

Value of a SHARP traffic analysis for highway companies: the experience of SAPRR

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The manager of a road network must know what its traffic is composed of Which profiles ? Which loads ?

The Societe des Autoroutes Paris-Rhin-Rhone uses equipment combining piezo electric sensors, a loop and computer processing.

This ground station can tell in real time and lane by lane:

- * the weight of each axle
- * the total weight
- * the distance between axles
- * the speed of the vehicle
- * the type of passing vehicle from among 22 categories
- * the elapsed time since the last vehicle.

From these accurate basic data, SAPRR has a particularly useful tool.

From knowing the aggressivity of driving loads, we can understand better the proportioning of road structures and maintenance strategies.

From knowing the precise traffic configuration, the frequency of each type of vehicle, the rate of lane occupation etc, we can understand better the economic function of the work.

From knowing the driving loads and overloads along with their speed, we can understand better which areas of security need to be developed.

INTRODUCTION

The Société des Autoroutes Paris Rhin-Rhone operates a road network of more than 1,400 kilometres, located at the crossroads of the major roadways of Western Europe. Situated in the Eastern part of France, our motorway network is directly connected with the Northern, Central and Eastern European motorway network which represents the framework of a reunited continent.

Our company is licensed by the State to build and operate motorways. Consequently, it is responsible for the building and the maintenance of the work and receives toll fees. The SAPRR is therefore a company which has three main responsibilities:

- motorway construction on all sites, designed and carried out taking into consideration the interests of the operator and environmental factors.

- operation of the network, using the most efficient means to ensure traffic flow, security and information to the motorist.

- finally, a service to our clients who wish to travel quickly from one place to another, both in security and in increasing comfort during their long journeys.

Today our traffic is much heavier and certain routes have a rate of 110,000 vehicles per day during mass migration periods. This traffic which is subject to strong seasonal variations, ranging from 1 to 6, includes an average 25 to 33% of heavy duty vehicles depending on the route.

To improve the management of its work in design, construction and operation, the manager of a network, whether a motorway, a major road or an urban network, must be aware of its type of traffic in terms of:

- vehicles categories
- loads
- flows
- speeds etc.

To improve our understanding, we are constantly developing a data acquisition and analysis traffic system.

WEIGHING IN MOTION

Notable progresses have been made in the areas of sensors, their installation, electronic processing systems and transmission networks by ELECTRONIQUE CONTROLE MESURE company.

The French bridges, tunnels and roads services have for a number of years been perfecting sensors using piezo electric cables to master "Weighing in motion".

"Weighing in motion" must respond to several requirements of the transport sector:

1. The proportioning and the maintenance of the roadways of the motorway and road networks, the understanding of heavy duty vehicles aggressivity and the development of tools to assist in the decision making process of maintenance and repair policies.

Actually the strategic choices taken during the construction of our road network, the on-going investments and the adaptation of structures to the traffic, are dictated by a concern for economic optimisation.

It is necessary for us to verify the initial hypothesis and we require an encompassing road monitoring tool.

The proportioning of a roadway is carried out by taking into account the cumulative number of axles that it must support during its life-span.

It is necessary for us to know the axle weight and therefore the aggressivity of heavy duty vehicles. Only "Weighing in motion" allows us to determine this aggressivity and therefore to correctly proportion a roadway.

2. The proportioning and the maintenance of bridges, in view of the revision of the present regulations concerning weights, the preparation of new European euro-codes, the verification of exceptional and specific projects (special schemes) as well as the study of fatigue in metallic or mixed bridges due to traffic.

3. The monitoring and understanding of loads on the routes, in order to check adherence to the laws currently in force and to gather statistical data to increase the security of users.

These various headings are of interest to the organisations concerned by "Weighing in motion" such as central government ministries, urban communities, the licensed motorway companies and the police forces in charge of security and law and order. In fact, any person concerned with the management and running of a road system.

Within the framework of the French research group "Weighing in motion", in collaboration with the Laboratoire Central des Ponts et Chaussées and French motorways companies, the company Electronique Contrôle Mesure has developed an original design of a detailed traffic analysis station.

Description

The latest management systems installed are composed of:

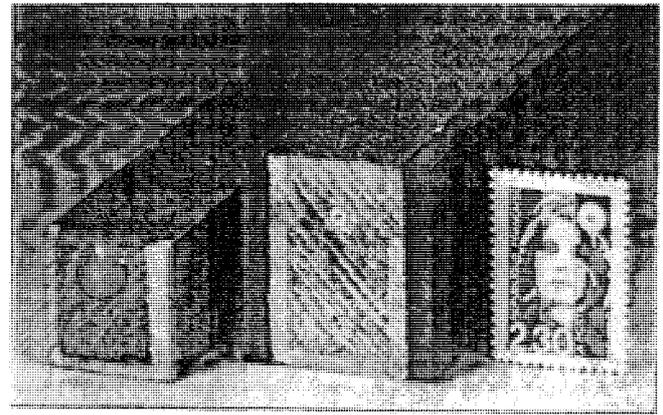
- two piezo electric sensors of the type industrialized by ECM, under licence from the LCPC
- one induction traffic loop per traffic lane.

For each vehicle we obtain:

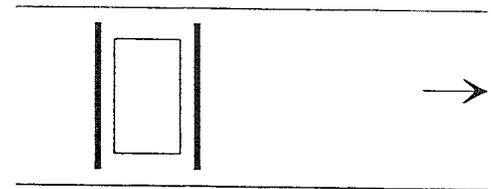
- its passage time
- its class
- its speed
- the weight of each of its axles
- its total weight
- the distance between each axle
- the length of vehicle
- the time since the preceding vehicle.

Each sensor is installed as shown on photography and in figure 0 (HESTIA). The resin used for the fitting of the sensors is chosen according to the mechanical properties of the roadway. The life-span of the sensors is five years or more than five million vehicles.

Informations from these sensors are sent to an intelligent detector which works by traffic lane and determines the measurement of each vehicle. Finally a central unit controls all the data from these detectors in order to process it according to the needs of the user and to communicate with the outside world.



HIGH SPEED CLASSIFICATION (HESTIA)



Classification from 25 to 200 km/h in 2 to 26 Categories by HESTIA with :
 - 1 loop
 - 2 PIEZOLOR C sensors

FIGURE 0

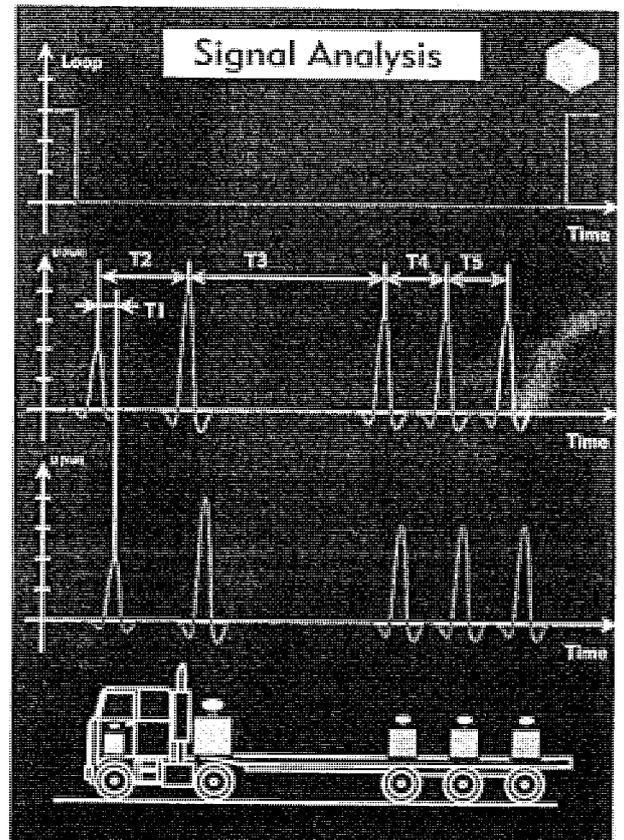


FIGURE 1

DIFFERENT CATEGORIES DETERMINED BY HESTIA STATION

PROFILES	HESTIA	EUROPE	NAME
	01	13	VOIT
	02	14	V1ess
	03	14	V2ess
	04	1	C2
	05	2	C3
	06	3	T2R1
	07	4	T2R2
	08	(4)	T3R1
	09	7	C2R2
	10	5	T2R3
	11	6	T3R2
	12	9	C3R2
	13	8	C2R3
	14	10	C3R3
	15	11	T3R3
	16	(7)	C4
	17	(5)	C5
	18	(4)	C2R2A
	19	(5)	C2R3A
	20	(6)	C3R2A
	21	(11)	C3R3A
More than 6 Axles	22	12	exp

FIGURE 2

CENTRAL UNIT

The main functions of the UC HESTIA card are the following:

- communication with the HESTIA DUs
- control of the memory
- control of the alarms
- communication with the outside world
- display of traffic in "real time".
- traffic data acquisition in four different forms defined by the user:

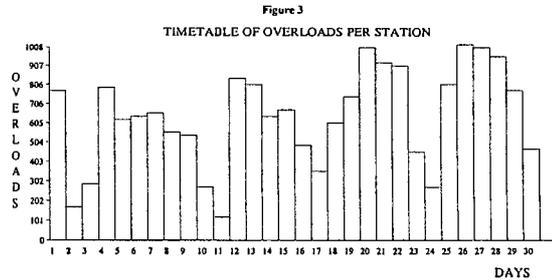
* vehicle by vehicle by integrating traffic lane choice and vehicle type

* SATL compatible statistics
 * LOTUS 123 C compatible expanded statistics allowing users to create their own software

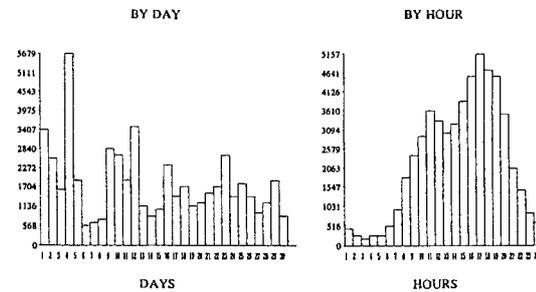
* real time which allows the station to be integrated into a traffic management network. The stored data only relates to classified flows, occupation rate, average speed by lane and by six minute periods.

From the information acquired, statistical processing is carried out according to the aims and interests of the user, e.g.:

- timetable of overloading per station in order to target potential heavy duty vehicles check days (figure 3)
- timetable of speeding by daily and hourly period (figure 3)
- tri-axle overloading (figure 4)
- distribution of number of axles by class of weight
- evolution of average traffic aggressivity (figure 5).



TIMETABLE OF OVERSPEEDING FOR LIGHT VEHICLES



RESULTS FOR NOVEMBER 1991

TRI-AXLES CLASSES OF WEIGHT - A 31 BEAUCHEMIN - TOUL SECTION

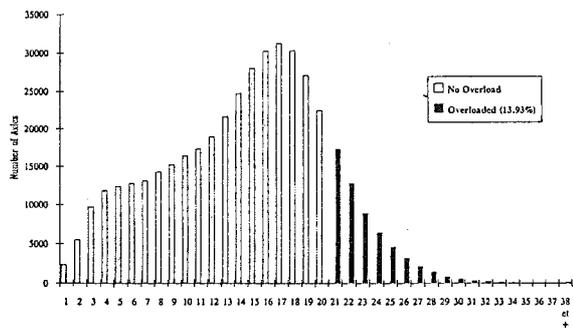


FIGURE 4

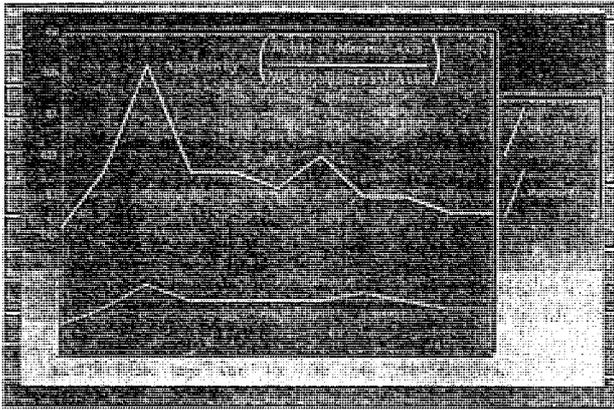


FIGURE 5

S.A.P.R.R. - Monthly Distribution of HDV. - Sample of 911 008 HDV

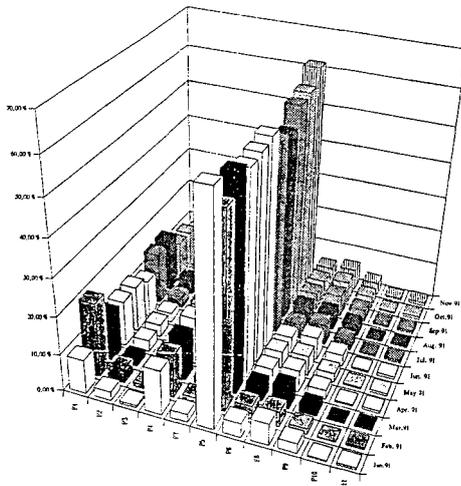


FIGURE 6

MEASUREMENT QUALITY

Accuracy and repeatability

Today the trials carried out on different sites have demonstrated that:

- speed accuracy is in the order of 2% for 95% of the vehicles and this without particular correction and independant of weather conditions.
- the classification by profile is close to 100% thanks to good speed measurement
- the weights on good profile roads (Holland) on four successive sensors show maximum deviation.

e = (maximum weight - minimum weight) average of the four weights

- of 10% for 60% of vehicles
- of 15% for 90% of vehicles

The repeatability in geometrically identical conditions therefore appears correct.

Various trials (CETE in Rouen, DOT in USA...) have shown that with continuous automatic calibration, 90% of vehicles are weighed to within ± 10% of their actual static weight, provided that the roadway is level.

Example of operation

Statistical operation

Figure 6 shows the pattern of the traffic on a SAPRR network at a fixed location.

Figure 7 show the statistical spread of loads according to axle type. These histograms are made up of one ton weight divisions.

Knowledge of this spread enables calculation of the traffic aggressivity and therefore facilitates roadway proportioning.

It is worth pointing out that non constraining dynamic weighing is the only interference-free method in the gathering of representative data, in constrast with constraining stationary weighing.

The stakes and objectives of tomorrow

We need an accuracy of less than 1.10^{-3} on the categories of vehicles to make progress in the field of rapid tolls or in-lane tolls.

However despite all the precautions taken on the choice of installations sites, the contact force values exerted by vehicles on the roadway will always be influenced by dynamic overloading due to excitation of the vehicles' suspension caused by the unevenness of the roadway.

Figure 7

SATL

MONTHLY NATIONAL INDICATOR

OF HEAVY LOAD AGGRESSIVITY

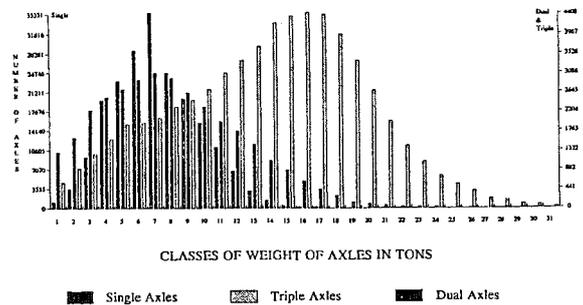
Results obtained for the month of November 1991 from all the stations installed in the national network.

The aim of this indicator is to determine average traffic aggressivity from the available data such as :

- total traffic in number of vehicles
- total traffic in number of axles
- number of heavy loads
- class of traffic (with reference to catalogue 77 of the types of structures of new roads).

Definition of heavy loads : vehicle whose total weight is greater than or equal to 3.5 tons.

DISTRIBUTION OF THE NUMBER OF AXLES PER CLASS OF WEIGHT



Multi sensor weighing must allow, through several evaluations of the values of the contact forces, to eliminate by digital processing most of these dynamic overloadings.

Numerous experimental and theoretical studies have already been carried out on this subject. However it is thought to be possible to increase the accuracy of the measurements by multiple linear regression between the statistical weight and the weighed values.

With the Laboratoire des Ponts et Chaussées and the company ECM, we are going to substantiate these findings by installing an example of this type in Spring 1992.

CONCLUSION

The quantitative analysis of road traffic is an important and constant preoccupation for the managers and engineers of the roads tunnels and bridges:

- To be able to have a maximum of traffic characterizing parameters

- To have sufficiently accurate knowledge of the composition, aggressivity and evolution of heavy traffic.

The evolution of technology today allows us to have a detailed traffic analysis station thanks to piezo electric sensors. Electronic and micro-computer developments allow the creation of increasingly complex equipment.

To link traffic data to meteorological data, to process them simultaneously in order to inform the users and the operators in real time is a new step forward towards the intelligent road.

The new European context, in a transit country such as France, is modifying traffic data. The help provided by the detailed traffic analysis stations in the decision making process, is and will continue to be highly appreciated from the economical and technological viewpoints.

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