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INVESTIGATING AND REDUCING PACKAGING AND TRANSPORT COSTS BY GIS APPLICATIONS

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Abstract. Nowadays the various IT solutions provide possibilities in all fields of life for collect and make detailed analysis of data. With the help of these devices an opportunity presents itself to measure and record the effects which are occur in products during transportation. These data also can be pared with the geographical coordinates of the transportation facilities. The goal of the article is to sketch and present an IT solution, which can prevent the product and packaging damages or help to establish the origin of the damages with the use of this data. After the operation describing of the principles, the article presents the possibilities of the application by means of a case study.

Keywords: packaging-products, transportation, GIS providing, damage.

Jel classification: L91

1. Introduction

As it defined logistics is a part of supply chain management equal with the planning, implementation and management process with the will to meet the customer's requirements that the materials, semi-finished and finished products, and the related information are to be transported from the origin to the location of use in an effective and cost friendly way (Szegedi, Prezenszki 2003).

System implementation should be cost-effective. Of course, the situation is more difficult considering we have to calculate with stochastic effects in case of different logistic chains. Against this, conditions and values exist that can be recorded in an easy way using Geographic Information System (hereafter GIS). If you use them during planning phase, the route that was more expensive before, will become more effective and cheaper in total.

The aim is to create the funds of a system that supports the decision on routes. This application is based on database, and supports logistic staff to find a more economical 'route-value' even in more expensive transport route.

We know it from real life that product damage is one of the most significant wastes during transportation period that we should avoid in any case. Loss like this occurs even in the cases when all of the standards are complied.

The costs can be easily definated, but hidden costs emerge usually later. Fuel and wages are costs that can be calculated in a previous time, but wearing of tyres, punctures, and the damages previously unplanned - even in vehicles or in the products - are typical hidden costs if the rate and the punctual time of occur is not known.

However in the vehicle- road destinations the effects that impact the product can be definated with high accuracy. The errors on the road, the rail crossings are fixed points on the route that worth avoiding, so you will be able to reduce the failure factor of the cargo.

The aim is to set up a database with the recording of these coordinates and defining location. By means of the database you are able to minimize the damaging of products during the transportation period, so you will reach higher profit with saving of the products.

2. Logistic stresses during road transportation

During a continental road transportation, which includes the handling and storage processes too, it is quite easy to define the qualitative characteristics of the logistic stresses. These kinds of stresses, which include both mechanical and environmental stresses, have got high importance in the field of product – packaging development (Soroka 2002).

Before the design or development process we have to know all the logistic stresses.

The stresses have to be well defined by values, indicators or indexes. In the followings, we describe shortly, those affects, which have got high importance during road transportation.

The vibration stress means the major item by the duration. During the complete transportation process, the product packaging systems, like transport loads, get the affects from continous vibration. These vibrations can be developed from the unevenness or roughness from the road (like railway crossings, pitch-holes, etc.), and the combination of the vehicle's spring characteristic and the force of inertia with the unbalanced loads. The vibrations on the load platform are stochastic type, which means that the combination of the vibration frequency and amplitude strongly fluctuating at time. There are frequencies, where the amplitude exceeds the acceleration. In these moments, the load abandon the platform, but during the continuously appearing platform vibration the fallen down load be able displace (Mojzes 2008, Panczel 2006). In those cases, where both vertical and horizontal load position displacement appear, we often have to count with product or minimally packaging damages. Extremely, these affects appear as a shock stress.

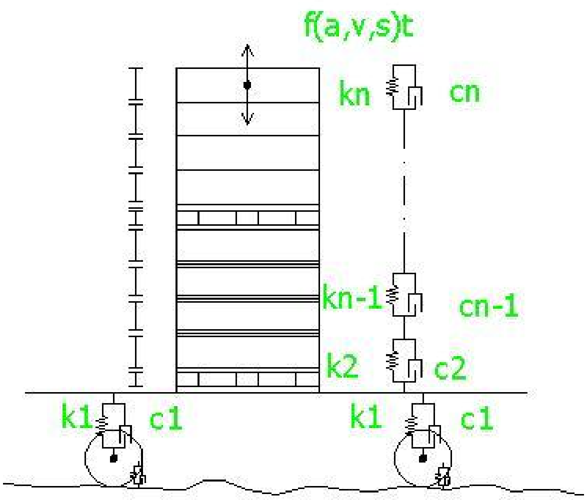

Fig. 1. Mass Spring Damper Model (Source: own drawing)

The Fig. 1. describe the simplified mass – spring model of a stacked load on a truck platform. The $k_{1..n}$ means the spring stiffness, the $c_{1...n}$ mean the spring stiffness.

The shock and impact stresses appear very often. But if we comparing a two different transport on a quite same route, the results will shows more differences in the number and intensity of the impacts. These characters highly influenced by more personal negligence and technical parameter. For example an improperly – means higher vehicle speed – passed railway crossing or road section, be able generate extreme high number impacts with extreme *g* values. The shocks and impacts also are able to appear in both vertical and horizontal versions. The horizontal impacts can cause, slipping of the loads (Mojzes 2007). For stacked loads the vertical impacts also can cause tippling or tip over. If we know the exact transportation way, the vertical impacts may be defined in quite good conditions, and critical areas and points also be able to predict well. During the handling and warehousing the impact characters also are able to forecast. (Burgess 1990). The Fig. 2.clearly describes those shock parameter interrelation, where the packaged product has got damge or not. The limits of the non – damage areas can be defined only be masurements.

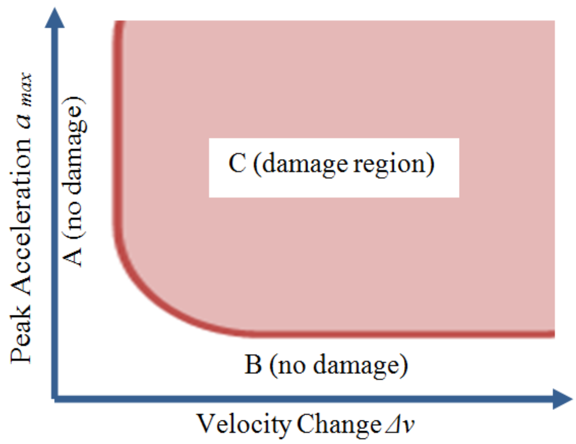

Fig. 2. Damage Boundary Curve of a packaged product (Source: own drawing)

Stacking during transportation or storage is a wide spread process, because by this we can improve more logistic indicator (Hellström 2007). So this parameter is essential during the product - packaging system development, but when we also count with the above mentioned stresses, we will get a very complex task, which conceal more design problem. Stacking stress can be appearing as a dynamic and as static stress too. Both types influenced by both technical and personal parameters on a wide range. By the improperly transportation and/or handling the distributed load is able to transform to a local load, which often cause product damage (Böröcz *et al.* 2008).

During an exact logistic process, which including the transportation, warehousing and handling, there is one more stress which continuously appear and attaching to the different mechanical stresses. This is affect is the different appearing forms of environmental or climatic stresses. During continental road transportation, the form and the exact values or parameters of the climate affects, can be well described and these are countable. A transport packaging which developed only for road transportation, the major effects are the relative humidity of the air, the temperature and its changes. The appearing versions of these parameters can highly influence the product protection function of the packaging system. There are many transportation task, when the developed packaging system has got good logistic and economic indicators and values, but the unknown or fail counted environmental stresses be able to reduce the efficiency and possible cause product damages (Böröcz 2007).

3. The summary of the operation

The summary of the operation is presented in Fig. 3. The device is tightly fixed to the load so it moves together with the goods when an impact presents on the road. The device writes the time, the latitude, the longitude and the measured values to its memory. After forwarding the collected data get copied into a computer. With the collected data the system is capable of looking for the cause of damage or buliding a database. In the first case it is possible to fix the time and position of the damage, and we can decide whether the damage could have been caused by driving, road conditions, weather conditions or other external factor. In the second case we can build a database by parametering a map with which we can decide which one of the two possible routes is the best.

When some damage happens after transporting then it is important to write down the typicals of the damage (Hirkó 1997). After that the process of the collected data is coming. The task is to select those data which are higher than the standard values.

So the task is to analyze the data of one route. Only the different values are important. The scale and the type of the value can explain the type of the damage. When these data are paired with latitudes and longitudes, the places of the events can be located. With the help of a map it is easy to decide whether the quality of the road, or a driver or other different external event is the cause of the damage (Street 2007).

A parametred map helps to choose different routes between two points in forwarding. Different routes had different distances, different road quality, different weather conditions, etc. So we can decide, that our product is packed strong enough for a shorter but harder route or we must choose a longer and more expensive route because the goods are too sensitive against external influences (Yao *et al.* 2008).

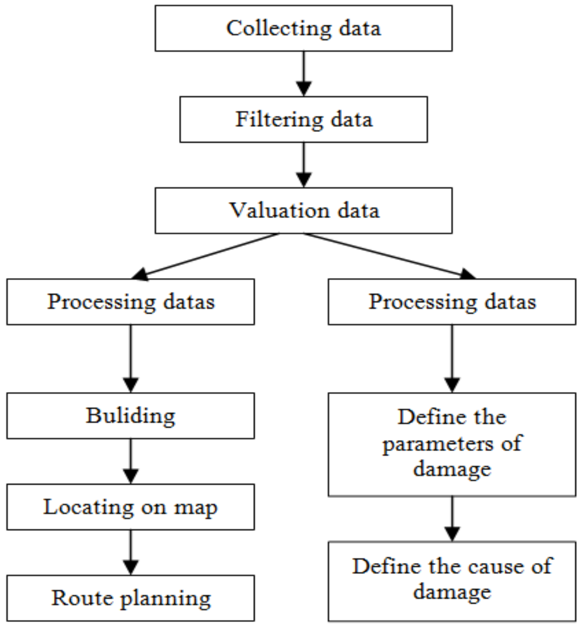

Fig. 3. The summary of the operation (own editing)

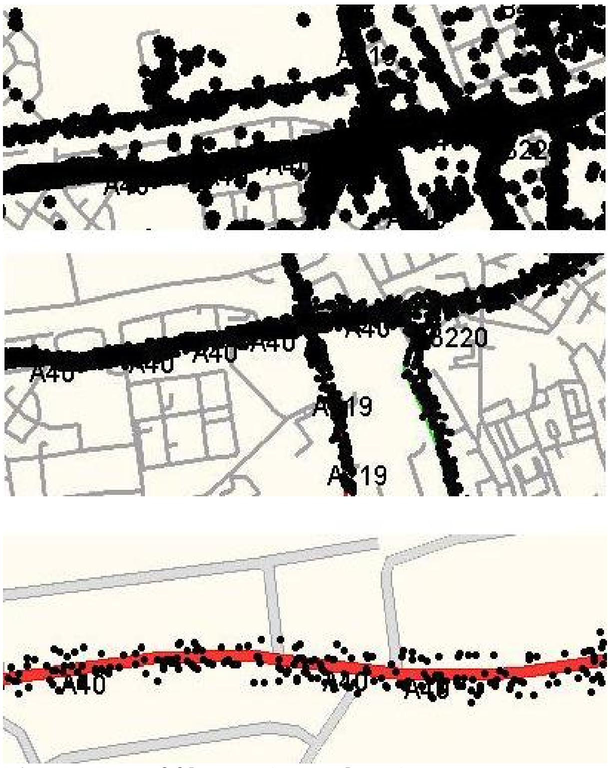

Fig. 4. Steps of filtering (own editing)

In this case a good map is required and a lot of collected data. The first step is to cut the normal values. The next step is to filter those data which are caused by the driving style (see Fig. 4). The model must point out just the road caused differences (Hirkó *et al.* 2005). When most of the collected data show the same differences on the same latitudes and longitudes then the possible place of the damage could be determinated. The latitude, longitude and the effect of the damage can be saved in the map database which is useful for the route planning. So with the help of the map and the database we can specify the suitable route and the exact cost of the forwarding.

4. Technological demands

The most significant participant in the system is a device, the data logger (Fig. 5). When the data logger collects all the required datas and the measuring frequency is thick then the collected datas are useable for a database. Of course not necessary to collect all the measured datas (Bajor *et al.* 2008). Practical if the data logger can filter the datas after they divergence and so collect just the datas what are above the limits.

The collecting of following datas is indispesable:

- temperature in the range -20°C - +60°C with min. 0,5°C resolutoin;
- humidity in the range 0 - 100% RH with min. 0,5% RH resolution;
- pressure in the range 300-1200 mbar with min. 0,5 mbar resolution;
- shock in the range 1,2-10 G with min. 0,01 G resolution.

For the accurate data collecting is necessary a few functional feature:

- wide operating enviroment, the device must work accurate when the temperature, humidity, pressure, shocks are in extreme value;
- long operating time, the duration of a forwarding from departure to arrival can be four or five weeks long and so the funtctioning and the data collecting must be continous at this time;
- memory and communication, a large quantity of datas come into being during a route, this datas must be saved on the devices memory or if its possible to send vis GSM/GPRS;
- recording rate, just the dense data recording give useful result, so the min. 0,5s recording rate is expecting.

The another significant participant is a good map. Not the levels of the map is the most significant in this case. A street level map is unnecessary. The most significant is the editing possibility of the map. In other words the adjustment of the sections of the roads with the collected datas (Taylor 1991). So during the planning we can se the highest shock value between the start point and the end point and with the datas of the packagings we can decide, that the selected route is suitable or we must choose another route for the transport. A possible solution can be Google Maps, which is a well usable device. With an easy software we can compare the datas of the routes with the datas of the goods and we can choose the best alternative (Horváth 2009) (Fig. 6).

Fig. 5. The components (own editing)

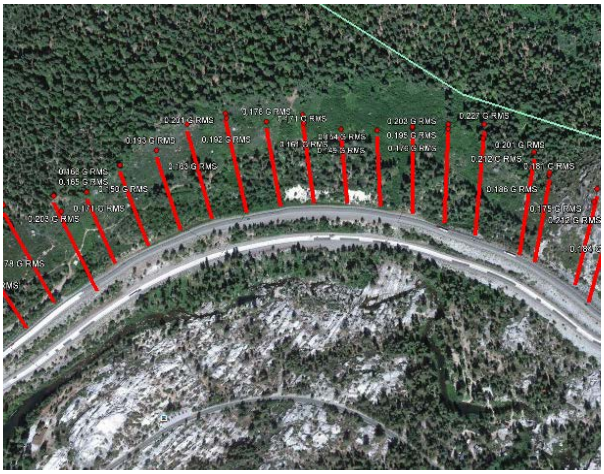

Fig. 6. Measured g values imported to Gmaps (Source: own measurement and Lansmont Ltd)

To absolve those requirements, which we describe, and to be able to measure the mechanical and climatic values, we have applied the apparatus with the following technical parameters.

- sampling frequency 50 – 10.000s/channel;
- acceleration (3 channel) (warning and limit settings);
- temperature -55 - +85 ^{o}C;
- continuous data recording;
- moisture (0-100% RH);
- GPS to Gmap;
- The battery life 30 days.

5. Case study

In Arad (Rom) produce company automotive products. They will transport regularly for a new partner to Moskva (Rus) these items. In the case of one sample's damage, the partner sends back the whole transport (as regular, according to the automotive requirements).

From Zhytomyr (Ukr) to Moskva the only possible road is main road. But from Arad to Zhytomyr are two possible ways. One is through Romania, and the other one is through Hungary. The Romanian roads are in worse conditions like the Hungarian roads, but the distance is lower at Rumanian version. What is the better decision? Shorter route with more stronger and expensive boxes, or longer distance with cheaper but not so minimalized strength boxes (Fig. 7 and Fig. 8).

The order quantity is 52 palettes. The usable vehicle is a 24t lorry. The shipment is on 1000×1200 mm palettes, 40 boxes on one palette. So when the palettes are in two stacks on the lorry, one lorry is enough for the transport of the order quantity.

The used box quality type is 22B. But the shorter way is main road with long mountain sections and over twenty rail crossings to Zhytomyr. So the 22B box type is not enough strong for stacking on the vehicle. In this case the company sends the order quantity with two lorries or use stronger box type for stacking to reach better logistic indexes. Based on mechanical and climate stresses and its simulation, the 32BC box quality type is necessary for this way.

The longer way is motorway in Hungary; there aren't mountain sections or rail crossings. The 22B box is enough strong for stacking.

The manufacturing costs are 0.42 EUR (22B) and 0.55 EUR (32BC) per box with 310 HUF/EUR rate.

The km cost of the lorry is 1.1 EUR/km., based on hungarian company's information

The total box quantity of the order:

$$Q_b = O_q * P_q \tag{1}$$

where:

Q_b – quantity of the boxes,

O_q – order quantity,

P_q – box quantity pro palette.

so:

$$Q_b = 52 * 40 = 2080 \ pcs$$

Manufacturing cost of the order quantity:

$$C_m = Q_b * C_t \tag{2}$$

where:

C_m – manufacturing cost,

Q_b – quantity of the boxes,

C_t – unit cost of the box type.

so:

$$C_m^{22B} = 2080 * 0{,}42 = 872 \ EUR$$

$$C_m^{32BC} = 2080 * 0{,}55 = 1141 \ EUR$$

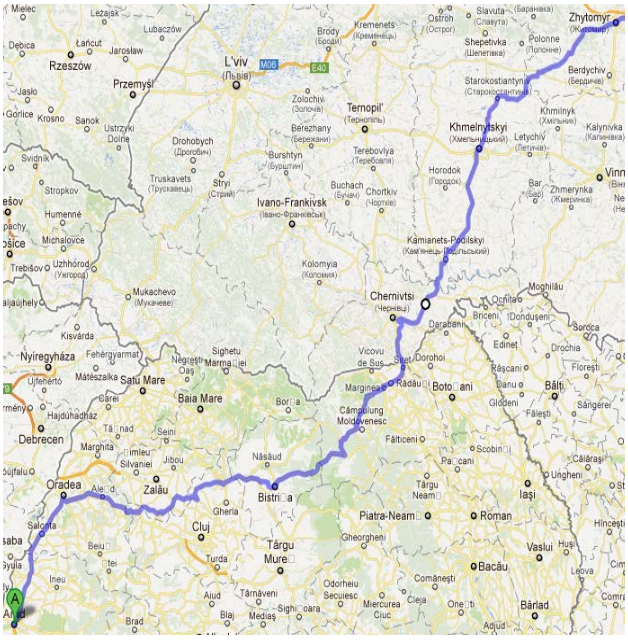

Fig.7. The shorter way (source Gmaps)

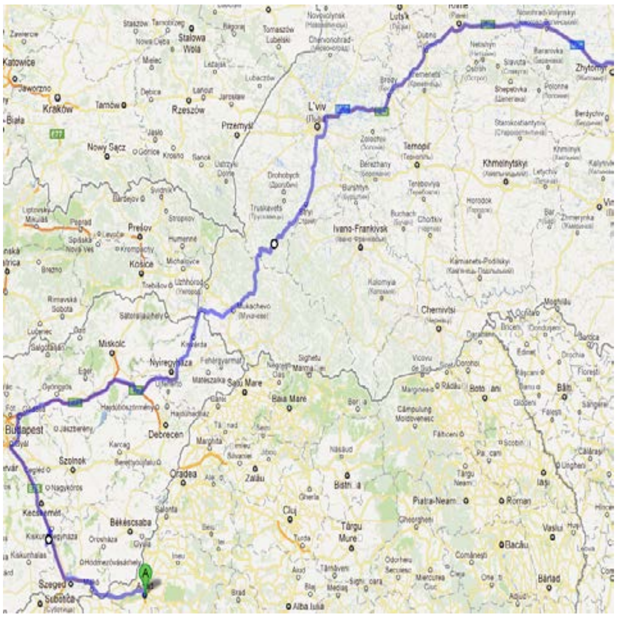

Fig. 8. The longer way (source Gmaps)

The comparison of transportation versions is presented in Table 1.

Based on the costs established that the transport costs are higher than the box costs so necessary to transport the order quantity stacked with one lorry, so version 1 is not useful. On other hand the difference of overall cost of version 2 and version 3 is just 43 EUR, ~ 1.3 % of the overall costs (Fig. 9).

Table 1. The compare of the versions

Version	1	2	3
Way	Shorter way	Longer way	Shorter way
Box type	22B	22B	32BC
Distance (km)	1974	2257	1974
Transport cost (EUR)	2 x 2171	2483	2171
Box cost (EUR)	872	872	1141
Overall cost (EUR)	5214	3355	3312

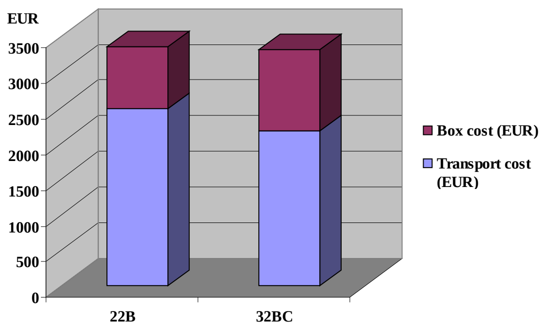

Fig. 9. The ratio of the box cost and the transport cost (own editing)

Comparing the results, the difference is minimal, but if we considering the below written complex packaging problems and the earlier measured logistic stresses, and the actual requirements of the automotive industry, we should chose that version, where the risk are less.

So additional factors be able to influence the decision between the versions.

6. Conclusions

Based on the previous measurements and the earlier performed data collection about the described route, it is clearly emerging, that the personal (driver) and infrastructural (road, etc.) parameters has got high importance in the transportation quality and the product damages.

The main task was to optimize the transport and packaging cost, and minimize the product damages on a constant road transport direction.

We compared two direction versions, and additionally calculated the transport and different kind of packaging costs. The main difference were that the distances and road qualities are different in the versions, these parameters and the mechanical and climatically stresses influence the possible applied box material qualities, which also affects the stack ability of the loads. The quality of the boxes has got high importance about stacking and transport efficiency.

From the calculations and the measured values, it is clear that costs of the longer route, with minimized quality boxes, are quite same with the short route with higher box material quality (both types are stacked). The originally applied version with low quality and shorter route showed worse values because in that case we could not apply stacking on the platforms, because the high risk product damages. If we count with the described additional effects and not only with the cost, it is clear that the longer route with more transport cost is worth.

The described methodology should be a good process to investigate the logistic stresses and should be good support to develop suitable product packaging system, both economical and logistic aspects.

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