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OPTIMIZATION OF INTERNATIONAL ROAD TRANSPORT ACTIVITY

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ABSTRACT: Enterprise Requirement Planning (ERP) softwares have many advantageous and disadvantageous properties. Most important advantage is that the software includes much information relating to the activity of the company. But disadvantage is that not easy to fit the standardized nonflexible software to the individual requirements and processes of the users and some special evaluations can not be prepared automatically. The paper introduces the conception of software to be developed for a company in frame of a research project. This software has two modules, the first is an evaluation module, and the second is a planning module. The planning module support the organization and optimization of transport loops which can result higher profit and lower operation costs for the company, lower specific transport cost for the customers and lower air pollution.
KEYWORDS: Enterprise Requirement Planning (ERP) softwares, planning & optimisation of transport

INTRODUCTION

Enterprise Requirement Planning (ERP) softwares have many advantageous and disadvantageous properties. Most important advantage is that the software includes much information relating to the activity of the company. But disadvantage is that not easy to fit the standardized nonflexible software to the individual requirements and processes of the users and some special evaluations can not be prepared automatically.

The aim of our research-development project is to develop a software module to provide and evaluate logistics indicators relating to the transport activity automatically and develop a transport planning software. Indicators can be useful for both of general management and route planners, the planning software results organization of cost effective transport loops.

At first we defined the structure of logistics indicators which can be provided based on available historical database and after it we make suggestions for improvement of actual database which required to the planning and optimisation of transport paths (Figure 1).

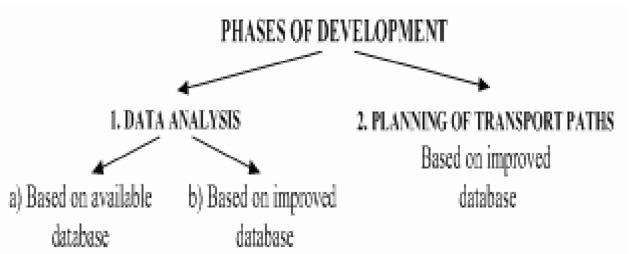

Figure 1. Phases of development

STRUCTURE OF INTERNATIONAL TRANSPORT LOOPS

The aim of transport loop planning are a more efficient transport activity, reduction of total amount of emission and the realization of higher profit, which require the integration of more transport tasks into one transport loop as it can be seen in figure 2.

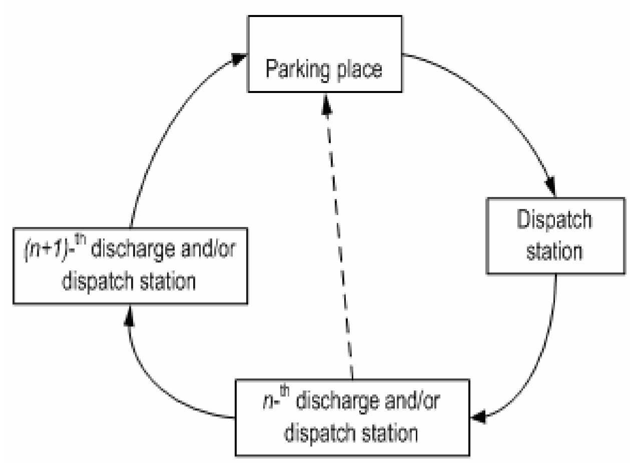

Figure 2. Structure of transport loops

It means that the vehicle starts from the parking place of the company to the first dispatch station where the products to be transported are loading in. After it the vehicle goes to the first discharge station where the products to be transported are loading out and goes to the next dispatch station. The number of dispatch and discharge stations can be n and a discharge station can be a dispatch station simultaneously. After the last discharge station the vehicle goes back to the parking place of the company. It is possible that only a part of the total transported load of a vehicle is loading in or loading out at some stations.

EFFECT OF ROAD TRANSPORT ACTIVITY ON ENVIRONMENT

International research report of DHL showed that the 30% of camions after the last discharge station on the back way are going without useful load (empty vehicles). It results approximately 33,5 milliard euro additional fuel cost and 20-30 tons of CO_2 emission per year.

Logistics has a significant role in environmental protection. Because of the transport cost represents the 30 % of the total supply chain cost, all of forwarding companies attempt to optimize their transport activities. Optimization means increase of utilization of transport loops, reduction of amount of burnt fuel and reduction of vehicles emission.

Possibilities of reduction of emission of international road transport activities are the followings:

- modernization of vehicle fleet, usage of low emission engines or hybrid powered vehicles,
- training of drivers which can improve driving techniques,
- application of multimodal transport mode which is the combination of road-, rail-, water- and air transportation,
- optimization of transport tasks:
  - integration of more transport tasks into one transport loop,
  - elimination of transport ways without useful load (empty vehicles),
  - maximization of vehicle capacity during the transport way (the adequate vehicle size is used),
  - selection of the optimal transport route (taking into consideration the topography (across flatland, downy or mountain)).

TOTAL PRIME COST OF A TRANSPORT LOOP

At first we have to define the total prime cost of a transport loop to find the possibilities of cost reduction. It is suggested to define the sections of the total loop. A section is a way between a dispatch station and a discharge station. The cost components of the sections are different due to the different volume of transported goods, fuel consumption depending on topography, etc.

Total prime cost of the α^{th} transport loop $(K_{T\alpha})$ can be calculated:

$$K_{T\alpha} = K_{L\alpha} + K_{UL\alpha} + K_{W\alpha} + K_{A\alpha} + K_{D\alpha} + K_{M\alpha} \quad (1)$$

where:

$K_{L\alpha}$ - cost of transport way with useful load (loaded);

$K_{UL\alpha}$ - cost of transport way without useful load (unloaded);

$K_{W\alpha}$ - cost of waiting time;

$K_{A\alpha}$ - total additional costs (fee of motorway usage, parking fee, ...);

$K_{D\alpha}$ - wage cost of drivers;

$K_{M\alpha}$ - maintenance cost of own vehicles;

α - identifier of the loop.

Cost of transport way with useful load

The cost of transport sections with useful load can be calculated:

$$K_{L\alpha} = k_{L\alpha} \cdot L_{L\alpha} \text{ [euro]} \quad (2)$$

where:

$k_{L\alpha}$: specific cost of way with useful load in case of α^{th} transport loop $\left[\frac{euro}{km}\right]$,

$L_{L\alpha}$: length of way with useful load in case of α^{th} transport loop [km].

$$k_{L\alpha} = \varepsilon^{\alpha}_{L1} \cdot \varepsilon^{\alpha}_{L2} \cdot \varepsilon^{\alpha}_{L3} \cdot k^{\alpha}_{L0} \left[\frac{euro}{km}\right] \quad (3)$$

where:

k^{α}_{L0}: specific cost of vehicle of α^{th} transport loop (in case of an empty vehicle)

$$k^{\alpha}_{L0} = \frac{f_R}{100} k_{fR} \quad \left[\frac{euro}{km}\right] \quad (4)$$

where:

f_R: specific fuel consumption $\left[\frac{litre}{km}\right]$

k_{fR}: cost of fuel $\left[\frac{euro}{litre}\right]$

$\varepsilon^{\alpha}_{L1}$: correction factor for fuel consumption depending on features of the ground

$\varepsilon^{\alpha}_{L2}$: correction factor for different fuel price of different countries

$\varepsilon^{\alpha}_{L3}$: correction factor for different loading condition (weight of useful load)

Cost of transport way without useful load

The cost of transport sections without useful load can be calculated:

$$K_{UL\alpha} = k_{UL\alpha} \cdot L_{UL\alpha} \text{ [euro]} \quad (5)$$

where:

$L_{UL\alpha}$: length of way without useful load in case of α^{th} transport loop [km].

$k_{UL\alpha}$: specific cost of way without useful load $\left[\frac{euro}{km}\right]$,

$$k_{UL\alpha} = \varepsilon^{\alpha}_{UL1} \cdot \varepsilon^{\alpha}_{UL2} \cdot k^{\alpha}_{UL0} \left[\frac{euro}{km}\right] \quad (6)$$

where:

k^{α}_{UL0}: specific cost of vehicle of α^{th} transport loop (in case of an empty vehicle)

$$k^{\alpha}_{UL0} = \frac{f_{Ü}}{100} k_{fÜ} \quad (7)$$

$f_{ü}$: specific fuel consumption $\left[\frac{litre}{km}\right]$

$k_{fü}$: cost of fuel $\left[\frac{euro}{litre}\right]$

$\varepsilon^{\alpha}_{UL1}$: correction factor for fuel consumption depending on features of the ground

e.g. 1 - normal (flatland),

1,3 - hard (mountain),

$\varepsilon_{UL2}^{\alpha}$: correction factor for different fuel prices of different countries

Cost of waiting time

The cost of waiting time during the transport way can be calculated as the sum of the following components:

$$K_{W\alpha} = (T_{RA\alpha} + T_{WA\alpha} + T_{HA\alpha} + T_{PA\alpha} + T_{SA\alpha}) \cdot k_{W\alpha} \text{ [euro]} \quad (8)$$

where:

$T_{RA\alpha}$: time consumption of loading in and loading out, $[hour]$

$T_{WA\alpha}$: waiting for loading in and loading out activity, $[hour]$,

$T_{HA\alpha}$: waiting time at the frontier station, $[hour]$,

$T_{PA\alpha}$: waiting time due to required resting, $[hour]$,

$T_{SA\alpha}$: waiting time due to camion stop, $[hour]$

$k_{W\alpha}$: specific cost of waiting, $\left[\frac{euro}{hour}\right]$.

Additional costs

Total additional cost is the sum of the motorway fee ($K_{AM\alpha}$) and parking fee ($K_{AP\alpha}$):

$$K_{A\alpha} = K_{AM\alpha} + K_{AP\alpha} \text{ [euro]} \quad (9)$$

- motorway fee: fee of motorway sections used by vehicles

$$K_{AM\alpha} = k_{AM}^{\alpha} \cdot m^{\alpha} \cdot \varepsilon_{AM}^{\alpha} \text{ [euro]} \quad (10)$$

where:

k_{AM}^{α} average fee of a motorway section $\left[\frac{euro}{section}\right]$

m^{α} number of sections of the loops

$\varepsilon_{AM}^{\alpha}$ correction factor relating to different cost of different countries

- parking fee: fee of parking times in the loops

$$K_{AP\alpha} = t_{P}^{\alpha} \cdot k_{P}^{\alpha} \cdot \varepsilon_{Pt}^{\alpha} \cdot \varepsilon_{Pd}^{\alpha} \cdot \varepsilon_{T}^{\alpha} \text{ [euro]} \quad (11)$$

where:

t_{P}^{α} average parking time of a loop $[hour]$

k_{P}^{α} average parking fee of a loop $\left[\frac{euro}{hour}\right]$

$\varepsilon_{Pt}^{\alpha}$ correction factor for the average parking time

$\varepsilon_{Pd}^{\alpha}$ correction factor for the average parking cost

ε_{T}^{α} correction factor depends on the category of vehicles (light track, camion, etc.)

Average wage cost of drivers

Average wage cost of drivers can be calculated with:

$$K_{D\alpha} = T_{\alpha} \cdot b_{\alpha} \cdot \varepsilon_{D}^{\alpha} \text{ [euro]} \quad (12)$$

where:

T_{α} is the time consumption of a transport loop [hour],

b_{α} is the average wage cost of a driver $\left[\frac{euro}{hour}\right]$,

ε_{D}^{α} is a correction factor for the average wage cost of a driver.

Maintenance cost of the vehicles

Maintenance cost of own vehicles include the costs which are independent on usage of vehicles, it means that these costs are realized when the vehicles are not on way (e.g.: leasing, maintenance, assurance ...).
Maintenance cost of a transport loop:

$$K_{M\alpha} = T_{\alpha} \cdot k_{M\alpha} \cdot \varepsilon_{M}^{\alpha} \text{ [euro]} \quad (13)$$

where:

T_{α} is the time consumption of achievement of a loop $[day]$,

$k_{M\alpha}$ is the specific maintenance cost of vehicles (leasing, maintenance, assurance, ...) $\left[\frac{euro}{day}\right]$,

ε_{M}^{α} is a correction factor for maintenance cost of different vehicles.

During the route planning optimization the total prime cost should be minimized.
The main aim of our software to be developed is the optimization of transport tasks.
Well organized transport loops result higher profit and lower operation costs for the company, lower specific transport cost for the customers and lower air pollution.

ROUTE PLANNING METHOD

Actually at the forwarding company the route planning is completed by planners without any optimisation. There is a demand for application of an efficient optimisation algorithm during the planning process.
The software module to be developed will be used during the long and short term route planning and generation of master- and fine scheduling.

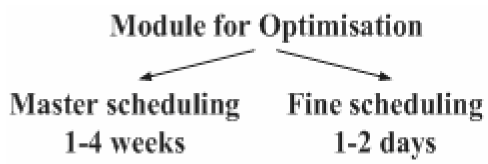

Figure 3. Time horizons of scheduling

Aims of master- and fine scheduling are the scheduling of forwarding activity and allocation of vehicles to destinations and tasks. Time interval of master scheduling is 1-4 weeks, 1-2 days in case of fine scheduling.
This software module can support the activity and decision making of general management and planners.
Figure 4 shows the generation algorithm of transport plans.

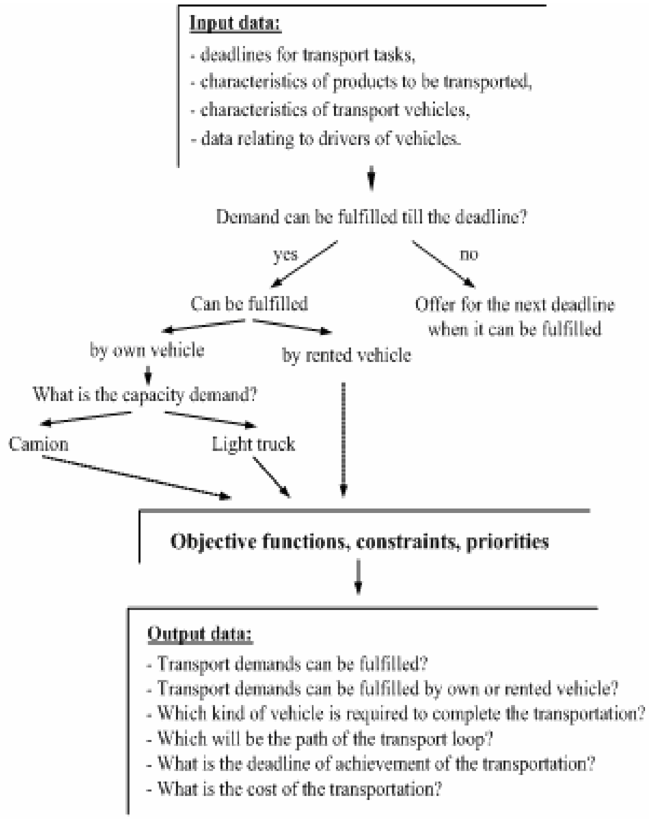

Figure 4. Process of generation of transport plans

Steps of master scheduling are the followings:

a. Input data are the followings:
- *deadline for transport tasks,*
- *characteristics of products to be transported,*
  - *volume,*
  - *special requirements,*
- *characteristics of transport vehicles,*
  - *available the required vehicle or not,*
  - *capacity demand,*
  - *fuel consumption,*
- *data relating to drivers of vehicles.*

b. Demand can be fulfilled till the deadline? If can not be fulfilled the next deadline should be defined till the transport task can be completed.

c. Task can be fulfilled by own vehicle or by rented vehicle. If the task can not be fulfilled by own vehicle or by rented vehicle offer for the next deadline when it can be fulfilled.

d. What is the capacity demand? Camion or light truck is required?

e. Objective functions, constraints, priorities are applied for the optimisation.

Possible objective functions of a multi-objective optimisation:
- *total prime cost of transportation should be minimal,*
- *lead times should be minimal (time consumption of transport activity, loading in and out, waiting time, ….).*

Constraints:
- *Utilization of resources should be maximised:*
  - *vehicles,*
  - *human resources.*
- *Customer demand satisfaction should be maximised.*
- *Constraints for vehicles:*
  - *Loading capacity (camion or light track).*
- *Constraints for products.*

Priorities:
- *for vehicles:*
  - *own or rented,*
  - *preferred one of own vehicles.*
- *for customers:*
  - *regular customers,*
  - *new customers.*
- *for transport loops:*
  - *task arrived earlier has priority.*
- *for products.*

f. Output data are the followings:
- *Transport demand can be fulfilled?*
- *Transport demand can be fulfilled by own or rented vehicle?*
- *Which kind of vehicle is suggested to complete the transportation?*
- *Which transport tasks can be integrated together to maximize utilization?*
- *Which will be the path of the transport loop?*
- *What is the deadline for achievement of the transportation?*
- *What is the cost of the transport task?*

ADVANTAGES PROVIDED BY THE APPLICATION OF SOFTWARE MODULES

Evaluation of logistics indicators relating to transport activity can provide useful information because the analysis of historic data provides a real view of the company activity. This information can be useful for decision making of the general management, and during the daily routine (planning on short and long time interval) on operative level.

Transport loop planning based on optimisation provides automatic / semi-automatic plans for short and long time intervals and optimal utilization of resources (human and vehicle). Application of this software module results planning of low cost transport loops so a higher profit can be realized at the company. The lower transport cost provides lower price for the customer, which results higher satisfaction of customers.

The amount of used fuel is globally can be decreased, which results lower air pollution.

The R+D project is under elaboration, after the finalization of optimization algorithm software modules will be developed.

SUMMARY / CONCLUSIONS

The paper introduces the conception of software to be developed for a company in frame of a research project.

This software has two modules, the first is an evaluation module, and the second is a planning module.

The planning module support the organization and optimization of transport loops which can result higher profit and lower operation costs for the company, lower specific transport cost for the customers and lower air pollution.

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REFERENCES

[1.] R+D report completed for a Hungarian forwarding company, University of Miskolc, Department of Materials Handling and Logistics, 2011.

[2.] CSELÉNYI, J.; ILLÉS, B.: Logisztikai rendszerek I. - Miskolci Egyetemi Kiadó, 2004.

[3.] SZEGEDI, Z., PREZENSZKI, J.: Logisztika-menedzsment - Kossuth Kiadó, 2003.,

[4.] CSELÉNYI, J.; ILLÉS, B. szerkesztők: Anyagáramlási rendszerek tervezése és irányítása I., Miskolci Egyetemi Kiadó, 2006.

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