

National research and development project on WIM

B. JACOB, Laboratoire Central des Ponts et Chaussées, Paris, France

SYNOPSIS : A research and development project began in France, early 1989, on the Weigh-In-Motion (WIM) techniques and devices, under the leadership of the Laboratoire Central des Ponts et Chaussées (LCPC). This paper briefly presents the objectives, organisation and results of this project.

1. OBJECTIVES OF THE WIM PROJECT

This WIM project was prepared during the year 1988, in a favourable context and to answer the expressed needs (ref. 1). The Bridge, Road and Transport Administration represented by its technical organisms (as the Public Works Research Laboratories including the LCPC), the major motorways companies, and the french manufacturers had acquired some experience since the late 70's, on the vehicle WIM. These research works were developed for various purposes, as the pavement and bridge design and maintenance, and the statistical knowledge of the traffic loads or the enforcement.

After more than 14 years of development of the WIM techniques by piezo-electric ceramic cables in France (refs. 2-4), it became useful to collect and compare the experiences of the various participants and to take better into account an increasing demand of the customers. It was also necessary to design and implement a new generation of WIM stations, including the latest improvements in electronic, computer hardware and software, and also in piezo-electric cable signal processing. Advanced research works were also undertaken on the multiple sensor WIM in order to improve the accuracy of the measured axle loads in comparison with the static loads, and on new types of sensors.

Therefore in accordance with the SETRA, the LCPC grouped together the abilities and the means, the manufacturers and the main customers of the WIM techniques and devices within a common R&D project. It intended to enhance the acquired experiences, to rationalize and to coordinate the research and development means, and above all to join together all the participants around common objectives by taking advantages of their complementarities.

The project answers to three main demands of the Public Works and Transport:

- the design and maintenance of the pavements on the highway and motorway networks, the revision of the pavement design code, the knowledge of the heavy traffic aggressivity and the fulfilment of some tools to help the repair and maintenance policies ;
- the design and maintenance of the bridges, including the revision of the existing bridge loading codes and the preparation of the new Eurocodes, the check of some particular or exceptional projects (as the future long cable stayed bridge of Normandie) and the fatigue studies for steel or composite bridges under traffic loads ;
- the survey and the control of the loads on the roads in order to enforce the law, and the gathering of statistical data for economical and safety purposes.

The main customers interested in this project are the road and bridge department, the transit department and the ground transports department of the Ministry of Public Works and Transports, the regional, urban and county authorities, the motorway (and tunnel or bridge) companies, and the manufacturers involved in the design and fabrication of the WIM devices.

2. ORGANISATION OF THE PROJECT

The project is conducted by the project manager (B. JACOB, LCPC) and the project vice-manager (M. SIFFERT, LRPC of Trappes). The participants are :

- **Public work laboratories and technical centers (Ministry of Transport) :** LCPC, Regional Laboratories of Trappes, Blois and Nancy, Centre d'Etudes Technique de l'Equipement (CETE) of Metz, Service d'Etudes Technique des Routes et Autoroutes (SETRA),

- **Motorways companies :** COFIROUTE, Autoroutes du Sud de la France (ASF), USAP,

- **Manufacturers and private companies :** Electronique Contrôle Mesure (ECM, manufacturer of the piezo-electric sensors and the new HESTIA WIM station), DROUARD (company which mounts the sensors in the roads), ALCATEL.

The project is organised in five Working Groups :

WG 1 : Development of a new WIM station HESTIA (chairman : M. MAEDER, ECM),

WG2 : Research works on the piezo-electric sensor, its mounting, the signal processing, and the calibration (chairman : M. SIFFERT, LROP),

WG 3 : Multiple-sensor WIM systems (chairman : M. EYMARD, LCPC),

WG 4 : New types of WIM sensors (chairman : M. CAUSSIGNAC, LCPC),

WG 5 : Customers requirements and project evaluation (chairman : M. PRUDHOMME, COFIROUTE).

The total budget reaches roughly 12 millions FF, including more than 70% of personal cost. 80% of the budget is covered by the Ministry of Transports through the LCPC, the rest is funded directly by non-governmental participants. All together, about 40 engineers and technicians are working at partial time in the project. The planned project lifetime is 4 to 5 years, then the end is expected in 1993.

The program includes theoretical research work on mathematical and statistical models, computer hardware and software developments, laboratory sensors and resins testing, experiments on roads with lorries, evaluation of the stations and working of the collected data.

3. RESULTS

The main results obtained after 3 years are :

WG1 : planning, design and development of the new WIM station "HESTIA" by ECM, presented in (ref. 5). This station was build following the specifications prepared by the LCPC, the SETRA, the LROP and the CETE de l'Est in 1988 (ref. 6). It answers to the demands listed in the paragraph 1/ and takes advantages of the most recent progresses in electronics, computer hard- and software and the experience on the piezo-electric sensors and the signal processing. HESTIA is a modular device, with a main card driving the data acquisition and processing, and one additionnal card per traffic lane. Each traffic lane contains generally 2 sensors measuring the axle loads independently. In this configuration HESTIA can manage up to 8 traffic lanes simultaneously. The integration of the signal delivered and the system calibration is automatically made sensor by sensor. The data may be either stored vehicle by vehicle or directly summarized into histograms on high capacity ROM memories (up to 8 Mb). The station may be initialized by a portable micro-computer, modifying the software or its parameters. Such a computer may either be used for data

storage or transfer. The data may also be sent by modem to a host computer. Some tests were made since 1990 with calibrated lorries and with real traffic vehicles in order to finalize the HESTIA station. Now more than a dozen of these stations are in operation all around the world.

WG2 : significant improvements of the WIM technique by piezo-electric sensors were obtained up to now. A new simple algorithm was just achieved for the signal integration in order to improve the accuracy and to avoid some double or triple axle misdetection. An automatic calibration procedure was introduced by the CETE de l'Est, using some characteristics of frequent heavy lorries, and implemented in HESTIA (ref. 7). Studies and comparisons were made on different resins for mounting the sensor in the road, in order to optimize the quality of the response and the durability of the sensor in the pavement. They lead to a guideline of sensor installation and calibration depending on the pavement properties. Quality control tests of the sensors before and after their installation are also developed.

WG3 : in order to reduce the variance of the measured axle loads and to close the gap between the dynamic and the static loads, due to the pavement roughness and the vehicle vibrations, a multiple-sensor WIM system was devised, using more than 2 sensors per lane. An advanced signal processing technique based on a weighted linear regression and a learning set of vehicles was developed, to combine the individual records of one axle on each sensor and to estimate properly the static load ; this procedure was tested by simulation (ref. 8) and is now under testing on real roads. HESTIA can handle up to 16 sensors for one lane.

WG4 : after many tests on various piezo-polymer cables, fibers and pads, we concluded that these products are clearly not proper for the WIM purpose. Some of them provide economical solution for counting or classifying heavy vehicles into a few classes, but they cannot give reliable enough individual

axle load. The main problem results from the inherent heterogeneity of the polymers, even when manufactured by the same producer.

A new type of sensor was found with the fiber optics, which may offer at a low cost a powerful WIM system and provide more information than existing sensors. A faisability study was conducted with on road testing and real vehicles, which showed the ability of such a system to measure axle loads with a very good sensitivity. A cooperation with ALCATEL is done to develop a prototype of a new optical WIM system.

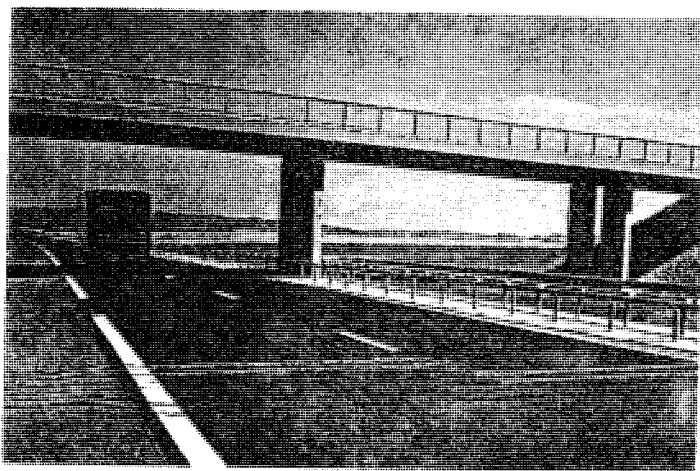
WG5 : the requirements of all WIM customers were collected, especially on the data transmission and the remote control of WIM stations. This lead to the adaptation of the new devices and to make them compatible with existing data transmission systems. The motorway companies especially take part in the development and testing of the HESTIA station. A guidebook of the WIM location choice and the pavement characteristics suitable to perform measurements with an acceptable or high standard of quality was prepared and is now printed. A databank of the collected traffic load data on all type of roads was created at the LCPC in 1990, in which a wide proportion of the traffic measurements in France (and some in EEC countries) are gathered. More than 150 traffic records over continuous periods between 1 and 8 weeks, recorded on more than 50 WIM locations since 1982 are already available. They contain all together about 2 millions of lorries. The databank stores information about the WIM location, the installed sensors and traffic station, the periods of measurement and the main statistics of the traffic parameters.

4. CONCLUSIONS

Beyond the fulfilment of the presented objectives and the achievement of the announced and expected devices, the thoughts of this project are to make better known the WIM tools and their applications, to be a forum for the

public and private authorities and customers, the researchers and the suppliers, where all the experiences may be exchanged and discussed, and to provide national technical and financial supports to the R&D actions. In september 1991 a national meeting was organized by the LCPC to widely present the project (ref. 9) ; more than 120 invited people attended this very successful meeting. Since the beginning of the project the R&D initiatives on WIM increased, are much better coordinated and becomes more efficient as before. The customers are much better informed about the new developments and the state of the art, they get fruitful councils from the technical institutes of the public Administration, they are associated to the R&D actions and support them. Their needs and demands are better and quicker taken into account in the new developments. The manufacturers and suppliers also get substancial technical assistance from the laboratories and from the Administration which puts the road and highway networks and some technicians at their disposal for testing sensors and stations.

Therefore all the participants in WIM actions benefit by such a national project, which initiated a strong dynamic current and activities.



A WIM site on a french motorway

5. REFERENCES

1. JACOB B., *Note de présentation générale du projet "Pesage en Marche" - Motivations et contenu technique*, LCPC Paris, Décembre 1988.
2. BESNARD S. and SIFFERT M., *Les câbles piézo-électriques : une innovation pour l'analyse de trafic*, Travaux n°572, pp 84-88, Décembre 1982.
3. JACOB B. and SIFFERT M., *An High Performant WIM System by Piezo-Electric Cables and its Applications*, Proceedings of the 1st International Conference on Heavy Vehicle Weights and Dimensions, Kelowna, B.C., June 1986.
4. SIFFERT M. and LESCURE B., *Evaluation of Heavy Vehicle Traffic and its Applications to Pavement Structural Design*, Proceedings 6th International Conference Structural Design of Asphalt Pavements, vol 1, University of Michigan, Ann-Arbor, July 1987.
5. MAEDER C., NICOLLE M., BOUGHABA A., *HESTIA Station - Second Generation Traffic Classification and WIM using Piezo-electric Sensors*, Proceedings of the 3rd International Conference on Heavy Vehicle Weights and Dimensions, Cambridge, UK, July 1992.
6. LROP-CCT and CETE Est, *Cahier des charges de la nouvelle station d'analyse du trafic*, Avril 1989.
7. STANCZYCK D. and CHRISTIAN B., *Pesage en Marche - Recherche des valeurs de consigne*, CETE Est, Janv 1991
8. EYMARD R., GUERRIER F., JACOB B., *Measurement of Axle Weights by Multiple Sensor Weighing*, Proceedings of the CERRA-ICASP'6, Mexico, Juin 1991.
- 9 JACOB B. & al., *Compte-Rendus de la Journée Nationale de Présentation du Projet Pesage en Marche*, LCPC Paris, 18 Septembre 1991.