SPECIFICATIONS OF PAC™ ²V5 ©(IDDN) SYSTEM
A CERTIFIED
AND INTEGRATED MOBILE DEVICE
FOR UNI or BI-DIRECTIONAL AIRFIELD LIGHTING PHOTOMETRY
CONTROL

Version 3.1
Edition March 2017
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<th>Status</th>
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<td>Quality Manager</td>
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10. PACV5\Documentation Manuels\Manuels GB

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## RECORD OF CHANGES

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<td>AIH</td>
<td>LLC</td>
<td>Addition of Summary Synthesis report and update of references</td>
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## USE RESTRICTION NOTICE

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SPECIFICATION OF PAC V5 and PAC²V5 (IDDN) SYSTEM
A CERTIFIED
AND INTEGRATED MOBILE DEVICE
FOR UNI or BI-DIRECTIONAL AIRFIELD LIGHTING PHOTOMETRY CONTROL

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1./ Introduction

In case of poor or bad visibility or at night, airfield lighting is the only system capable of offering proper visual guidance to pilots when landing, taxiing or taking-off.

Airfield lighting is therefore a major actor in terms of safety of people and equipment.

The Annex 14 of ICAO Edition 5 July 2009 describes the standards that need to be achieved in order to fulfil this key safety role. Standards cover not only technical performances of the equipment to be installed but also describe maintenance schedules to be implemented in order to keep the installations at the required level of quality – see chapter 10.4 para. Visual Aids.

It is mentioned that airfield lighting fittings have to be regularly checked “with in-field measurement of the intensity, the beam spread and orientation”. This must be carried out by measuring “all light fittings installed on the airfield as far as practicable.”

Furthermore:
- One fitting is declared unserviceable when its main beam average intensity is less than 50 per cent of its specified value.
- In order to provide continuity of guidance, an unserviceable light shall not be permitted adjacent to another unserviceable light.
- The number of serviceable fittings for each facility (APP, EDGE, TDZ, etc…) has to always be above specified percentage level.

Within the frame of its preventative maintenance programme, the airport has to comply with the ICAO standards and recommendations that define also the frequency of such measurements and checks and that cannot be “less than twice a year for in-pavement lights and not less than once a year for other lights”. This frequency of checks has also to be increased depending on the traffic and environmental conditions (para. 10.4.6 Annex 14 of ICAO Edition 5 July 2009).

ICAO also recommends that Measurement of beam spread and orientation of lights included in approach and runway lighting systems for a precision approach runway category II and III should be undertaken using a mobile measuring unit of sufficient accuracy to analyze the characteristics of the individual lights (para. 10.4.5. Annex 14 of ICAO Edition 5 July 2009).

Since October 2003, airports have to supply reports of compliance of their installations with regard to the standards of their Aviation Authority that have to be forwarded to ICAO.
In order to fulfil these requirements, FB Technology, in co-operation with the French Air Navigation Technical Department attached to the French Civil Aviation Authority (S.T.A.C.), has developed in 1995 the PAC system (Photometric Airfield Calibration).

PAC system is the most reliable, precise and easiest measurement instrument that has gained many airport users satisfaction worldwide – kindly refer the list of airports at the end of this document.

PAC system is a certified mobile photometry device that calibrates, certifies and accurately measures the performance of light fittings on airfield runways and taxiways for CAT II/III airports. This device also integrates necessary functions for daily maintenance operation of airfield lights.

The PAC system is certified by two Civil Aviation Authorities:

2. Italian Air Navigation Department attached to the Italian Civil Aviation Authority (E.N.A.C.) in 2011.

The PAC V5 system integrates the latest technology available in terms of Information technology and data processing by using high speed PLC. The PLC technology provides the ultimate solution in terms of reliability of the measurements and is far superior to any PC-based solution.

The System can also be provided in bi-directional configuration – the PAC² V5 – which is specifically requested by the airports where access time to runways or taxiways is shorter very month and also by the contractors who want saving a lot of measuring time on the airports.

The PAC V5 and PAC² V5 are protected by a worldwide patent. They have been approved by Italian Civil Aviation Technical Services in April 2014.
ENAC
Protocollo del 10/04/2014
0038304/ENAC/PROT

Airport Infrastructures & Air Space
Central Director

Spett. FB TECHNOLOGY
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SUBJECT: FB Technology PAC²V5 System – 2nd Version of Mobile device for AGL photometric measurements of airfield lighting systems – Addendum to Enac Certification n.99275/IPP of 27/07/2011

- Having regard to following reference regulation:
  - ICAO - Annex14 - § 5.3 “Lights” and Appendix 2;
  - ENAC – Aerodromes Regulation – Chapter 6;
  - ENAC – Attachment to Circular APT 13/A – (Manual on Aerodrome visual aids acceptance criteria);
  - ENAC – Circular APT 28 “Aerodrome devices acceptance criteria”.

- Having regard to Technical-Operational Standard ENAC APS-02/2nd Edition “Mobile devices for measuring photometric features of AGL on the field”.

- Having regard to following manufacturer’s documents:
  - PAC²V5 Bi-Directional Photometrical Airfield Calibration, which includes:
    - PAC²V5 - Hardware Manual
    - PAC²V5 - Software Utilization Guide
    - PAC²V5 - Operator’s Manual
    - PAC²V5 - Certificate of Calibration;

- Whereas PAC²V5 FB Technology device adopts technical changes to a previous version certified by Enac certification number 099275/IPP of 27/07/2011.

- Whereas documentation analysis issued a positive outcome.

- ENAC hereby states that the following device:

<table>
<thead>
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<th>Article</th>
<th>Description</th>
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<tr>
<td>FB Technology PAC²System Version 5</td>
<td>Mobile AGL photometric measuring system</td>
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2./ General specifications of PACV5 and PAC²V5

1. This mobile device measures both inset and elevated light sources and provides the measurement results according to the requirements specified by the ICAO in Annex 14.

2. This mobile device is an embedded test equipment, precise, fast, with automatic software functions, easy to use, to manipulate and to transport. Data collection is carried out using an industrial PLC installed directly in the sensors strip with high reliability and high speed.

3. The PAC² V5 system can measure bi-directional lights in one single run – this is especially efficient for the runway centreline, runway edge and taxiway centreline lights. It not only cuts the measuring time in half but also reduce considerably the waiting time to get ATC clearance for performing the photometry tests.

4. A differential GPS can be installed as an option. There is no requirement for utilisation of D-GPS to carry out the photometry measurements.

5. As described below, the system is a wireless system except for the power supply cable still needed to supply the sensors strip and the cable linking the distance measurement radar and the sensors strip (and the optional D-GPS).

6. Communication between the sensors strip and the operator’s laptop can be done either via Wi-Fi or, if WiFi communications is not authorised on the airport, using a shielded industrial Ethernet cable.

7. The mobile system for measuring and collecting data is fixed steadily on the vehicle.

8. An independent camera system integrated in the sensors strip module provides a correct alignment while driving towards the light source. A touch screen monitor installed in front of the driver displays the optimal path to follow and adds comfort to the driver during operation.

9. The light measurement process of PAC is completely independent of: the colour of the light source, the light manufacturer make and model, the airport configuration, the total number of lights or the section to measure. There is no requirement for knowing the type of fittings to be measured before the beginning of the measurements sessions.

10. The device provides as a result the real values in candela obtained from the light intensity being measured. No comparative measurements are done. Up to 15,000 digital samples can be recorded per light source.
11. Calibration or sensors adjustments and reference settings are done once and are not requested to be adjusted prior each light measurement.

12. The device measures all the light fixtures that provide access for a vehicle to run over or to run by it. The following light functions are normally covered:
   - Inset or low elevated Approach;
   - Inset or elevated Threshold;
   - Inset or elevated Runway End;
   - Runway centreline;
   - RETIL;
   - Runway elevated and inset Edge;
   - TDZ;
   - Taxiway Centreline and curves;
   - Stop-bars and hold-bars.

13. Facilities like stop-bars and inset or low elevated threshold, end, low elevated approach centreline and crossbars can be measured in one run with the vehicle running parallel to the line of fittings to be verified – provided that the vehicle can be driven on a hard-top surface in front of the fittings at an adequate distance. This is what we call vertical or transverse measurement.

14. The light measurement process can be interrupted at any point and the system is able to continue measurement from the last point where stopped.

15. The lights are measured continuously for the selected section and the mobile system does not stop at each light to make a measurement.

16. The light measurement sensors (Lux) have a precision better than ±5%.

17. The recommended speed is 40 km/h in straight sections, 15 km/h in TWY curve sections, although a maximum speed of 60 km/h can be obtained.

18. At this speed of 40 km per hour, very good repeatability of measurements is achieved at below 5% (repeatability of measurements being the percentage of deviation between values measured on the same light fitting after 5 consecutive surveys in same conditions).

19. The same sensors strip will be used for all type of measurements either on horizontal and transverse positions. For future airport requirement, the same sensors strip could also be used for workshop of lab photometry.

20. See below for the different sensors strip configurations:
Configuration for inset lights measurement with unidirectional PAC V5

Configuration for edge elevated lights measurement with unidirectional PAC V5

Configuration for inset or elevated lights in line (such as runway threshold, runway end, stop-bars lights and approach cross-bar light – inset or low elevated approach provided vehicle can have smooth access along a line parallel to the fittings) with unidirectional PAC V5
Configuration for inset lights measurement with bidirectional PAC² V5

For Configuration for edge elevated lights measurement with bidirectional PAC² V5, the carriage needs simply to be lift up.
Configuration for inset or elevated lights in line (such as runway threshold, runway end, stop-bars lights and approach cross-bar light – inset or low elevated approach provided vehicle can have smooth access along a line parallel to the fittings) with bidirectional PAC² V5

Installation of the supporting frame on existing tow hitch ball:

The frame is then installed in the back of the vehicle’s hitch ball. The extension beside the vehicle allows for measurements of elevated runway fittings situated 1m80 metres away from the vehicle.
Sensors strip support for vertical positioning for transverse measurements
2. Main features of PAC system

2.1/ Compact and integrated system

2.2/ Practically all wireless connections

2.3/ Quick installation and set-up

2.4/ User friendly Human Machine Interface

2.5/ Fast and reliable measurements with high accuracy and high repeatability performances.

2.6/ Measurement of Bi-directional light fittings done in ONE single run (runway edge, centreline and taxiway centreline light fittings). The measurement is carried out by driving above the fittings as shown below:

The system first makes the data acquisition of the light beam when driving towards it, then it gets the position of the fitting with the detection sensors.

After this, the system switches over to the sensors on the other and starts the data acquisition for the opposite beam until it leaves that beam and prepares itself for the next fitting.
The related data will be stored in two different report files – one for each direction that has been measured.
3. PAC System specification

3.1 Mobile device - Hardware

The mobile device includes:

- Adapting frames to hold the sensors strip
- Light sensors strip module to measure the light beam including:
  - High resolution and very stable position sensors
  - Alignment camera system integrated in the sensors strip module.
  - Programmable Industrial Logical Controller and input/output modules to process data
- Portable computer or tablet PC for system operation and data visualisation.
- OPTIONAL DGPS module to identify the light fittings

Note A: The hardware configuration of PAC system shall be modified by the manufacturer according to the latest technologies available on the market, without any prior notice.
3.1.1/ Light sensors strip

This module is comprised of 13 light intensity sensors, 2 colour sensors and 9 light detection sensors for unidirectional PAC V5 and 2x13 light intensity sensors, 2x2 colour sensors and 9 light detection sensors for bidirectional PAC V5.

The light intensity sensors are highly accurate and identical to CLASS-A LUX meters and provide continuous measurement of light intensity of airfield lights. The sensors are pre-calibrated in our laboratory.

3.1.2/ Distance Measurement sensor

The quality and precision obtained during light measurement depend mostly on the precision of the distance measurement sensor in order to provide accurate positioning of the collected samples. This device measures the distance travelled in centimetre using Doppler technology.

Note: Due to its low precision a DGPS module should not be used for the purpose of distance measurement.

3.1.3/ Input Output modules

The sensors are connected to input modules positioned inside the sensors strip – four sensors per module. The sensors are supplied from these modules and provide the analogical signals they generate. These modules are part of a network connected to the PLC situated nearby inside the sensors strip.
3.1.4/ Alignment camera

The alignment camera is advisable and therefore integrated in the light sensors strip, because this is the only method for the driver to achieve a correct alignment while driving the vehicle. While driving, the lights to measure pass below the middle point of the sensors strip and thus provide a correct reading. The camera is sending pictures via Wifi or Ethernet cable to the laptop computer connected with a USB cable to a video monitor installed in front of the driver.

3.1.5/ Navigation module (OPTIONAL)

The DGPS (Differential Global Positioning System) is used in order to identify the lights being measured. A database of lights is integrated in the PAC program, which includes for each light the GPS coordinates and their respective identification numbers as per Airport numbering scheme. The DGPS uses 20Hz data refreshment frequency in order to improve accuracy of the global positioning. The light measurement reports therefore display the identification numbers of each light being measured.

The GPS module has to be connected to the PLC in order to process the position information of the lights.
3.1.6/ Programmable Logical Controller and laptop

The PLC is supplied from a dedicated DC power supply connected to the vehicle battery. The PLC receives the data from the modules network. It also collects the pulses coming from the radar and the GPS co-ordinates provided by the GPS receiver (optional). All these data are collected together, formatted and sent via a WiFi Tx/Rx or Ethernet cable to the laptop or tablet inside the vehicle. The operator can either issue instructions or visualise the results in real-time.

*View of the PLC*

*(PLC model and specifications subject to change for improvement purpose without prior notice)*
General Overview of the PAC V5 system:

(Dotted lines are radio communication – WiFi or Bluetooth), full lines are cables)

Note (*): Alternatively the shielded Ethernet cable can be replaced by a Wi-Fi connection.
3.2/ Mobile device - Software

The following software functions are provided with a user friendly environment. The PAC Program runs under Windows XP/ Vista or 7.

*Note B: The software program of PAC system shall be modified by the manufacturer according to the latest updates available, without any prior notice.*
3.2.1/ Data collection

Light measurement process is fully automated in PAC system. However before starting a light measurement the user selects the light function, selects the standard distance between lights, input the number of lights to measure and click "GO". When the exact number of lights is not known then a maximum of 400 lights can be entered.

The following windows display the real-time process control panel and the light selection window.

This panel gives the real time information about the measurement progress. ID of light in progress gives the number of the light being measured. Total Lights Measured gives the total number of lights that have been measured.

Actual Position gives the position in millimetres between two lights. Once the system has finished to measure a light the position is reset (0 value).

On clicking the "GO" button the "Function Selection" window will appear.
To start a measurement: select the light function, then the distance, then enter the number of lights, confirm if measurement is bi-directional by clicking in the “Bi-directional” box and finally click “OK”.

All the airfield lighting functions are covered by the system, for example the RETIL system as per latest ICAO Annex 14 edition.

For each light the following results are provided after a light measurement:
- Average value in candela
- Maximum point value in candela within the measured beam
- Maximum point value in candela within the main beam area
- Minimum point value in candela within the main beam area
- Positions of the three above maximum or minimum points in vertical and horizontal degrees.
- The ratio between maximum and minimum values within the main beam area
- The identified light colour
- The percentage of ICAO compliancy
- The status whether passed or failed according to the ICAO compliancy level
- The isocandela diagram with high resolution of the light beam. This diagram is used to find the anomalies of the light beam such as faulty angle elevation and shape of the main beam area.
- The samples of each light.
- A list of the non-aligned lights shall be automatically generated.
- A list of the non compliant lights shall be automatically generated.
3.2.2/ Data calculation

Once the last light is measured, the system stops automatically and the calculation of the results starts automatically. The results can be viewed or printed instantly. The following three printings are provided: a light list displaying the measurement details of all the lights being measured, a bar graph displaying the values in candela of all the light being measured and a job report sheet of the lights for maintenance purpose.

3.2.3/ Data analysis

After data have been collected and stored in the database of the computer, the following results can be reviewed or printed instantly on site or later at office.

This report window is issued instantaneously after each Measurement Run. It gives the graphical representation of the runway and the iso-candela diagram of each fitting.

A bar graph corresponding to the fitting luminous intensity is displayed. The dotted horizontal lines display the minimum required level for the runway lights, which are 2500 candela for white lights and 350 candela for red lights, example shown on above picture. Two levels can be displayed
1. The 50% ICAO standard definition of failure
2. The local Airport Authorities warning level – that can be set at any value above 50%.
For each fitting selected on table, the iso-candela diagram is displayed that allows checking the quality and homogeneity of the beam. This diagram is based upon the collection of up to 20,000 samples and therefore provides the user with a very accurate picture of each light fitting.
All the measurement reports and views are stored in the hard disk of the computer unit.
The measurement values of the lights can be exported to a text file for the operator to draw further type of analysis on Excel.

By clicking on the bargraph area, operator can display either the candela bargraph displaying the values in candela and the colours of each fitting or alternatively the percentage with respect to ICAO standards with three different colours: Green for fitting above maintenance level, Orange for fittings below maintenance level but above the 50% ICAO and red for fitting below the 50% ICAO.

Note: In above picture, GPS was not used, therefore Light Id is not provided and the column displays “Not found”.
The software includes a database. The measurements of each light shall be stored for at least one year (Measurement of each light at least once per week).

**Export report files**

All the lights and details being measured can be exported in two ways:

Direct export in various file formats can be done by clicking on the small icon as shown below. This allows for exporting the selected column in Excel, Word or XML formats.

Other possible export can be performed on the measurement file by selecting “Print/Save” button. Later at office or instantly on site the operator can review or print the following graphs:
3.2.3.1/ Bar Graph

Graphical display illustrating the light numbers against their respective values in candela on the whole section of lights being measured.

The above preview will be displayed before printing the bar graph. Standard deviation per colour facility is provided (here for white and red fittings) as well as a statistical display showing the percentage of compliance of the overall facility:
The same information can be printed for percentage bargraph display:

As seen before, direct export in various file formats can be done by clicking on the small icon as shown above. This allows for exporting the files in Excel, Word, PDF formats. The above image can also be exported in jpeg format.
3.2.3.2/ Detailed lights list

The lights list provides the measurement values for each light: average value in candela, ICAO percentage, maximum point value in candela, position of the maximum point in V° & H°, max/min ratio, identified colour of the light, the light identification numbers and the GPS coordinates (only in the version using the DGPS).

The above preview will be displayed before printing the light list.

The light fitting list can be saved in the different file formats such as Word, Excel, PDF or the list can be directly sent via e-mail.

This allows for saving the files on the hard disk for a later utilisation – for example printing together all necessary files after they have been selected.

*Note: The light reference or identification will be displayed only in the version that integrates a DGPS system.*
3.2.3.3/ Summary Report synthesis

A Summary Report provides the synthesis of the measurements carried out on a specific facility.

The Summary Report will summarize the results obtained on one or many measurements according to the desired facility.
It will therefore:

- list the concerned reports (one or many);
- display the number and percentage of fittings whose average candela values is within specified percentages and below ICAO 50% level in one chart;
- list the faulty fittings
- provide some statistics (percentage compliancy as per ICAO) and standard deviations according to the colour
- provide the status of compliancy with the corresponding percentage
- explain why the facility is compliant or non-compliant – in this case, reasons can be either percentage of serviceable lights too low or two adjacent fittings are unserviceable or both.

For the Summary report, two possibilities are offered:
1. Either single printing for one given report
2. Or multiple printing for confirming the compliancy of the whole facility:
   a. Runway edge – 2 combined reports for one QFU (both sides of the runway)
   b. TDZ – 6 (or 8) reports combined for the whole TDZ

For example, the following Summary Report for an Approach line could be issued taking into account and synthesizing 9 different reports measured on the 09R Approach.
### PAC System - Photometry Summary Report 09R

**Agent:** BELKACEM

**Report list:**

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**Summary of results:**

- **Number of fittings measured:** 68

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<th>Percentage total fitting</th>
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<td>19.1%</td>
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<td>From 35% to 30%</td>
<td>4</td>
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- Total number of fittings below 50%: 17 (25.0%)
- Total number of fittings above 50%: 51 (75.0%)

**List of Unserviceable fittings:**

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3.2.3.4/ Repair report

The system can retrieve the list of the lights that are below 50% of the ICAO standards.

The following window displays the faulty lights:

Note: In above picture, Light Id column shows “Not found” as no GPS identification was available for this specific measurement run.
3.2.3.5/ Maintenance report sheets

This document can be printed for each selected light. This document provides for maintenance purpose: the isocandela diagram of the light source, the measured average value in candela, the alignment of the light beam in V° and H°, the identified colour, the ICAO percentage and necessary fields for maintenance record on this particular light fitting.

These Job Report Sheets ensure:
- Optimisation of the agents intervention time,
- Diagnosis of troubles in office to prepare the maintenance on the fitting beforehand,
- Speed up the training and understanding of the halos by the agents.

It is advised to store these sheets in archive in order to identify recurring faults.

The above job report sheet will be printed out in order to keep written record of the light to be maintained.
As seen before, direct export in various file formats can be done by clicking on the small icon as shown above. This allows for exporting the files in Excel, Word or pdf formats.
The above isocandela images can also be exported in jpeg format.
Additional graphs are provided for maintenance purpose when the optional DGPS is used.

The Trend of Functions below provides the different results of the selected facilities in the past measurements.
The Trend Chart below provides the values obtained for a selected light fitting in selected time period. 

*Note: the following graph is provided in the DGPS version only.*

### 3.2.4/ Supervisor/ Operator status

Users of the PAC software program are classified as either Supervisor or simple Operator.

1. The Supervisor can add/delete a person, assign passwords to users, modify personal details, delete a measurement record or change light measurement process parameters.
2. The simple User can only make light measurements and display the results.
4./ Sites testing and commissioning

The system will be tested and commissioned on the airport where it is intended to be made operational. This will be carried out within two weeks of the delivery at dates and times convenient to each airport requirements in line with their own operational constraints.

5./ Sites training

Further to the system commissioning on the site, a training course shall be provided The aim is to familiarise the users with the system and to help them optimise their operation of the PAC system for control and follow-up of their airfield lighting installations. A certificate is issued for each successful trainee who is able to operate the system.

Following points shall be developed during the training:

- Refresh on photometry, ICAO standards and requirements
- Light measurement concept used in P.A.C. System
- General handling of the system
- Detailed presentation of the hardware
  - Description of the functional design
  - Light measurement strip
  - Cells
  - Distance measurement device
  - PLC and I/O modules
  - Portable computer
- Detailed presentation of the software
  - Description of the functional design
  - Definition and presentation of the different screens/ windows
  - Introduction to the system parameters and setting
  - Description of principles of data acquisition and processing
  - Description of results editing and analysis
- Description of the system operation
  - Preparation of tests runs
  - Review of computer screens/ windows
  - Review of reports
- Maintenance and trouble shooting of the system
- Queries and feedback

These training will be complemented with actual site runs on airports.
6. Support and maintenance

The system guaranty lasts one (1) year after the testing and commissioning – longer period available on request.

Complete documentation about the system and its operation are provided in the Operator manual.

A complete Guarantee Extension and Maintenance contract is also proposed with the system including:

- Calibration and eventual replacement of defective sensors and components manufactured by FB Technology.
- The calibration of the whole system with issuance of calibration certificate is carried out in our laboratory using a Standard Reference Light Source traceable to NIST for Quality Control.
- Guarantee against any software bugs in the standard PAC system or in the airport-tailored parts.
- Technical support on the utilisation via e-mail or telephone.
- Verification of the reports every three months – the users transmits samples of his files by e-mail and we check that there are no anomalies.
- Up-grade of software versions.

The Guarantee Extension contract does not include:

- Free replacement or repair of mechanical parts and/or sub-assemblies/equipment supplied by FB Technology but not manufactured by FB Technology.
- Free replacement or repair of cells or electronic parts damaged following wrong use or handling.

Spare parts and supports shall be available for the fifteen years after the warranty period expires.
7./ References

References of airports or organisations that have purchased PAC system and running the system regularly on runways and taxiways:

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<th>Nr of supplied PAC LAB</th>
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