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THE TIME FACTORS OF MAINTENANCE LOGISTICS

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ABSTRACT
Time factors of maintenance logistics in regard to service process.
In the realization of maintenance processes the logistics activities, the maintenance logistics processes create a determining part. The realization of maintenance process has a bearing on purchaser satisfaction basically too. The maintenance activity like a influential factor of purchaser satisfaction appear in three basic area:
- in the production and service process,
- by the purchasers by the maintenance and servicing of the product,
- in case of administration of maintenance service.

Dominant activity of the maintenance logistics:
- supply tasks of the materials, components, tools and services,
- operating of the supply chain of maintenance logistics,
- store management of the maintenance logistics,
- maintenance inverse logistics.

On the maintenance logistics area the time factors and the influential parameters are formulated by means of the mathematics and we define the optimal time of the maintenance activity starting by the lead-time.

KEYWORDS:
logistics, maintenance logistics, process of maintenance, time factor, optimisation.

1. INTRODUCTION

The shaping of the process of the maintenance logistics and the applied logistical strategies are basically determine the transit time of the maintenance activity by which the satisfying filling is substantially influenced of the given products customers.

It was investigated whether which time parameters are determinable for the transit time.

The basic condition of the start of the maintenance activity is the existence of the followings at the object under the activity:
- the necessary type of materials in suitable quality and quality,
- the necessary type of constituents in suitable quantity and quality,
- the necessary type of facilities in suitable quantity and quality,
- the necessary services to the maintenance and the staff.

The assurance of the above conditions is the task of the maintenance logistics.

2. TIME FACTORS

In case of the time parameters of the maintenance logistics two main factors are considered as can be seen in (1).

$$t_a = t_M + t_H \tag{1}$$

where

t_M transit time of the order process of the necessities,

t_H time of demand of delivery, that is the total time of the logistical activities connected to the maintenance object

3. PROCESS OF ORDER OF THE MAINTENANCE NECESSITIES

The ordering process of the necessities (materials, constituents, facilities, service, staff) can be seen in Figure 1.

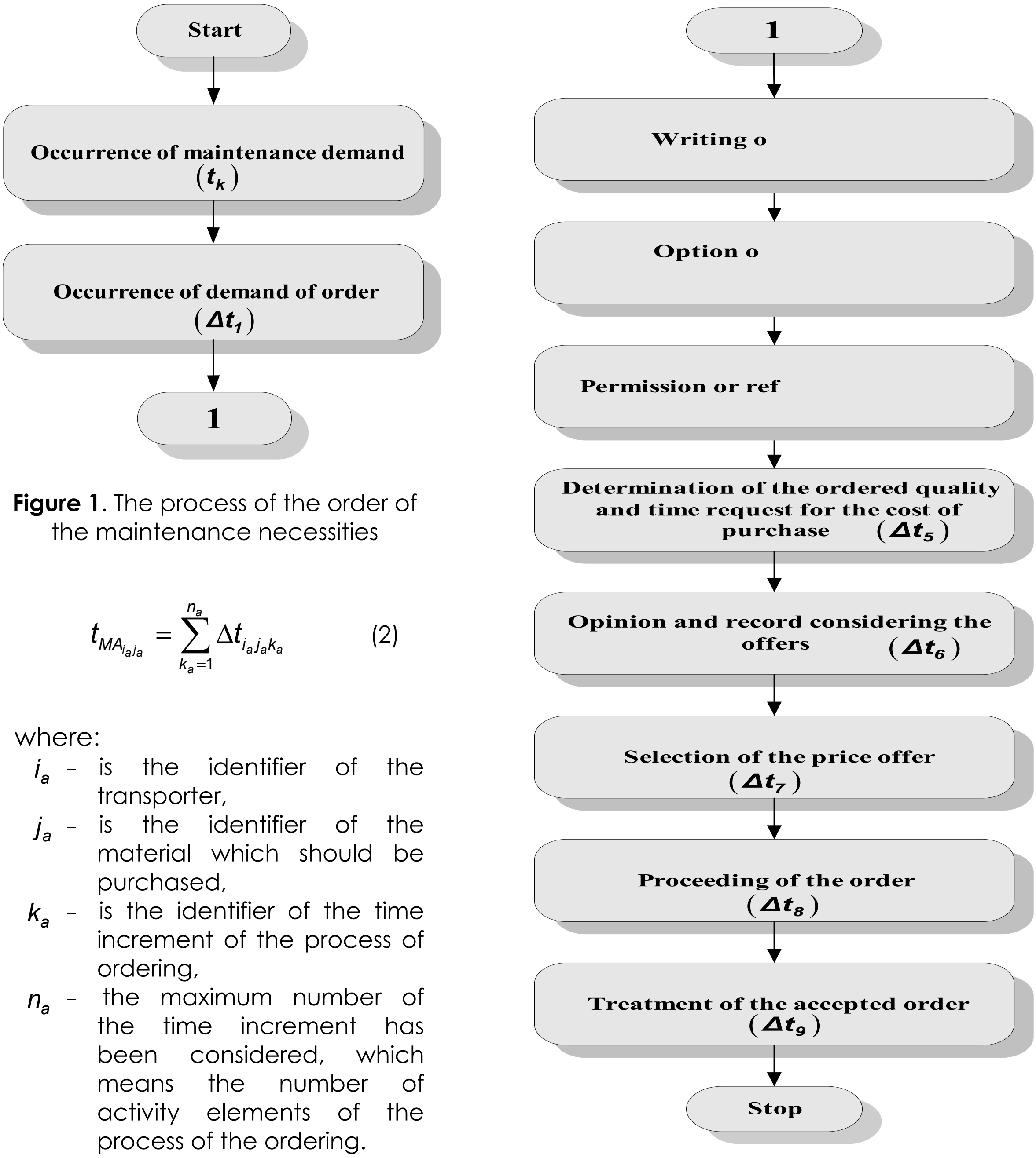

Figure 1. The process of the order of the maintenance necessities

$$t_{MA_{i_a j_a}} = \sum_{k_a=1}^{n_a} \Delta t_{i_a j_a k_a} \tag{2}$$

where:

i_a – is the identifier of the transporter,

j_a – is the identifier of the material which should be purchased,

k_a – is the identifier of the time increment of the process of ordering,

n_a – the maximum number of the time increment has been considered, which means the number of activity elements of the process of the ordering.

– for the constituents of the maintenance process

$$t_{MR_{i_r j_r}} = \sum_{k_r=1}^{n_r} \Delta t_{i_r j_r k_r} \tag{3}$$

where:

i_r – is the identifier of the transporter,

j_r – is the identifier of the constituent to be purchased,

k_r – is the identifier of the time increment at the ordering process,

n_r – the maximum number of the time increment has been considered, which means the number of activity elements of the process of the ordering.

– for the maintenance facilities:

$$t_{ME_{i_e j_e}} = \sum_{k_e=1}^{n_e} \Delta t_{i_e j_e k_e} \tag{4}$$

where:

i_e – is the identifier of the transporter,

j_e – is the identifier of the constituent to be purchased,

k_e – is the identifier of the time increment of the ordering,

n_e – the maximum number of the time increment has been considered which means the number of activity elements of the process of the ordering.

– for the maintenance service:

$$t_{MS_{i_s j_s}} = \sum_{k_s=1}^{n_s} \Delta t_{i_s j_s k_s} \tag{5}$$

where:

i_s – is the identifier of the given service,

j_s – is the identifier of the service to be purchased,

k_s – is the identifier of the time increment of the ordering process,

n_s – is the maximum number of the time increment has been considered which means the number of activity elements of the process of the ordering.

By using (2), (3), (4) and (5) the transit time can be given for the materials, constituents, facilities and services which are necessary for the ordering of maintenance. It is expedient to write the followings:

$$t_{MA_{i_a j_a}} = \sum_{k_a=1}^{n_a} \Delta t_{i_a j_a k_a} = \min \tag{6}$$

$$t_{MR_{i_r j_r}} = \sum_{k_r=1}^{n_r} \Delta t_{i_r j_r k_r} = \min \tag{7}$$

$$t_{ME_{i_e j_e}} = \sum_{k_e=1}^{n_e} \Delta t_{i_e j_e k_e} = \min \tag{8}$$

$$t_{MS_{i_s j_s}} = \sum_{k_s=1}^{n_s} \Delta t_{i_s j_s k_s} = \min \tag{9}$$

4. LOGISTICAL FEATURES OF DEMAND OF DELIVERY NECESSARY FOR MAINTENANCE

In the followings the time factors to be connected with the demand of delivery of the necessities will be investigated. The time factors are belonging to the place where the necessity should be satisfied and to the object being under the maintenance. These factors can be:

- times for logistical activities,
- waiting times for the necessary facilities and equipments.

Logistical type of activities in field of maintenance logistics can be the next:

- different kind of storage activities, activities in connection with stores (transmission in and out),
- activities in connection with demolition or making of unit packages,
- commission,
- transportation,
- packing,
- classification
  - removable constituent
  - constituent for recycling
  - pieces for putting as waste

The time necessity for the demand of delivery of maintenance will be given in Figure 2. taking the logistical type activities into regard.

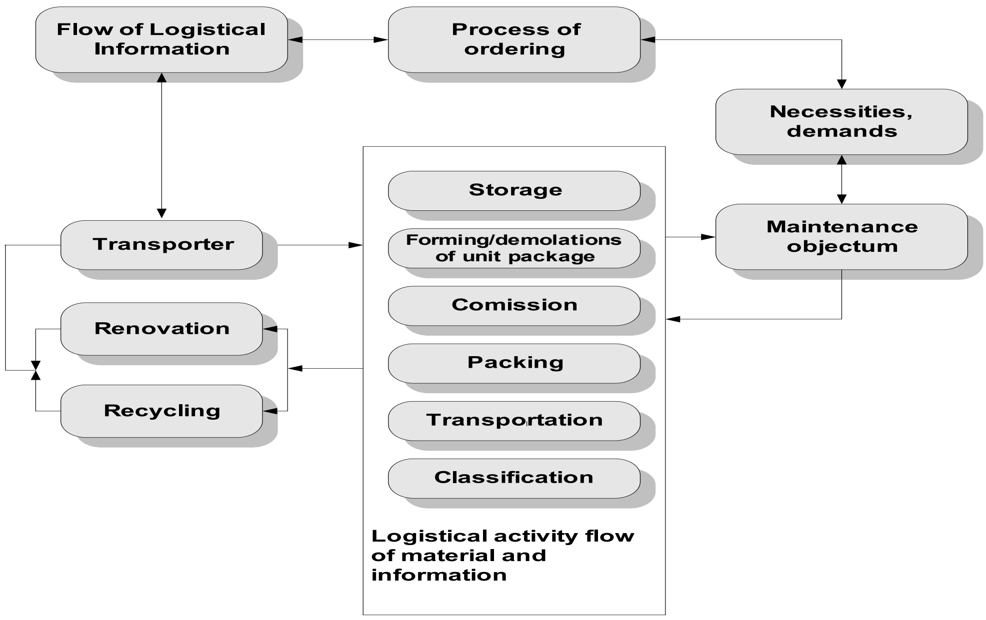

Figure 2. Logistical features of demand of delivery necessary for maintenance

In the system of the demand of delivery for the maintenance activity all the time new material and facility transportation is taken into regard, because for example in case of material the necessary oil or glum can't be renovated and also the facilities are considered not to have to be renovated due to the maintenance demand.

The satisfactions for the constituents can be carried out from the point of the logistics is three different ways:

- transportation of the new constituents from the transportation in store or transportation of a renovated constituent has been in the store,
- the constituent has to be manufactured before the transportation,

- the given constituent has to be removed from the original place and then after reparation should be put back.

If the transportation is proceeded from the transportation in storage, (new or renovated constituent) then the time for demand of delivery is:

- in case of parallel activity

$$t_{HR1} = \max_{i_r}\left\{t_{HR1_{i_r}}\right\} \tag{10/a}$$

- in case of serial activity

$$t_{HR1} = \sum_{i_r} t_{HR1_{i_r}} \tag{10/b}$$

$$t_{HA1i_r} = t_{T_{i_r}} + t_{E_{i_r}} + t_{K_{i_r}} + t_{R_{i_r}} + t_{S_{i_r}} \tag{11}$$

where:

t_{HR1} - time of demand of delivery for given maintenance task in case of demand of delivery from store,

$t_{HR1_{i_r}}$ - time of demand of delivery of a transported constituent for the transporter i_r in case of given maintenance activity,

$t_{T_{i_r}}$ - the storage time necessity in case of supply between the transporter i_r and the maintenance object,

$t_{E_{i_r}}$ - the time necessity for forming and demolition of unit package in case of supply between the transporter i_r and the object under maintenance,

$t_{K_{i_r}}$ – time necessity for commission in case of supply between the transporter i_r and the object under maintenance,

$t_{R_{i_r}}$ – the time necessity of storage in case of supply between the transporter i_r and the object under maintenance,

$t_{S_{i_r}}$ – the time necessity in case of supply between the transporter i_r and the object under maintenance.

$$t_{T_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_t=1}^{n_{\kappa_r}(i_r,j_r)} t_{T_{i_r,j_r,\kappa_t}} \qquad i_r = 1,2\cdots n_{i_r} \tag{12}$$

where:

$t_{T_{i_r,j_r,\kappa_t}}$ - the storage time in the sore κ_t for the constituent j_r and transporter i_r during the supplying process,

$n_{\kappa_r(i_r,j_r)}$ - the number of stores for the constituent j_r and transporter i_r during the process of supply,

n_{i_r} - number of the transporters being involved.

n_{i_r} - number of the transporters being involved.

$$t_{E_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_e=1}^{n_{\kappa_e}(i_r,j_r)} t_{E_{i_r,j_r,\kappa_e}} \tag{13}$$

where:

$t_{E_{i_r,j_r,\kappa_e}}$ - the time for the construction and demolition of the unit packages κ_e at the constituent κ_e and transporter i_r -during the process of supply,

$n_{\kappa_e}(i_r, j_r)$ - the number of construction and demolition of unit packages in case of transporter i_r and constituent j_r during the process supply.

$$t_{K_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_k=1}^{n_{\kappa_k}(i_r,j_r)} t_{K_{i_r,j_r,\kappa_k}} \tag{14}$$

where:

$t_{K_{i_r,j_r,\kappa_k}}$ - the time for commission κ_k in case of the transporter i_r and constituent j_r during the process supply,

$n_{\kappa_k}(i_r, j_r)$ - the number of commission in case of the transporter i_r and constituent j_r.

$$t_{R_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_r=1}^{n_{\kappa_k}(i_r,j_r)} t_{R_{i_r,j_r,\kappa_r}} \tag{15}$$

where:

$t_{K_{i_r,j_r,\kappa_r}}$ - the time for storage κ_r in case of constituent j_r and transporter i_r-in case of the process of the supply,

$n_{\kappa_r}(i_r, j_r)$ - the number of storage in case of the constituent j_r and transporter i_r.

$$t_{S_{i_r}} = \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_s=1}^{n_{\kappa_s}(i_r,j_r)} t_{S_{i_r,j_r,\kappa_s}} \tag{16}$$

where:

$t_{S_{i_r,j_r,\kappa_s}}$ - the transportation time κ_s in case of the constituent j_r and transporter i_r in the process of supply,

$n_{\kappa_s}(i_r, j_r)$ - the number of transportations in case of constituent j_r and transporter i_r.

Summarizing the content of (10), (11), (12), (13), (14), (15), (16):

$$t_{HR1} = \max_{i_r} \left\{ \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_t=1}^{n_{\kappa_t}(i_r,j_r)} t_{T_{i_r,j_r,\kappa_t}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_e=1}^{n_{\kappa_e}(i_r,j_r)} t_{E_{i_r,j_r,\kappa_e}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_k=1}^{n_{\kappa_k}(i_r,j_r)} t_{K_{i_r,j_r,\kappa_t}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_r=1}^{n_{\kappa_r}(i_r,j_r)} t_{R_{i_r,j_r,\kappa_r}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_s=1}^{n_{\kappa_s}(i_r,j_r)} t_{S_{i_r,j_r,\kappa_s}} \right\} \tag{17}$$

It can be prescribed as an object function that (17) should be minimal:

$$t_{HR1} = \max_{i_r} \left\{ \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_t=1}^{n_{\kappa_t}(i_r,j_r)} t_{T_{i_r,j_r,\kappa_t}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_e=1}^{n_{\kappa_e}(i_r,j_r)} t_{E_{i_r,j_r,\kappa_e}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_k=1}^{n_{\kappa_k}(i_r,j_r)} t_{K_{i_r,j_r,\kappa_t}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_r=1}^{n_{\kappa_r}(i_r,j_r)} t_{R_{i_r,j_r,\kappa_r}} + \sum_{j_r=1}^{n_{j_r}(i_r)} \sum_{\kappa_s=1}^{n_{\kappa_s}(i_r,j_r)} t_{S_{i_r,j_r,\kappa_s}} \right\} = \min \tag{18}$$

On base of (18) it can be concluded, that the value of the object function in case of supply of the constituents for the maintenance from a transportation in storage is depend on the:

- number of the transporters being involved,
- number of the constituents being transported,
- and on
  - the number of the storages $\left(n_{i_r}\right)$,
  - the number of the compositions and demolitions of unit packages $\left(n_{j_r}\right)$,
  - the number of applied commissions $\left(n_{\kappa_t}\right)$,
  - the number of applied storages $\left(n_{\kappa_e}\right)$,
  - the number of transportations $\left(n_{\kappa_k}\right)$,
  - per transporters and constituents $\left(n_{\kappa_r}\right)$.
- the time demand of given logistical activities in case of given transporters and constituents.

The real time necessity of the logistical activities are added by two parts:
- the real technological time of the logistical activity,
- the waiting times for facilities, equipments, which are necessary for the given logistical activities and perhaps also the waiting time for the maintenance object.

All of the elements in (11) can be written as

$$t_{\alpha_{i_r,j_r}} = t'_{\alpha_{i_r,j_r}} + t''_{\alpha_{i_r,j_r}} \quad (19)$$

where:

$t_{\alpha_{i_r,j_r}}$ - at given maintenance activity the real time for the logistical activity α in case of the product j_r at the transporter i_r,

$t'_{\alpha_{i_r,j_r}}$ - at given maintenance activity the technological time for the logistical activity α in case of the product j_r at the transporter i_r,

$t''_{\alpha_{i_r,j_r}}$ - at given maintenance activity the waiting time for the logistical activity α in case of the product j_r it the transporter i_r.

Bellowing to the information of (18) the followings can be started:

$$t_{\alpha_{i_r,j_r}} = t'_{\alpha_{i_r,j_r}} + t''_{\alpha_{i_r,j_r}} = \min \quad (20)$$

or

$$t''_{\alpha_{i_r,j_r}} \to 0 \quad (21)$$

$$t'_{\alpha_{i_r,j_r}} = \min \quad (22)$$

If the assurance of the necessary constituent bellowing to a given maintenance activity a carried out by renovation of the dissembled constituent at an external place, then for the determination of the time of the demanded of delivery the followings should be taken in to consideration:
- the time necessity of the logistical activity being proceeded between the object under maintenance and the renovation place $\left(t_B\left(i_r, j_r\right)\right)$,
- the real time of the renovation

In this case the time for the demand of delivering:

$$t_{HR2} = t_{HR1} + t_B\left(i_r j_r\right) + t_F\left(i_r j_r\right) \quad (23)$$

If the maintenance activity is proceeded by the re-manufacturing of the necessary constituent the total manufacturing time should be taken into consideration $\left(t_G\left(i_r, j_r\right)\right)$:

$$t_{HR3} = t_{HR1} + t_G\left(i_r j_r\right) \tag{24}$$

The materials, facilities the necessary times of demands of deliveries can be written in a similar way by using (18); (23) and (24).

By using (1) let us denote the necessary times for carrying out the maintenance activity:

$$t_{a_A} = t_{MA} + t_{HA}; \quad \text{for materials,} \tag{25}$$

$$t_{a_R} = t_{MR} + t_{HR}; \quad \text{for constituents,} \tag{26}$$

$$t_{a_E} = t_{ME} + t_{HE}; \quad \text{for facilities,} \tag{27}$$

t_{a_s} - is the time for demand of delivery .

Let us denote the time when it turns out the maintenance has to be proceeded by t_k. So the possible start of the maintenance activity at the object is

$$t_{IND} = t_k + \max\left\{t_{a_A}; t_{a_R}; t_{a_E}; t_{a_S}\right\} \tag{28}$$

where:

t_k - is the time of occurence of the demand of the maintenance.

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