WIBS AND NEW ROAD PRICING FOR HEAVY TRUCKS

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1. PROBLEMS

1.1. Pavement damage

The load carried by each vehicle axle determines its destructive effect.

Pavement damage factor is proportional with Load Equivalency Factor LEF (AASHO Road Test):

$$LEF = \left(\frac{P}{80}\right)^4$$

where (Fig. 1)

P=actual axle load [kN]

Standard axle load: P_N = 80kN

P_N =FS (Full Scale)

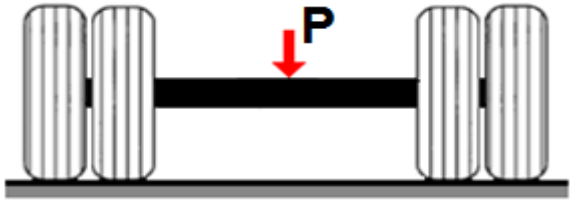

Fig. 1. Single axle

- All axle loads and configurations are converted into an equivalent number of standard axles.

Tab. 1. Damage result

(according to *The damaging effects of overloaded heavy vehicles on roads*, Department of Transport, Pretoria, South Africa, [1])

Vehicles		**Damage Result [%]**
Cars		small
Heavy Vehicles (HV)	**Legally loaded** (80-85% from HV traffic)	40%
	Overloaded (15-20% from HV traffic)	60%

Some trucks avoid enforcement on primary roads by using secondary and urban roads, which have thinner surfaces, more susceptible to overload damage.

1.2. Other effects of overloading

As well as damaging the road, overloading produces also the following undesired effects.

a. *Increased risk of accident*:
    - The overloaded vehicles are unstable and difficult to steer;
    - The braking distances are significantly increased;
    - Overheating of the brakes and tires;
    - Accelerated tiredness of drivers.
b. *Increases fuel consumption*
c. *Increases pollution*
d. *Premature vehicles and tires wear*
e. *Unfair competition in the transport field etc*.

1.3. Weigh-in-motion (WIM) sensors

WIM sensors, mounted in the roads, are used for overload detection, traffic monitoring, data collection for road design and maintenance and toll applications. WIM systems are expensive, their use is very limited and they can't to limit enough the trucks overloading.

1.4. Deficiencies of the existing pricing systems

- It doesn't take into consideration the *real wearing* of the roads and bridges *produced by each vehicle*;
- For the vehicles from the same category, the same price is paid regardless of the transported load, the distance, the road structure type (primary, secondary or urban roads, asphalt, concrete, earth roads), regardless of the bridge usage etc.;
- In the some countries, the same fee is paid, even if the vehicles circulate or not;
- *It is hidden and inequitable*.
- The penalty for the overloaded vehicles (if they are traced down!) depends on the overloading percentage above the maximum allowable load (FS), regardless of the transportation distance;
- The overloading inspections (WIM or static weighing performed with mobile platforms) are not so frequent and they are not discouraging enough this type of practice (the WIM systems are costly, and the use of platforms produce traffic jams).

2. STATE OF THE ART

2.1. Weighing-In-Built System (WIBS)

On the market there are many types of WIBS or on-board overload monitoring systems, used by drivers and fleet trucks managers [2, 3].

Functions:

- Axle, axle group and gross/net weight, displayed with a better accuracy (±1% ÷ ±3%, instead of ±6% ÷ ±10% for WIM);
- Overload protection;
- Balanced load distribution;
- Maximize payload capacity;

- Create customized reports;
- Automatic trailer identification ;
- 24 / 7 data collection;
- Telematics output and wireless access for real-time and audit/post audit activities.
- Quick and easy installation on all types of trucks (there are kits for existing trucks).

2.2. GPS Recorder with tracker systems

On the market there are many types of real-time GPS vehicle tracking systems with data logger, for professional fleet management [4].

Functions:

- GPS Recorder can be installed on any vehicle. It track, record and allow reports;
- The tracker reports its location to the server base or mobile phone and also indicates exact route, standing durations, speed, direction etc.
- Stored GPS logs can be transferred to any computer, allowing the *Travel History*, displayed on a digital map.

WIBS (on-board scale) and GPS Recorder save time and money.

3. SOLUTION

SOLUTION = *Modified* Weighing-In-Built System (**WIBS**) + *New* road pricing system (Fig. 2).

The innovation put to work together two existing techniques (WIBS and GPS Recorder), which works now independently. Using this connection between the two systems and a new pricing system, a lot of benefits can be obtained (Fig. 3, Fig. 4).

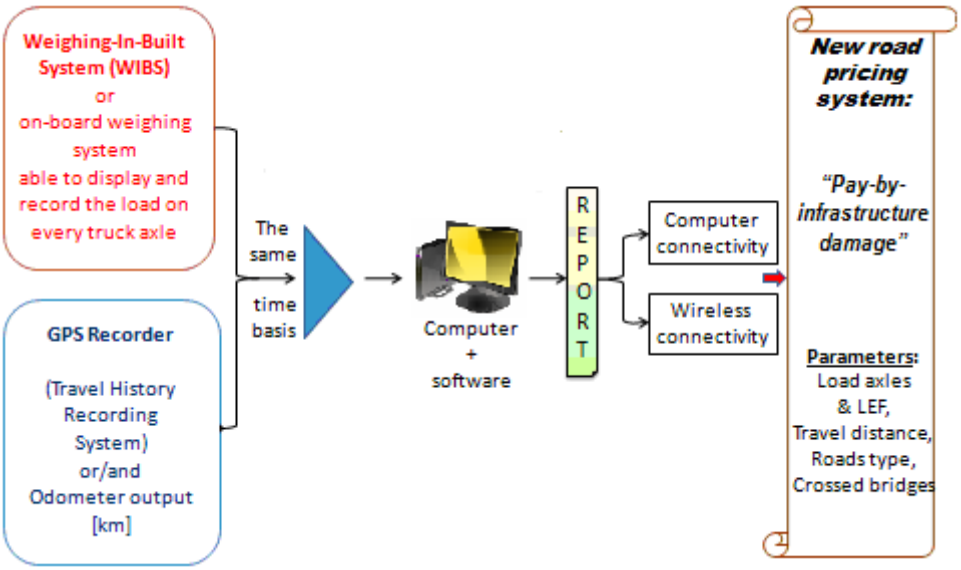

Fig. 2. Innovation presentation (flow chart)

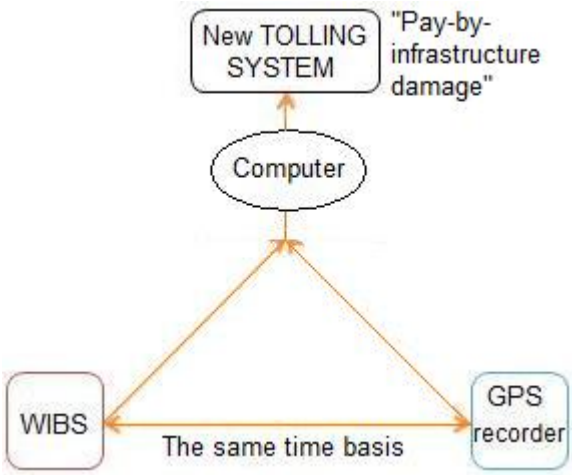

Fig 3. The basic idea of innovation

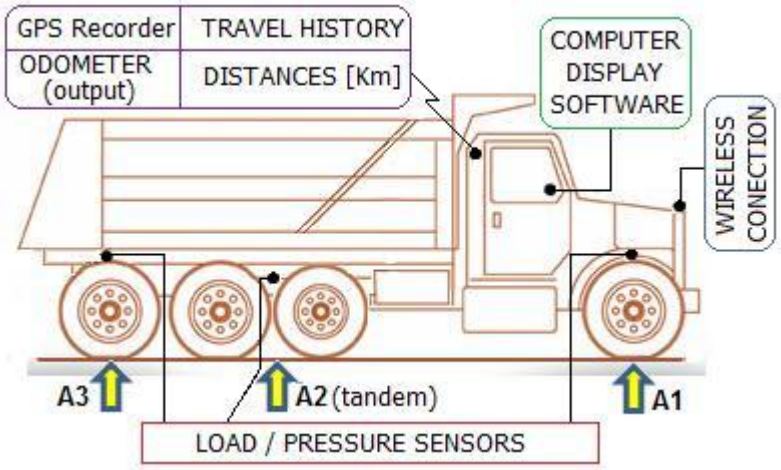

Fig. 4. Implementation of innovation on a truck

The travel history of a heavy truck and its axle A2 is presented in Fig. 5 and Fig. 6 respectively.

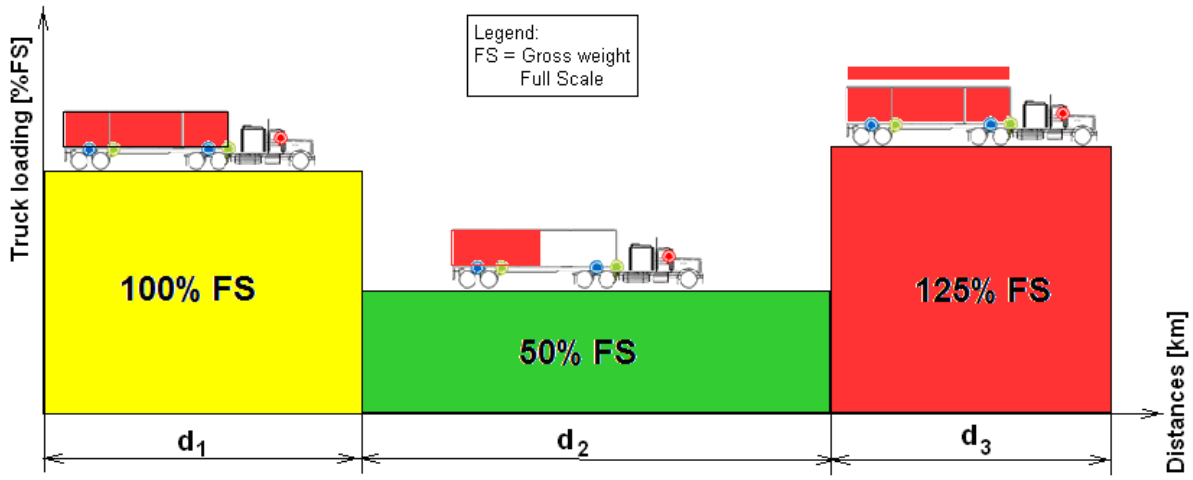

Fig. 5. Travel history of a heavy truck

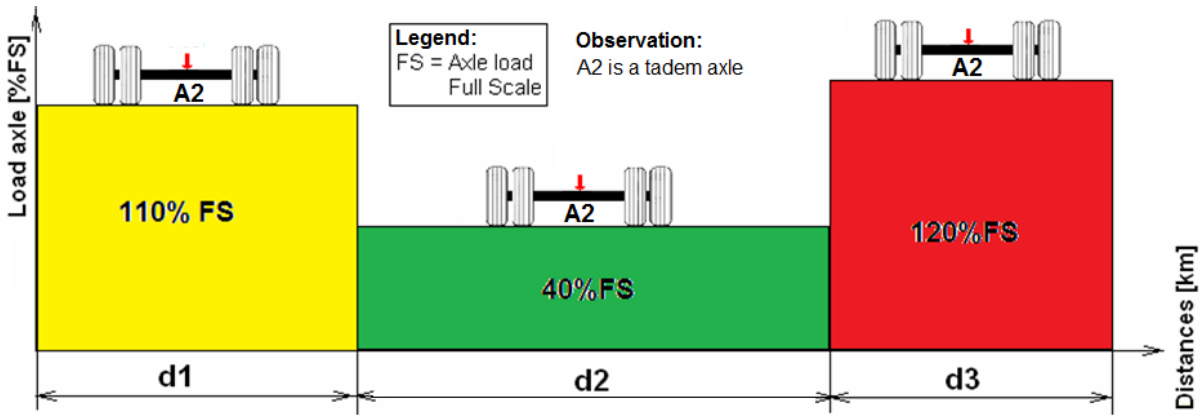

Fig. 6. Travel history of A2 axle

Pavement damage produced by A2 tandem axle and all truck respectively is proportional with (Fig. 4, Fig. 6):

$$D_T^{A2} \approx CFT\left[\left(\frac{1.1P}{80}\right)^4 \times d_1 + \left(\frac{0.4P}{80}\right)^4 \times d_2 + \left(\frac{1.2P}{80}\right)^4 \times d_3\right]$$

$$D_T^T = D_T^{A1} + D_T^{A2} + D_T^{A3}$$

where: CFT = Correction Factor for Tandem axle

4. ADVANTAGES

The innovation has the following advantages:

- The pricing is proportional to the damage caused to roads and bridges;
- The new road pricing system is more transparent and equitable (the cost of damages is no longer paid by the general public, but by instigators);
- The axle overloading can be better supervised at the national level;
- Structural pavement integrity protection;
- The system is also useful for the truck fleet professional management;
- It allows the weighing in motion inside the localities (nowadays they have very few available WIM systems);
- The damage produced by the axels carrying a load bigger than 100%FS will be paid (taking into account the travel distance, the road structure type, the crossed bridges etc.). The overloading penalty already imposed by existing regulation will also be added.

The acquired data can be transmitted to the authorities by the transporter:

- At previously established regulated time intervals (monthly, annually) and locations (e.g. along with the digital tachograph data, i.e. driving/resting diagram);
- With the occasion of unforeseen inspections;

- Telemetric (for example, when truck passing through WIM stations, the WIBSs can be checked, the transporter being noticed about the possible loss of calibrations) etc.

5. MARKETING

- 6.2 million medium and heavy trucks were in use only in EU in 2008, accounted for more than 75 percent of all inland transports, forming a € 250 billion industry [5]. 2 billion heavy trucks were produced in 2011 in the entire world.
- In the world there are 60 billion km of highways. Damage cost due to overloaded trucks is estimated to be from $0.8 to $2.50 per ton-mile, depending on vehicle weight [6].
- The number of fleet management systems in active use is forecasted to grow at a compound annual growth rate of 20.7 percent from 2.0 million units at the end of 2010 to 5.0 million by 2015 [7].
- The modified WIBS (including GPS recorder) will raise the price of a new heavy truck by about 5%. Some fleet managers (about 2 million in 2010) pay this price now, in order to facilitate the fleet management, without the benefits of this innovation advantages. Including innovation, they will pay the some price for more advantages.

The equivalent solutions are unknown.

In table 2, those who would be interested by this innovation are presented.

Tab. 2. Possible interest for this innovation

Who would be interested?	Why?
Governments and local authorities	• Better pavement and bridges protection • Decreases number of accidents and pollution • Fair competition in the transport field
Truck fleet managers	• Decreases cost-per-ton • Better and easier fleet management
Automotive industry	• More performing trucks will be produced
Suppliers for automotive industry	• Increases kits production (WIBS and GPS Recorder)

ACKNOWLEDGEMENTS

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