HVTT15: Estonian VELUB system for more efficient and greener transport VELUB SYSTEM IS A SMALL PART OF THE MUCH BIGGER, THEORETICAL, MVMC SYSTEM (E^{N} DIMENSIONAL MOVEMENT CONTROLLING SYSTEM)



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Abstract

Hard conditions for road building and maintaining in Estonia have pushed us, since 2010y to develop the digital solution to help the road owners and police to monitor the abnormal heavy vehicle movements in the Estonian roads. At the beginning digital temperature sensors were installed into road construction over Estonia for winter time transport efficiency. Last years the GPS signal must be provided to get VELUB digital permit for year-round operating with 52t. Digital strong corridor (purple lines) on the road map must be followed. Efficiency growth is estimated up to 25%, greenhouse gasses degreases in the same time ca 20%. As nearly 2 times more tires are demanded than ordinary minimum, the tensions to the pavement goes down more than 50%. The week bridges are not marked inside the purple (strong) corridor. The next step is to develop VELUB 2.0, were the GPS log files are automatically controlled and compared with allowed purple corridor. All interested road owners may contact with us, for developing universal cloud platform.

Keywords: Estonian VELUB System; Efficient and Greener Transport; Reducing pavement tensions, Theoretical MVMC System

1. Introduction

Estonia had before 2011y regulation that only 52t timber trucks, with 6-axle vehicles were allowed to drive, if there was at least 2 weeks frost, below -8*C. It was the first version of that kind heavy vehicle movement controlling legislation. It had a big safety factor, because it meant ca1m frozen pavement construction.

The time in 2010y was only ca 2 weeks, the 52t trucks could practically use that regulation. Also, the special permit was given for a two week, what was not OK, if there was a warm cyclone coming in a few days. The climate had changed, we noticed then, in the practical, every day's life in Estonia – no classical winter anymore (with a few freeze-thaw cycles).

But the freight volumes are growing in all over the Europe (Figure 1) and we have now more moisture in the road constructions when ever before. It makes the construction much weaker – so the engineer technical solution must be found, we thought in Estonia in 2010 year.



Figure 1 - Freight transport activity, 1990-2030y

2. Objectives

Estonia has developed for 52t timber transport 2 possibilities with help of the many scientific studies.

First option is the winter time, when the roads are 0,5m in deep frozen. In every 15 counties, there is one temperature sensor stick which measures up to 2m in deep temperatures. If 0,2m and 0,5m sensors are >-0,1*C by 16.00, o'clock, then for the next day the 52t are allowed to

load (for who have applied the licence for 52t in VELUB system). The 18,75m vehicle must have min 6 axles then.

For the year round 52t timber transport (second option), the 18,75m vehicle must have 7-axles, double tires and the GPS and pay the fee 500EUR/y + each municipality 100/y according to legislation. According to the legislations the municipalities can authorize (6 different options) Estonian Road Administration to collect the fee and mark in the VELUB map the roads for 52t transport (with purple colour).

3. Research approach

In the VELUB System the trucks must start the e-cargo paper while loaded (in the mobile app). At the moment, most of the GPS system suppliers (ca 6) have passed the signal and the trucks can be seen and registered in the system (Figure 2).



Figure 2 - Digitized Estonian road map for 52t transport (purple lines)

The loads are at the moment declared by the driver when starting in the VELUB in the e-cargo paper. With the help of the VELUB GPS data, since 2018y the police can a bit better way to monitor the traffic and measure also with static weights the declared loads. GPS data is sent in every 5 min interval.

In the near future, there can be sent to the VELUB also the WIM (legally taught) data from the trucks central computer, so that the e-cargo paper can be started i.e. automatically then the truck

is heavily loaded. This data can be sent with GPS coordinates in every 5min. Also, the VELUB <u>can be programmed to alert if not driving in allowed corridors</u>. The log files can record 1-year data, until the next licence approval time.

We hope that the VELUB system is developing every year a bit and maybe in one day something similar is going to be used in whole Europe for longer and/or heavier vehicles to monitor the trucks to protect other road users and road in most effective way.

4. Expected results

All the VELUB Systems and the connected world (Figure 3) can be described in our understandings as following bigger theoretical model: automated digital Multidimensional Vehicle Movement Controlling System (ADMVMCS, or **MVMC System**), E_n Dimensionsal system).

VELUB System is not just a theory, its running, constantly tested and developed system in ecountry Estonia. ERA's VELUB System was developed and deployed first in the world, in the whole road network level in Estonia. You can apply even <u>e-residency</u> in Estonia (a government-issued **digital ID** available to anyone in the world, i.e. for using and testing VELUB, or i.e. starting a HV logistic company etc).



Figure 3 - VELUB – The Estonian Road Administration's special permit application system; ELVIS – State Forest Management's electronic cargo list information system

<u>The VELUB System Dimensions</u> ($\underline{E^n}$ perpendicular layers), in developing order:

- 1) § The <u>Text</u> Dimension, is needed for:
 - a) the concentrated and exact, results orientated, <u>text</u> descriptions for the scientific work orderings from scientific institutions (since 2010y);
 - b) the connected legislations, with the optimised amount of the clear <u>text</u>, according to the studies input (since 2012y);
 - c) optimized <u>text</u> Forms for the special vehicle permit applying via e-systems, i.e. VELUB, (since 2015y);
 - d) checking the validity of the all dimensions via e-systems, automatically and manually by the police (with the mobile app help etc), (since 2017y).
- 2) Θ (K) <u>Temperature</u> Dimension (<u>SI</u>, or Celsius ^odegree mostly used), is needed for:
 - a) determining in the winter time, the next day's 52t digitized road map area (15 county's sections separately, by 16.00 o'clock see the Time Dimension). Allowed then by legislation, min 6-axle, max 52t vehicles (must have always valid VELUB permit). Digitized roadmap of the winter time layer (see the Figure 4 & 5) is depending of the freezing temperature, at 0,2m (<-0,2*C) and at 0,5m (<-0,1*C) depth (ca10x higher pavement bearing capacity MPa then);
 - b) may also be used i.e. to restrict the HV traffic if pavement <u>temperature</u> (asphalt, bitumen) is too hot in summer time etc.
- 3) T (s) The <u>Time</u> Dimension (SI), is needed for:
 - a) validation the period for special permit (<u>time</u> depending licence in the VELUB System), (since 2015y);
 - b) In case of the violation, it can be set <u>time off</u> period for special permits etc (near future option);
- 4) € (sent) Economical Dimension, is needed for:
 - a) <u>CBA</u> (<u>HDM-4</u> method or similar, is also for Environment impact, Social aspects etc) analyses in the scientific research period. It is needed for deciding the best socioeconomical *methods and options* to develop further:
 - i) the country <u>network constructions</u> (specially some old, long span bridges strengthening, rebuilding etc for 52t vehicle) or,
 - ii) the <u>Heavy Vehicle (HV)</u> on top of the network construction (demanding more axles, double tires, GPS data, WIM on board data, etc) or,
 - iii) both options simultaneously with VELUB System (ADMVCS) like in Estonian case.
 - b) e-payment solutions to compensate the VELUB System development and the maintenance etc for the ERA (500 EUR/y) and for the municipalities (79 municipals since 2018y, 100 EUR/y each applied, since 2015y);
- 5) X(m) Length (longitude) Dimension (SI), is needed for:

- a) along the road transport controlling, 1D (milestones)
- b) GPS&Galileo real-time tracking for special permit transport (52t, since 2017y);
- 6) Y(m) Width (latitude) Dimension (SI), is needed for:
 - a) the surface (and the sea) transport controlling in whole World, 2D
 - b) GPS&Galileo real-time tracking for special permit transport (52t, since 2017y);
- 7) Z (m) Hight (altitude/elevation) Dimension (SI), is needed for:
 - a) <u>the near future</u>: air (<u>e-taxi drones</u> in Dubai, planes, etc); underwater; space (not with GPS, but with better range) vehicles movement controlling.
 - b) with the z-coordinate can also be described digitized roadmap (purple in VELUB)
 lines in 3D (with the xyz-axle line radius/thickness) so that it can look like the
 <u>Virtual 3D flying corridor</u> (similar 3D tube <u>samples</u> in transport systems), what is
 depending on other Dimensions (Time, Temperature etc so they are opened
 automatically for the single time flight, i.e. for the drone taxi single flight, from
 random point A to B, via the 3D digitized tubeline);
 - c) GPS&Galileo real-time tracking for special permit transport (52t, since 2017y). The mountain area ground transport better controlling (but it is also possible with 2D map).
- 8) M (kg) The Mass Dimension (SI), is needed for controlling the vehicle <u>masses</u> (via constant (i.e. 5 min interval). <u>WIM on board data transfer</u> (by the axle loads and total masses etc planning to test it in Estonia in 2018y);
- 9) I (A) Electric Current Dimension (SI) (Energy Supply Dimension), is needed for:
 - a) the electric energy supply for the e-vehicle movements in near future. Movement is controlled by energy supply (no e-energy no movement soon or later);
 - b) the green electric energy collecting with 5G (5th generation) <u>electric pavement</u>. It will be after 2030y integrated to the road surface, probably in quite large amount of the road surface area, around the world (see the <u>China</u> 1km in December). So, it is possible to integrate that layer to **MVMC System** by that time to control the (self-driving) e-vehicle movements, by suppling (via the €-Dimension, the clean energy them);
 - c) 5G pavement, for the electricity production and selling (i.e. with induction in dynamic mode, or static battery change/loading). Integrated LED traffic signs, marking, heating etc systems can in future integrated to the 5G supporting pavement (F=-F, supporting the HV load on the top).
- 10) ∞ Infinite Loop is needed for the generating and optimizing <u>constantly</u> the other Dimensions in the real time **MVMC System** (VELUB System is just a smaller, but with the same principles System).



Figure 4 - Digitized roadmap of winter times layer, depending of the freezing Temperature, at 0,2m (<-0,2*C) and at 0,5m (<-0,1*C) depth (06.02.18)



Figure 5 - Digitized roadmap of winter times layer - <u>west coast (1 county) is missing</u> – because the warmer sea area at this day

5. Conclusions and discussion

We see the future of the theoretical **MVMC System** (E_n <u>Dimensional</u> system). It gives as a lot of ideas where, and then, we should develop further our VELUB System, what we use daily in our e-country, Estonia. Also, we think and try to manage with all the HVTT15 central topics in small Estonia (Figure 6).



Figure 6 – HVTT15 topics

In small Estonian state, the 52t timber transport project saves already ca 10mln EUR/y and ca 20% CO2, NOx. In the future, the road and bridge constructions can be protected even more (more savings) when VELUB System is going to alert (with the WIM on board) and store the overloaded axles, total loads, especially in spring thaw time. Theoretical limit is with 52t (with all cargo mode) ca 50mln EUR/y in a small Estonia, but in the World it may be billions/y (+environment savings if controlled the vehicle movement in right corridor, with the right mass on top, etc).

We'd like to know, if the other countries are seeing also the need for the theoretical Multidimensional Vehicle Movement Controlling System (**MVMC System**) to develop further and also the need for the practical **VELUB System**, based on this theoretical **MVMC System** model?

But you should consider, that **MVMC System** is not just a 100% theory, it is running partially in the VELUB System, is constantly tested and developed system in e-country Estonia. ERA's VELUB System was developed and deployed first in the world, in the whole road network level in Estonia. You can even apply <u>e-residency</u> in Estonia (a government-issued **digital ID** available to anyone in the world, i.e. for using and testing VELUB, or i.e. starting a HV logistic company etc).

Do you think, it's too much with 2030y computing power, in the whole state level, to handle that BIG data (with 5G mobile speed), via MVMC System Cloud (ca 5min interval E_n -dimensional, small, text files transfers (possible to change the data interval step from nanoseconds to the days). Or, do you think, MVMC System and VELUB Systems might be strong alternative to take the maximum out from Multimodal Transport Mode? There will be also be soon in the EU, the first PB standard (v.1.0) to help the road owners (NRA's) to define the Dimensions (digital layer limitation) values, with the required min safety factors still included (Figure 5).



Figure 5 - FALCON Project standard architecture scheme

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