AIRFIELD PAVEMENT MONITORING
SPECIFIC TOOLS AT PARIS AIRPORTS LABORATORY

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ABSTRACT

Over the two last years, the duties of the Laboratory of Paris Airports, in charge of Airfield Pavement Monitoring, have been modified due to the changes in the Company organisation, in the aerodrome certification process, and in the new recommendations for airfields operation.

At each main Paris Airport (Charles de Gaulle, Orly, and Le Bourget), a unit named “Operational Unit” is fully in charge of the airfield pavement maintenance.

This unit is at the same time the owner of the facilities and the operator.

- As the owner it is in charge of optimisation of maintenance policy during the life cycle of pavement.
- As the operator it has to fulfil ICAO and national recommendations.

The Laboratory provides services for this unit:

- Diagnosis of pavement condition, setting up and actualisation of the pavement database for maintenance management purposes,
- Operational assistance like friction measurement or FOD preventive auscultation.

This paper will focus on two special tools and equipment used for pavement tests and surveys:

- A Geographic Information System (GIS) dedicated to pavement survey, with data collection in situ. A GPS antenna is used aboard the vehicle during the survey. This was developed with Esri products such as ArcGis 9.2.

- A special trailer for friction test. Although this trailer “IMAG” was first developed 15 years ago together with the Civil Aviation Technical Services, some new improvements and new rules during the two last years have allowed an accreditation (COFRAC), and approval by the French Civil Aviation Administration for the equipment.

1. INTRODUCTION

Aéroports de Paris Laboratory performs a comprehensive pavement monitoring and evaluation for the three main airports, Charles de Gaulle (CDG), Orly, and for Le Bourget (Business airport) and eleven smaller general aviation aerodromes.

Over the two last years, the duties of the Laboratory of Paris Airports, in charge of airfield pavement monitoring, have been modified due to the changes in the Company organisation, in the aerodrome certification process, and in the new recommendations for airfield operation.

This paper will in a first part give some elements about pavements to be evaluated at the two main airports of Aéroports de Paris; in a second part it will present the organisation in charge of the operation and maintenance of these infrastructures. In a third and a fourth parts two specific tools developed by Aéroports de Paris for pavement auscultation will be described:

- A geographic Information System dedicated to pavement survey, with data collection in situ,
- A special trailer for friction test.

2. MOVEMENT AREAS AT AEROPORTS DE PARIS

Movement Areas of the two main airports of Aéroports de Paris were built :

- Principally from 1950 to 1970 for Paris – Orly
- From 1973 to present time for Paris – Charles de Gaulle

Values of the 2007 total pavement surfaces can be summarised as follows:

Airport	Runways (Length in m)	Taxiways (m^2)	Apron (m^2)
Paris Orly	06/24 (3650) 08/26 (3320)	1 Million	0,4 Million
Paris Charles de Gaulle	08R/26L (2700) 08L/26R (4200) 09R/27L (4200) 09L/27R (2700)	2,7 Millions	2,0 Millions

At Paris Charles de Gaulle, the four runways are operated in 2 pairs of close parallel runways: internal runways (long runways) are dedicated to take off, external runways (short runways) are dedicated to landing operations.

From 1995 to 2005, the number of runways at CDG Airport doubled from 2 to 4, the total taxiway surface increased by 60%.

Over a long period, all pavements were built with rigid structure (dowelled or not dowelled cement concrete slabs).

The first rehabilitation projects with bituminous overlays on rigid pavement were implemented at the beginning of the nineties.

After 1995, some semi-rigid structures were built with hydraulic bound material in sub base course and asphaltic materials for base and wearing courses.
The runway 09L/27R was built in 2000 with this type of semi-rigid structure.

All the aprons, where the static loads and the shearing stresses are greater, are still built with rigid pavements.

3. MAINTENANCE AND OPERATION OF MOVEMENT AREAS AND LABORATORY DUTIES

A unit called « Operational Unit » is fully in charge of the airfield pavement maintenance for each airport. This unit is at the same time the owner of the facilities and the operator.

As the **Owner**, it is in charge of optimisation of maintenance policy during the life cycle of pavement in order to guaranty durability of the patrimony.

As the **Operator**, it has to fulfil ICAO and national rules or recommendations for operations. It has to provide some safe movement areas, without immediate (Foreign Object Damage or FOD) or long term (avaibility) risks.

A contract is signed between the Laboratory and this Operational Unit.

The **Operator** is requesting from the laboratory the following tasks :

- Measurement of skid resistance according to national and ICAO rules,
- Measurement of other surface characteristics like roughness and macrotexture,
- Technical assistance for determination of immediate risks (ravelling, corner breaks and other poor areas creating FOD risk).

The Owner aims to optimise maintenance costs during life cycle. It implements a pavement management system (PMS) with definition of maintenance priorities.

In the PMS process, the Laboratory will set up and actualise the pavement database and will perform the technical diagnose with following investigations which are part of the contract:

- Distress monitoring and mapping,
- Deflexion measurement on flexible pavement and load transfer on rigid pavement,
- Georadar to characterise interfaces,
- Corings,
- Roughness and skid resistance measurement.

Some forward-looking investigation and measurement frequencies are decided in the contract between the Laboratory and the Operational Unit:

- The distress survey is continuous throughout the year. Every week a technical inspection at a runway gives the opportunity to actualise data collection.

- Friction characteristics of wet paved runway are measured three to four times a year by the mean of IMAG device.

- Roughness is measured every four years on runways.

- Deflection or load transfer or slab movement is measured every two years on runways.

For other tests and other facilities (taxiways, aprons), measurement frequency is variable and is arranged every year during contract preparation.

Among the list of test and measurement equipments, some of them are common to road network and airport auscultation and monitoring. But two specific tools were specially developed for aeronautical pavement auscultation purpose by Aéroports de Paris, in partnership with the STAC (Civil Aviation Technical Center, Former Airbase Technical Service STBA) for the second one:

- A Geographic Information System,

- A special trailer for friction test, IMAG.

4. GEOGRAPHIC INFORMATION SYSTEM SIGADI DEDICATED TO PAVEMENT SURVEY

From 1973 to 1990, a simple software developed by Aéroports de Paris was used for the registration of distresses on cement concrete slabs. It was able to collect the types and number of damages and the repairs for each slab.

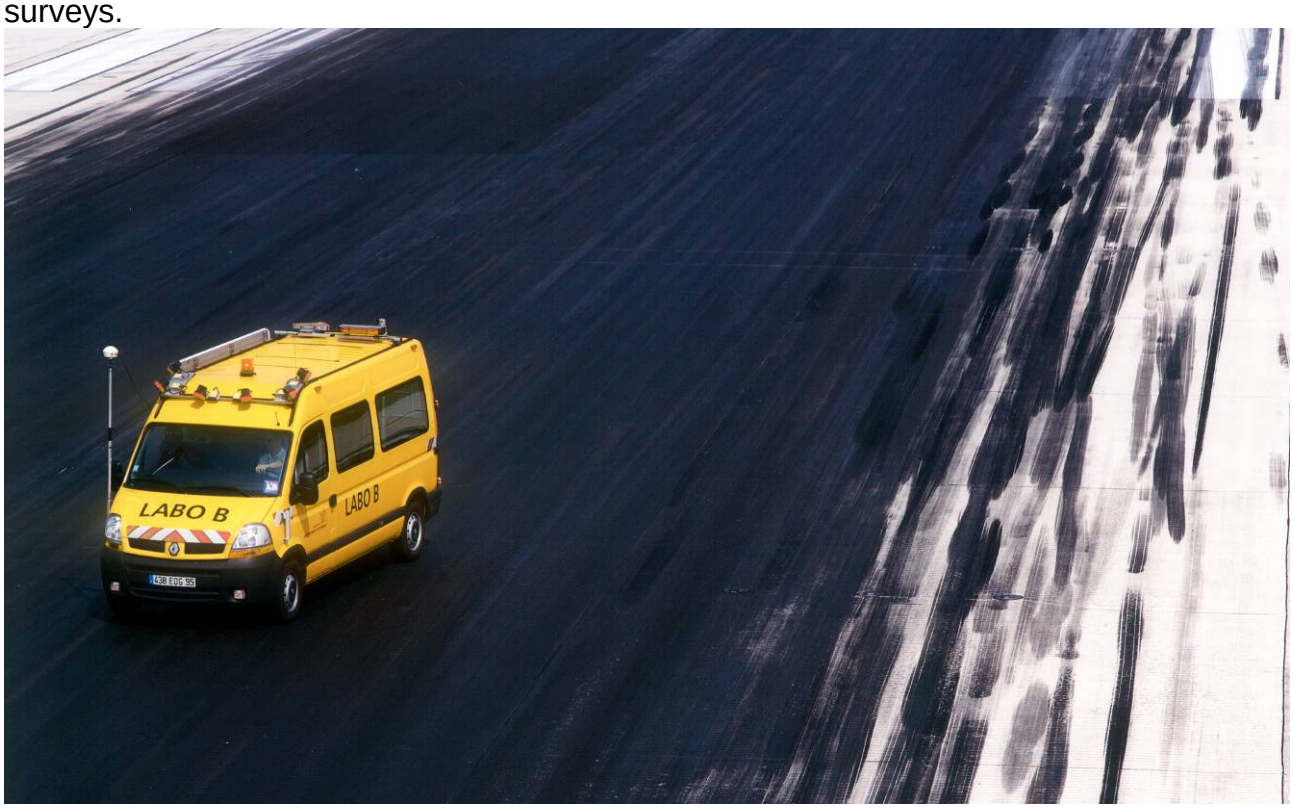
After 1992, with the increase of surfaces, the various types of structures (rigid, composite, semi-rigid, flexible…) and the development of bituminous materials, the global complexity made this software not more able to represent pavement condition.

At this period, after searching new tools and resources to help to manage the main maintenance, it was decided to develop a Geographic Information System (GIS), dedicated to pavement condition management and called SIGADI (GIS dedicated to infrastructures maintenance).

From 1995 until today, GIS and GPS technologies have progressed, SIGADI is becoming after each upgrading more reliable and accurate. Standards products are used, such as ESRI tools (ARCGIS 9 with ArcView, ArcEditor, ArcServer) completed by specific development.

This is a geo-referenced data base that allows the use to collect, analyse, and represent all the information.

The Global Position System is a satellite based navigation system made up of a network of 24 satellites orbiting the earth. A GPS antenna is used aboard the vehicle during the surveys.



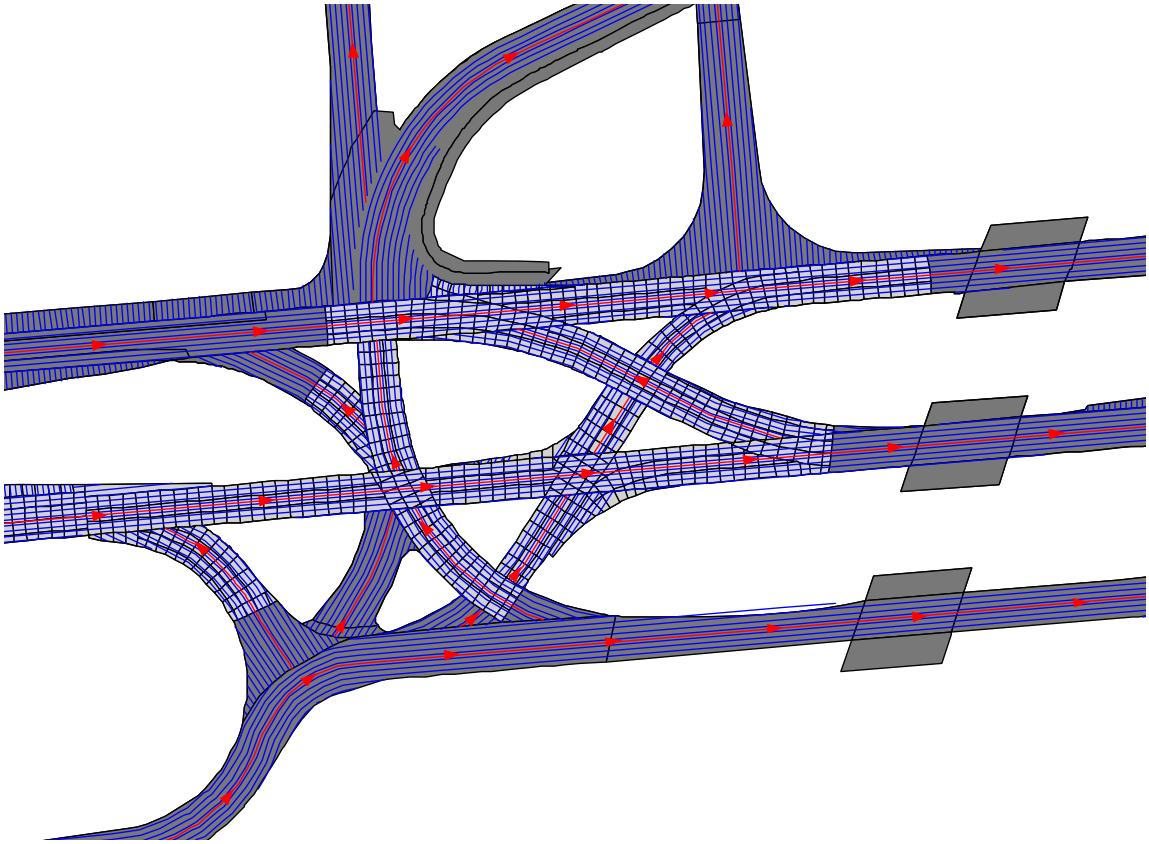
Vehicle and its GPS antenna.

A Differential Global Position System (DGPS) is used to get better accuracy for data collection during inspection. This pay-service allows to correct GPS signals to get a precision in X,Y about one meter.

4.1 Geo-referenced System

Geo-referenced system is defined either by X,Y coordinates or by curvilinear coordinates:

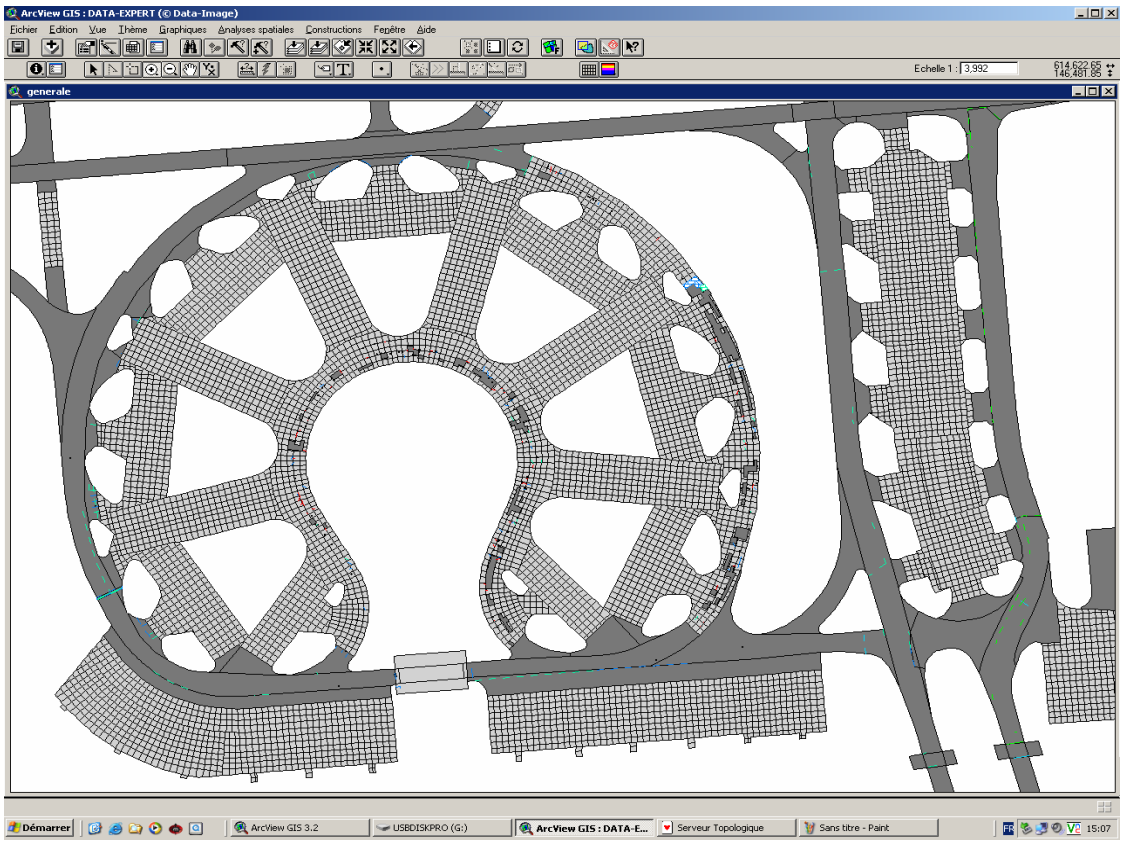
- X, Y coordinates, for registration such as points, lines, poly-lines…
- Curvilinear coordinates: surfaces of pavement are split up into an elementary network of axles (example in the picture below). Measurements are registered in tables. Spatial relationship is created between the tables and these axles.



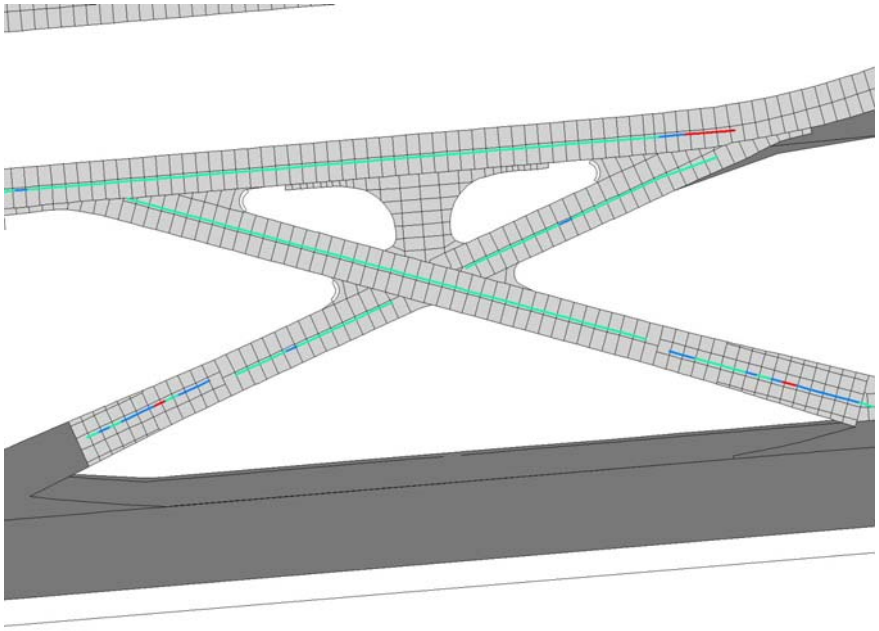
4.2 Database

The database contains the following information:

- Pavement structure with polygons corresponding to homogenous layers: thickness, materials, history,
- Data on structural strength (deflection, slab movements, load transfer, georadar data),
- Data on surface quality (skid resistance, roughness),
- Distress mapping, according to the classification done by Civil Aviation Technical Center and Central Laboratory of Road Administration.

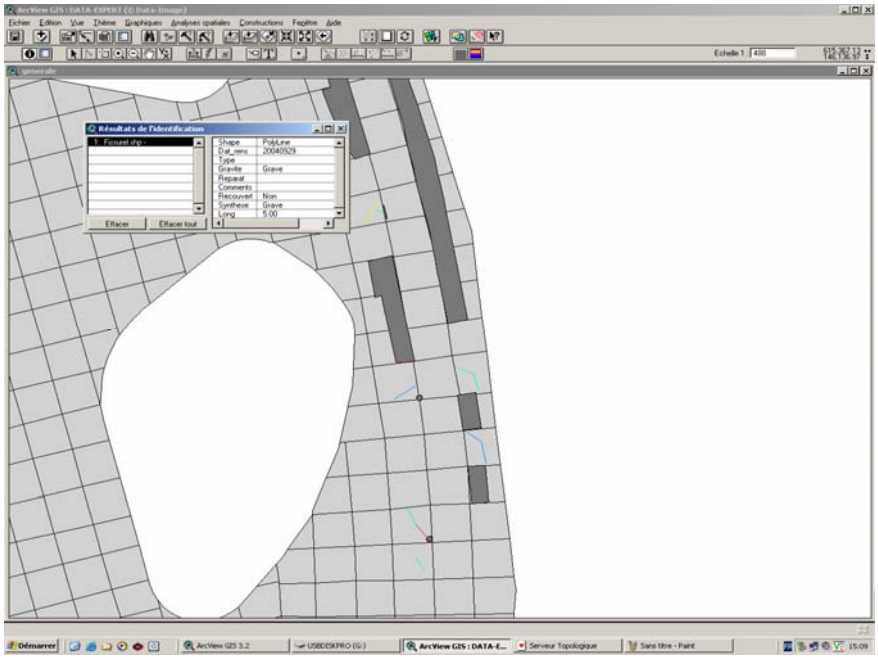


Type of pavement and distress mapping



Example of slab movement measurements. Colours correspond to level intervals.

4.3 Analyse



GIS tools make following analysis possible:

A simple request will give information on the selected item. In the above example, the selected crack is linked to the following information:

- Shape (type of representation, polyline in that case),
- Date of collection,
- Severity,
- Length,
- Information if the damage is overlaid or not.

A tabular analysis allows basic functions such as sorting or frequency.

Some more complex types of requests are available:

- Alphanumeric,
- Spatial, such as “intercept”, “select features within distances”…

They may be applied to a full element (one runway, one taxiway…) or to a part only.

The purpose of this analysis is to estimate following relationships:

- Location and gravity of distress versus type of pavement, age of pavement,
- Evolution (number and gravity) according to time, speed of increase.
- …

As additive tool for analyse, some index can be created in the system, comparable to Pavement Condition Index (PCI) or to Indice de Service (IS).

The future development must include a better knowledge of traffic and loadings with focus on New Large Aircraft.

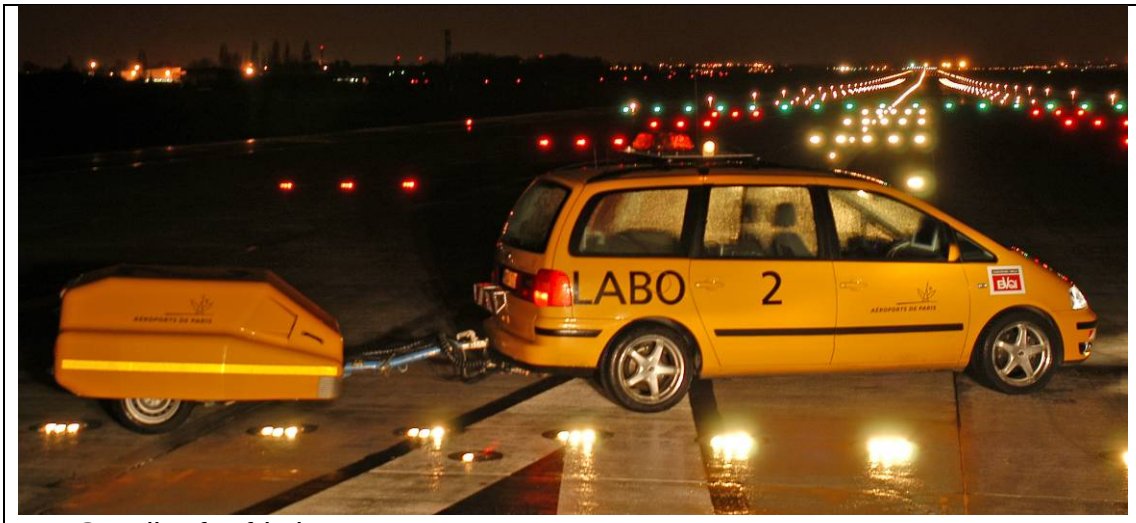
4.4 Visualisation and sharing of information

Maps are the primary means for communicating geographic information. Maps can be printed or published over network or intranet.
Using Intranet Web technologies, the internal client, it means each Operational Unit, will be able to visualise data concerning its patrimony in the database.
Receiving a password, It can read the available pavement information and create its own "working layer" in SIGADI, but without any possibility at present time for changing the content of the layers managed by the Laboratory.

5. SPECIAL TRAILER FOR FRICTION TEST – IMAG

5.1 History

IMAG is a French acronym for "Instrument for automatic friction measurement". This device fits the recommendations of ICAO. It was developed by STBA/STAC (former Airbase Technical Service, present Civil Aviation Technical Center,) together with Aéroports de Paris 15 years ago.



IMAG trailer for friction measurement

It is the reference for IRFI (International Runway Friction Index).

In 2005 Aéroports de Paris got an Accreditation Certificate COFRAC for this measurement.

cofrac ESSAIS	COFRAC is the French Committee for Accreditation according to ISO/CEI 17025 Certificate n° 1-0050

This device is on the way to be industrialised by the company VECTRA (First devices in exhibition during the present 2007 AIPCR Congress).

5.2 National Rules

According to ICAO recommendations, French Civil Aviation Administration has developed standards for determination of friction characteristics of wet paved runways.

A Ministerial Order, dated July 10th 2006, related to aerodromes certification, gives rules for friction measurement:
Friction test with continuous self wetting equipment, approved by French Civil Aviation Administration, must be performed at interval smaller than 2 years.

The first approval campaign was hold in October 2006 at LCPC (Central Laboratory of Road Administration) in Nantes. Each trailer is compared to the national reference vehicle. The Laboratory of Aéroports de Paris has succeeded with its two trailers to pass the approval test.

A certificate with correlation factors (a and b) is given by Administration for each trailer:

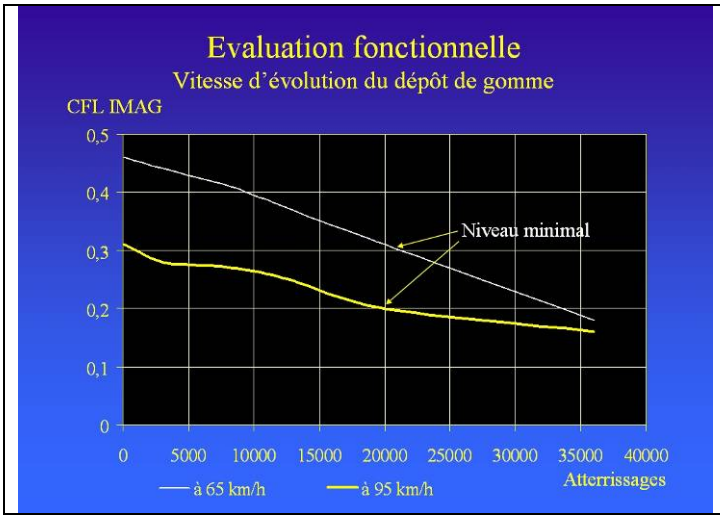
$$CFL = a \times CFL_{\text{national reference vehicle}} + b$$

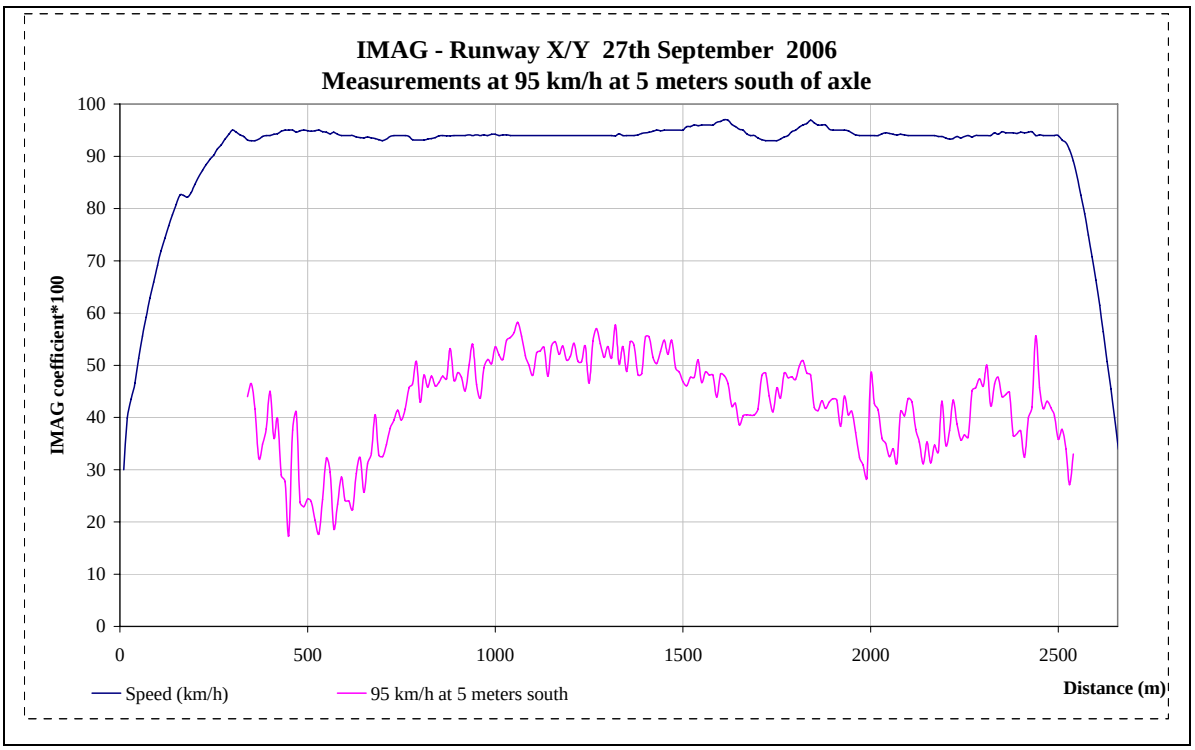
With CFL = longitudinal friction coefficient

This relationship allows do produce the effective skid resistance of the pavement compared with some thresholds defined by Civil Aviation Administration (maintenance threshold and action threshold).

5.3 Skid Resistance Data

For the more frequently used runways, friction measurement is done at least every 3 months and some additional measurements when requested by the Operational Units.

	CFL (skid resistance) versus number of landings at two speeds, 65 km/h and 95 km/h.



Typical measurement, before rubber removal. Cement concrete surface

Additional measurement can be requested just before or/and after rubber removal.

A contract is awarded to a company for rubber removal on runways. Two means are used for this rubber removal:

- mainly high pressure water,
- shot blasting in certain cases when macrotexture must be restored.

Skid resistance winnings after rubber removal are between 0,05 and 0,1.