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

We distribute:

$$-p_{10\ 11} = 1$$

into the probabilities of transitions

$$p'_{37\ 41} = 0.9693, p'_{37\ 42} = 0.017,$$

$$p'_{37\ 43} = 0, p'_{37\ 44} = 0.0137;$$

$$-p_{10\ l} = 0, l = 1,2,\dots, 10,12, \dots, 18,$$

into the probabilities of transitions

$$p'_{37\ 4(l-1)+1} = 0, p'_{37\ 4(l-1)+2} = 0,$$

$$p'_{37\ 4(l-1)+3} = 0, p'_{37\ 4(l-1)+4} = 0,$$

$$l = 1, 2, \dots, 10, 12, \dots, 18;$$

and additionally we assume

$$p'_{38\ 37} = 1, p'_{38\ l} = 0, l = 1, 2, \dots, 36, 38, \dots, 72,$$

$$p'_{39\ 37} = 1, p'_{39\ l} = 0, l = 1, 2, \dots, 36, 38, \dots, 72,$$

$$p'_{40\ 37} = 1, p'_{40\ l} = 0, l = 1, 2, \dots, 36, 38, \dots, 72;$$

to replace the 10th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{11\ 12} = 1$$

into the probabilities of transitions

$$p'_{41\ 45} = 0.9693, p'_{41\ 46} = 0.017,$$

$$p'_{41\ 47} = 0, p'_{41\ 48} = 0.0137;$$

$$- p_{11\ l} = 0, l = 1, 2, \dots, 11, 13, \dots, 18,$$

into the probabilities of transitions

$$p'_{41\ 4(l-1)+1} = 0, p'_{41\ 4(l-1)+2} = 0,$$

$$p'_{41\ 4(l-1)+3} = 0, p'_{41\ 4(l-1)+4} = 0,$$

$$l = 1, 2, \dots, 11, 13, \dots, 18;$$

and additionally we assume

$$p'_{42\ 41} = 1, p'_{42\ l} = 0, l = 1, 2, \dots, 40, 42, \dots, 72,$$

$$p'_{43\ 41} = 1, p'_{43\ l} = 0, l = 1, 2, \dots, 40, 42, \dots, 72,$$

$$p'_{44\ 41} = 1, p'_{44\ l} = 0, l = 1, 2, \dots, 40,$$

to replace the 11th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0$$

$$0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{12\ 13} = 1$$

into the probabilities of transitions

$$p'_{45\ 49} = 0.9693, p'_{45\ 50} = 0.017,$$

$$p'_{45\ 51} = 0, p'_{45\ 52} = 0.0137;$$

$$- p_{12\ l} = 0, l = 1, 2, \dots, 12, 14, \dots, 18,$$

into the probabilities of transitions

$$p'_{45\ 4(l-1)+1} = 0, p'_{45\ 4(l-1)+2} = 0,$$

$$p'_{45\ 4(l-1)+3} = 0, p'_{45\ 4(l-1)+4} = 0,$$

$$l = 1, 2, \dots, 12, 14, \dots, 18;$$

and additionally we assume

$$p'_{46\ 45} = 1, p'_{46\ l} = 0, l = 1, 2, \dots, 44, 46, \dots, 72,$$

$$p'_{47\ 45} = 1, p'_{47\ l} = 0, l = 1, 2, \dots, 44, 46, \dots, 72,$$

$$p'_{48\ 45} = 1, p'_{48\ l} = 0, l = 1, 2, \dots, 44, 46, \dots, 72;$$

to replace the 12th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{13\ 14} = 1$$

into the probabilities of transitions

$$p'_{49\ 53} = 0.9693, p'_{49\ 54} = 0.017, \\ p'_{49\ 55} = 0, p'_{49\ 56} = 0.0137;$$

$$- p_{13\ l} = 0, l = 1, 2, \dots, 13, 15, \dots, 18,$$

into the probabilities of transitions

$$p'_{49\ 4(l-1)+1} = 0, p'_{49\ 4(l-1)+2} = 0, \\ p'_{49\ 4(l-1)+3} = 0, p'_{49\ 4(l-1)+4} = 0, \\ l = 1, 2, \dots, 13, 15, \dots, 18;$$

and additionally we assume

$$p'_{50\ 49} = 1, p'_{50\ l} = 0, l = 1, 2, \dots, 48, 50, \dots, 72, \\ p'_{51\ 49} = 1, p'_{51\ l} = 0, l = 1, 2, \dots, 48, 50, \dots, 72, \\ p'_{52\ 49} = 1, p'_{52\ l} = 0, l = 1, 2, \dots, 48, 50, \dots, 72;$$

to replace the 13th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{14\ 15} = 1$$

into the probabilities of transitions

$$p'_{53\ 57} = 0.9693, p'_{53\ 58} = 0.017, \\ p'_{53\ 59} = 0, p'_{53\ 60} = 0.0137;$$

$$- p_{14\ l} = 0, l = 1, 2, \dots, 14, 16, \dots, 18,$$

into the probabilities of transitions

$$p'_{53\ 4(l-1)+1} = 0, p'_{53\ 4(l-1)+2} = 0, \\ p'_{53\ 4(l-1)+3} = 0, p'_{53\ 4(l-1)+4} = 0, \\ l = 1, 2, \dots, 14, 16, \dots, 18;$$

and additionally we assume

$$p'_{54\ 53} = 1, p'_{54\ l} = 0, l = 1, 2, \dots, 52, 54, \dots, 72, \\ p'_{55\ 53} = 1, p'_{55\ l} = 0, l = 1, 2, \dots, 52, 54, \dots, 72,$$

$p'_{56\ 53} = 1, p'_{56\ l} = 0, l = 1, 2, \dots, 52, 54, \dots, 72;$
to replace the 14th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{15\ 16} = 1$$

into the probabilities of transitions

$$p'_{57\ 61} = 0.9693, p'_{57\ 62} = 0.017, \\ p'_{57\ 63} = 0, p'_{57\ 64} = 0.0137;$$

$$- p_{15\ l} = 0, l = 1, 2, \dots, 15, 17, \dots, 18,$$

into the probabilities of transitions

$$p'_{57\ 4(l-1)+1} = 0, p'_{57\ 4(l-1)+2} = 0, \\ p'_{57\ 4(l-1)+3} = 0, p'_{57\ 4(l-1)+4} = 0, \\ l = 1, 2, \dots, 15, 17, \dots, 18;$$

and additionally we assume

$$p'_{58\ 57} = 1, p'_{58\ l} = 0, l = 1, 2, \dots, 56, 58, \dots, 72, \\ p'_{59\ 57} = 1, p'_{59\ l} = 0, l = 1, 2, \dots, 56, 58, \dots, 72, \\ p'_{60\ 57} = 1, p'_{60\ l} = 0, l = 1, 2, \dots, 56, 58, \dots, 72;$$

to replace the 15th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0].

We distribute:

$$- p_{16\ 17} = 1$$

into the probabilities of transitions

$$p'_{61\ 65} = 0.9693, p'_{61\ 66} = 0.017, \\ p'_{61\ 67} = 0, p'_{61\ 68} = 0.0137;$$

$$- p_{16\ l} = 0, l = 1, 2, \dots, 16, 18,$$

into the probabilities of transitions

$$p'_{61\ 4(l-1)+1} = 0, p'_{61\ 4(l-1)+2} = 0, \\ p'_{61\ 4(l-1)+3} = 0, p'_{61\ 4(l-1)+4} = 0, l = 1, 2, \dots, 16, 18;$$

and additionally we assume

$$p'_{62\ 61} = 1, p'_{62\ l} = 0, l = 1, 2, \dots, 60, 62, \dots, 72, \\ p'_{63\ 61} = 1, p'_{63\ l} = 0, l = 1, 2, \dots, 60, 62, \dots, 72, \\ p'_{64\ 61} = 1, p'_{64\ l} = 0, l = 1, 2, \dots, 60, 62, \dots, 72;$$

to replace the 16th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0.9693\ 0.017\ 0\ 0.0137; \\ 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{17\ 18} = 1$$

into the probabilities of transitions

$$p'_{65\ 69} = 0.9693, p'_{65\ 70} = 0.017, \\ p'_{65\ 71} = 0, p'_{65\ 72} = 0.0137;$$

$$- p_{17\ l} = 0, l = 1, 2, \dots, 17,$$

into the probabilities of transitions

$$p'_{65\ 4(l-1)+1} = 0, p'_{65\ 4(l-1)+2} = 0, \\ p'_{65\ 4(l-1)+3} = 0, p'_{65\ 4(l-1)+4} = 0, l = 1, 2, \dots, 17;$$

and additionally we assume

$$p'_{66\ 65} = 1, p'_{66\ l} = 0, l = 1, 2, \dots, 64, 66, \dots, 72, \\ p'_{67\ 65} = 1, p'_{67\ l} = 0, l = 1, 2, \dots, 64, 66, \dots, 72, \\ p'_{68\ 65} = 1, p'_{68\ l} = 0, l = 1, 2, \dots, 64, 66, \dots, 72;$$

to replace the 17th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0.9693\ 0.017\ 0\ 0.0137] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We distribute:

$$- p_{18\ 1} = 1$$

into the probabilities of transitions

$$p'_{69\ 1} = 0.9693, p'_{69\ 2} = 0.017, \\ p'_{69\ 3} = 0, p'_{69\ 4} = 0.0137;$$

$$- p_{18\ l} = 0, l = 2, 3, \dots, 18,$$

into the probabilities of transitions

$$p'_{69\ 4(l-1)+1} = 0, p'_{69\ 4(l-1)+2} = 0, \\ p'_{69\ 4(l-1)+3} = 0, p'_{69\ 4(l-1)+4} = 0, l = 2, 3, \dots, 18;$$

and additionally we assume

$$p'_{70\ 69} = 1, p'_{70\ l} = 0, l = 1, 2, \dots, 68, 70, \dots, 72, \\ p'_{71\ 69} = 1, p'_{71\ l} = 0, l = 1, 2, \dots, 68, 70, \dots, 72, \\ p'_{72\ 69} = 1, p'_{72\ l} = 0, l = 1, 2, \dots, 68, 70, \dots, 72;$$

to replace the 18th row of the matrix $[p_{pl}]_{18 \times 18}$ given by (2) by the following 4 rows of the matrix $[p'_{pl}]_{72 \times 72}$

$$[0.9693\ 0.017\ 0\ 0.0137; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0]$$

[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 1 0 0 0].

Finally, we transform the corresponding matrix $[M_{bl}]_{18 \times 18}$ of the mean values of the conditional sojourn times θ_{bl} , $b, l = 1, 2, \dots, 18$, at operation states into the the matrix $[M'_{bl}]_{28 \times 28}$ of the mean values of the conditional sojourn times θ_{bl} , $b, l = 1, 2, \dots, 72$, according to the procedure defined by (5.21)-(5.24) [3], in the following way:

- if $M_{bl}(0) \neq 0$, $b, l = 1, 2, \dots, 18$,

we fix the mean values

$$M'_{4(b-l)+1+i \ 4(b-l)+1} \quad i = 1, 2, 3, \quad b = 1, 2, \dots, 18,$$

on the basis of expert opinions and assume

$$M'_{4(b-l)+1+i \ j} = 0, \quad i = 1, 2, 3, \quad \text{and } j \neq 4(b-l)+1, \\ j = 1, 2, \dots, 72,$$

and

$$M'_{4(b-l)+1 \ 4(l-l)+1} = M_{bl} - \sum_{i=1}^3 M'_{4(b-l)+1+i \ 4(b-l)+1},$$

- if $M_{bl}(0) = 0$, $b, l = 1, 2, \dots, 18$,

we replace it by

$$M'_{4(b-l)+1 \ 4(l-l)+1} = 0, \\ M'_{4(b-l)+1 \ 4(l-l)+1+i} = 0, \quad i = 1, 2, 3,$$

for $b, l = 1, 2, \dots, 18$.

Considering expert opinions (MSMSG, GMU, MOG) that in all operations states of the maritime ferry, the mean value of the time needed to eliminate a human error is approximately equal to 1 minute, the mean value of the time needed to eliminate a terrorist attack is equal to 0 minutes (it is assumed that the system does not work under that threats), the mean value of the time needed to eliminate a heavy sea traffic (to leave the heavy sea traffic area) is approximately equal to 1 miute, we distribute the mean values of the maritime ferry operation process conditional sojourn times at the operation states (6.3) [3] in the following way:

We fix the mean values:

$$M'_{21} = 1, \quad M'_{31} = 0, \quad M'_{41} = 1.$$

We replace:

$$- M_{12} = 54.67$$

by the mean values

$$M'_{15} = 52.67, \quad M'_{16} = 52.67, \quad M'_{17} = 52.67, \quad M'_{18} = 52.67;$$

$$- M_{1l} = 0, \quad l = 1, 3, \dots, 18,$$

by the mean values

$$M'_{1 \ 4(l-1)+1} = 0, \quad M'_{1 \ 4(l-1)+2} = 0, \\ M'_{1 \ 4(l-1)+3} = 0, \quad M'_{1 \ 4(l-1)+4} = 0, \quad l = 1, 3, \dots, 18;$$

and additionally we assume

$$M'_{2l} = 0, \quad l = 2, 3, \dots, 72, \\ M'_{3l} = 0, \quad l = 2, 3, \dots, 72, \\ M'_{4l} = 0, \quad l = 2, 3, \dots, 72;$$

to replce the 1st row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

[0 0 0 0; 52.67 52.67 52.67 52.67; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]

We fix the mean values:

$$M'_{65} = 1, \quad M'_{75} = 0, \quad M'_{85} = 1.$$

We replace:

$$- M_{23} = 2.60$$

by the mean values

$$M'_{59} = 0.60, \quad M'_{510} = 0.60, \\ M'_{511} = 0.60, \quad M'_{512} = 0.60;$$

$$- M_{2l} = 0, \quad l = 1, 2, 4, \dots, 18,$$

by the maen values

$$M'_{5 \ 4(l-1)+1} = 0, \quad p'_{5 \ 4(l-1)+2} = 0, \\ M'_{5 \ 4(l-1)+3} = 0, \quad M'_{5 \ 4(l-1)+4} = 0, \quad l = 1, 2, 4, \dots, 18;$$

and additionally we assume

$$M'_{17\ 21} = 524.43, M'_{17\ 22} = 524.43,$$

$$M'_{17\ 23} = 524.43, M'_{17\ 24} = 524.43;$$

$$- M_{5\ l} = 0, l = 1,2,\dots, 5,7, \dots, 18,$$

by the mean values

$$M'_{17\ 4(l-1)+1} = 0, M'_{17\ 4(l-1)+2} = 0,$$

$$M'_{17\ 4(l-1)+3} = 0, M'_{17\ 4(l-1)+4} = 0,$$

$$l = 1,2,\dots,5,7, \dots, 18;$$

and additionally we assume

$$M'_{18\ l} = 0, l = 1,2, \dots, 16,18, \dots, 72,$$

$$M'_{19\ l} = 0, l = 1,2, \dots, 16,18, \dots, 72,$$

$$M'_{20\ l} = 0, l = 1,2, \dots, 16,18, \dots, 72;$$

to replace the 5th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$524.43\ 524.43\ 534.43\ 524.43\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We fix the mean values:

$$M'_{22\ 21} = 1, M'_{23\ 21} = 0, M'_{24\ 21} = 1.$$

We replace:

$$- M_{6\ 7} = 37.16$$

by the mean values

$$M'_{21\ 25} = 35.16, M'_{21\ 26} = 35.16,$$

$$M'_{21\ 27} = 35.16, M'_{21\ 28} = 35.16;$$

$$- M_{6\ l} = 0, l = 1,2,\dots, 6,8, \dots, 18,$$

by the mean values

$$M'_{21\ 4(l-1)+1} = 0, M'_{21\ 4(l-1)+2} = 0,$$

$$M'_{21\ 4(l-1)+3} = 0, M'_{21\ 4(l-1)+4} = 0, l = 1,2,\dots,6,8, \dots, 18;$$

and additionally we assume

$$M'_{22\ l} = 0, l = 1,2, \dots, 20,22, \dots, 72,$$

$$M'_{23\ l} = 0, l = 1,2, \dots, 20,22, \dots, 72,$$

$$M'_{24\ l} = 0, l = 1,2, \dots, 20,22, \dots, 72;$$

to replace the 6th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$35.16\ 35.16\ 35.16\ 35.16; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 1\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We fix the mean values:

$$M'_{26\ 25} = 1, M'_{27\ 25} = 0, M'_{28\ 25} = 1.$$

We replace:

$$- M_{7\ 8} = 7.02$$

by the mean values

$$M'_{25\ 29} = 5.02, M'_{25\ 30} = 5.02,$$

$$M'_{25\ 31} = 5.02, M'_{25\ 32} = 5.02;$$

$$- M_{7\ l} = 0, l = 1,2,\dots, 7,9, \dots, 18,$$

by the mean values

$$M'_{25\ 4(l-1)+1} = 0, M'_{25\ 4(l-1)+2} = 0,$$

$$M'_{25\ 4(l-1)+3} = 0, M'_{25\ 4(l-1)+4} = 0, l = 1,2,\dots,7,9, \dots, 18;$$

and additionally we assume

$$M'_{26\ l} = 0, l = 1,2, \dots, 24,26, \dots, 72,$$

$$M'_{26\ l} = 0, l = 1,2, \dots, 24,26, \dots, 72,$$

$$M'_{28\ l} = 0, l = 1,2, \dots, 24,26, \dots, 72;$$

to replace the 7th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 5.02\ 5.02\ 5.02\ 5.02; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0]$$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0;$$

$$0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0].

We fix the mean values:

$$M'_{30\ 29} = 1, M'_{31\ 29} = 0, M'_{32\ 29} = 1.$$

We replace:

$$- M_{8\ 9} = 23.26$$

by the mean values

$$M'_{29\ 33} = 21.26, M'_{29\ 34} = 21.26,
 M'_{29\ 35} = 21.26, M'_{29\ 36} = 21.26;$$

$$- M_{8\ l} = 0, l = 1, 2, \dots, 8, 10, \dots, 18,$$

by the mean values

$$M'_{29\ 4(1-1)+1} = 0, M'_{29\ 4(1-1)+2} = 0,
 M'_{29\ 4(1-1)+3} = 0, M'_{29\ 4(1-1)+4} = 0,
 l = 1, 2, \dots, 8, 10, \dots, 18;$$

and additionally we assume

$$M'_{30\ l} = 0, l = 1, 2, \dots, 28, 30, \dots, 72,
 M'_{31\ l} = 0, l = 1, 2, \dots, 28, 30, \dots, 72,
 M'_{32\ l} = 0, l = 1, 2, \dots, 28, 30, \dots, 72;$$

to replace the 8th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 21.26 21.26 21.26 21.26; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0].

We fix the mean values:

$$M'_{34\ 33} = 1, M'_{35\ 33} = 0, M'_{36\ 33} = 1.$$

We replace:

$$- M_{9\ 10} = 53.69$$

by the mean values

$$M'_{33\ 37} = 51.69, M'_{33\ 38} = 51.69,
 M'_{33\ 39} = 51.69, M'_{33\ 40} = 51.69;$$

$$- M_{9\ l} = 0, l = 1, 2, \dots, 9, 11, \dots, 18,$$

by the mean values

$$M'_{33\ 4(1-1)+1} = 0, M'_{33\ 4(1-1)+2} = 0,
 M'_{33\ 4(1-1)+3} = 0, M'_{33\ 4(1-1)+4} = 0,
 l = 1, 2, \dots, 9, 11, \dots, 18;$$

and additionally we assume

$$M'_{34\ l} = 0, l = 1, 2, \dots, 32, 34, \dots, 72,
 M'_{35\ l} = 0, l = 1, 2, \dots, 32, 34, \dots, 72,
 M'_{36\ l} = 0, l = 1, 2, \dots, 32, 34, \dots, 72;$$

to replace the 9th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 51.69 51.69 51.69 51.69; 0 0 0
 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0].

We fix the mean values:

$$M'_{38\ 37} = 1, M'_{39\ 37} = 0, M'_{40\ 37} = 1.$$

We replace:

$$- M_{10\ 11} = 2.86$$

by the mean values

$$M'_{37\ 41} = 0.86, M'_{37\ 42} = 0.86,
 M'_{37\ 43} = 0.86, M'_{37\ 44} = 0.86;$$

$$- M_{10\ l} = 0, l = 1, 2, \dots, 10, 12, \dots, 18,$$

by the mean values

$$M'_{37\ 4(1-1)+1} = 0, M'_{37\ 4(1-1)+2} = 0,
 M'_{37\ 4(1-1)+3} = 0, M'_{37\ 4(1-1)+4} = 0,
 l = 1, 2, \dots, 10, 12, \dots, 18;$$

and additionally we assume

- $M_{13\ 14} = 508.60$

by the mean values

$$M'_{49\ 53} = 506.60, M'_{49\ 54} = 506.60, \\ M'_{49\ 55} = 506.60, M'_{49\ 56} = 506.60;$$

- $M_{13\ l} = 0, l = 1, 2, \dots, 13, 15, \dots, 18,$

by the mean values

$$M'_{49\ 4(l-1)+1} = 0, M'_{49\ 4(l-1)+2} = 0, \\ M'_{49\ 4(l-1)+3} = 0, M'_{49\ 4(l-1)+4} = 0, \\ l = 1, 2, \dots, 13, 15, \dots, 18;$$

and additionally we assume

$$M'_{50\ l} = 0, l = 1, 2, \dots, 48, 50, \dots, 72, \\ M'_{51\ l} = 0, l = 1, 2, \dots, 48, 50, \dots, 72, \\ M'_{52\ l} = 0, l = 1, 2, \dots, 48, 50, \dots, 72;$$

to replace the 13th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 506.60\ 506.60\ 506.60\ 506.60; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We fix the mean values:

$$M'_{54\ 53} = 1, M'_{55\ 53} = 0, M'_{56\ 53} = 1.$$

We replace:

- $M_{14\ 15} = 50.14$

by the mean values

$$M'_{53\ 57} = 48.14, M'_{53\ 58} = 48.14, \\ M'_{53\ 59} = 48.14, M'_{53\ 60} = 48.14;$$

- $M_{14\ l} = 0, l = 1, 2, \dots, 14, 16, \dots, 18,$

by the mean values

$$M'_{53\ 4(l-1)+1} = 0, M'_{53\ 4(l-1)+2} = 0, \\ M'_{53\ 4(l-1)+3} = 0, M'_{53\ 4(l-1)+4} = 0,$$

$l = 1, 2, \dots, 14, 16, \dots, 18;$
and additionally we assume

$$M'_{54\ l} = 0, l = 1, 2, \dots, 52, 54, \dots, 72, \\ M'_{55\ l} = 0, l = 1, 2, \dots, 52, 54, \dots, 72, \\ M'_{56\ l} = 0, l = 1, 2, \dots, 52, 54, \dots, 72;$$

to replace the 14th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

$$[0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 48.14\ 48.14\ 48.14\ 48.14; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0] \\ [0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; \\ 0\ 0\ 0\ 0; 1\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0; 0\ 0\ 0\ 0].$$

We fix the mean values:

$$M'_{58\ 57} = 1, M'_{59\ 57} = 0, M'_{60\ 57} = 1.$$

We replace:

- $M_{15\ 16} = 34.43$

by the mean values

$$M'_{57\ 61} = 32.43, M'_{57\ 62} = 32.43, \\ M'_{57\ 63} = 32.43, M'_{57\ 64} = 32.43;$$

- $M_{15\ l} = 0, l = 1, 2, \dots, 15, 17, \dots, 18,$

by the mean values

$$M'_{57\ 4(l-1)+1} = 0, M'_{57\ 4(l-1)+2} = 0, \\ M'_{57\ 4(l-1)+3} = 0, M'_{57\ 4(l-1)+4} = 0, \\ l = 1, 2, \dots, 15, 17, \dots, 18;$$

and additionally we assume

$$M'_{58\ l} = 0, l = 1, 2, \dots, 56, 58, \dots, 72, \\ M'_{59\ l} = 0, l = 1, 2, \dots, 56, 58, \dots, 72, \\ M'_{60\ l} = 0, l = 1, 2, \dots, 56, 58, \dots, 72;$$

to replace the 15th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 32.43 32.43 32.43 32.43;
 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0].

We fix the mean values:

$$M^{62\ 61} = 1, M^{63\ 61} = 0, M^{64\ 61} = 1.$$

We replace:

$$- M_{16\ 17} = 4.59$$

by the mean values

$$M^{61\ 65} = 2.59, M^{61\ 66} = 2.59,
 M^{61\ 67} = 2.59, M^{61\ 68} = 2.59;$$

$$- M_{16\ l} = 0, l = 1, 2, \dots, 16, 18,$$

into the probabilities of transitions

$$M^{61\ 4(l-1)+1} = 0, M^{61\ 4(l-1)+2} = 0,
 M^{61\ 4(l-1)+3} = 0, M^{61\ 4(l-1)+4} = 0, l = 1, 2, \dots, 16, 18;$$

and additionally we assume

$$M^{62\ l} = 0, l = 1, 2, \dots, 60, 62, \dots, 72,
 M^{63\ l} = 0, l = 1, 2, \dots, 60, 62, \dots, 72,
 M^{64\ l} = 0, l = 1, 2, \dots, 60, 62, \dots, 72;$$

to replace the 16th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (6.36) by the following 4 rows of the matrix $[M^{bl}]_{72 \times 72}$

[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 2.59 2.59 2.59 2.59;
 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0; 0 0 0 0].

We fix the mean values:

$$M^{66\ 65} = 1, M^{67\ 65} = 0, M^{68\ 65} = 1.$$

We replace:

$$- M_{17\ 18} = 7.92$$

by the mean values

$$M^{65\ 69} = 6.92, M^{65\ 70} = 6.92,
 M^{65\ 71} = 6.92, M^{65\ 72} = 6.92;$$

$$- M_{17\ l} = 0, l = 1, 2, \dots, 17,$$

by the mean values

$$M^{65\ 4(l-1)+1} = 0, M^{65\ 4(l-1)+2} = 0,
 M^{65\ 4(l-1)+3} = 0, M^{65\ 4(l-1)+4} = 0, l = 1, 2, \dots, 17;$$

and additionally we assume

$$M^{66\ l} = 0, l = 1, 2, \dots, 64, 66, \dots, 72,
 M^{67\ l} = 0, l = 1, 2, \dots, 64, 66, \dots, 72,
 M^{68\ l} = 0, l = 1, 2, \dots, 64, 66, \dots, 72;$$

to replace the 17th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M^{bl}]_{72 \times 72}$

[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 5.92 5.92 5.92 5.92]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0]
 [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 1 0 0 0; 0 0 0 0].

We fix the mean values:

$$M^{70\ 69} = 1, M^{71\ 69} = 0, M^{72\ 69} = 1.$$

We replace:

$$- M_{18\ 1} = 18.74$$

by the mean values

$$M^{69\ 1} = 16.74, M^{69\ 2} = 16.74,
 M^{69\ 3} = 16.74, M^{69\ 4} = 16.74;$$

- $M_{18l} = 0, l = 2, 3, \dots, 18,$

by the mean values

$$M'_{69\ 4(1-1)+1} = 0, M'_{69\ 4(1-1)+2} = 0, \\ M'_{69\ 4(1-1)+3} = 0, M'_{69\ 4(1-1)+4} = 0, l = 2, 3, \dots, 18;$$

and additionally we assume

$$M'_{69l} = 0, l = 1, 2, \dots, 68, 70, \dots, 72, \\ M'_{71l} = 0, l = 1, 2, \dots, 68, 70, \dots, 72, \\ M'_{72l} = 0, l = 1, 2, \dots, 68, 70, \dots, 72;$$

to replace the 18th row of the matrix $[M_{bl}]_{18 \times 18}$ given by (3) by the following 4 rows of the matrix $[M'_{bl}]_{72 \times 72}$

```
[16.74 16.74 16.74 16.74; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 1 0 0 0]
[0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0;
 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0; 1 0 0 0].
```

4. Conclusion

The proposed statistical methods of identification of the unknown parameters of the critical infrastructure operation processes including operating environment threats allow us for the identification of the models discussed in [3] and next their practical applications in evaluation, prediction and optimization of safety of real critical infrastructures. This possibility is illustrated in the appliqué reports [EU-CIRCLE Report D3.3-GMU7, 2016], [EU-CIRCLE Report D3.3-GMU8, 2016], where on the basis of these methods and the statistical data presented in this paper, the identification and next the safety evaluation and prediction of the ferry technical system will be done.

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