

Embedded Meteorological Airport Systems

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Abstract

Computation of the meteorological parameters in airport environment is a more difficult task than it may appear -at first. This work contributes with a practical description to describe this question when embedded systems are available. It is based on the author's experience as system designers and in international rules from the International Civil Aviation Organization (ICAO). Sensors embedded in the system, the calculation of solutions and the integration level of the airport complex are described.

Keywords

Meteorological airport system, International Civil Aviation Organization, sensor integration, embedded system, sensor processor.

1. Introduction

The meteorological information systems are in charge of the acquisition, the treatment, display, register and disclosure of the data relative to the ruling meteorological conditions in an airport. The information generated by such systems is used by many different users, like passengers, pilots, air traffic controllers, other systems installed in the airport, and external systems to the airport. These systems are crucial for the determination of the operation characteristics in the airport. The measured parameters are, among others, temperature, direction and wind speed in diverse locations, luminosity, height of clouds, atmospheric pressure, rain detection and humidity.

Depending on the measurement, automatic sensors or appreciations made by humans are used.

The system must be able to automatically calculate certain parameters of interest for the airport, like the visibility, the runway visual range (RVR) or the dew point, based on the observation, obtained in real time.

This article aims to disclose the characteristics of the most commonly used sensors for the automatic observation of aeronautical meteorological parameters, and how they are integrated in a particular airport system.

The paper is structured as follows. Second section describes the general structure of such systems. The third section, outlines the main features of some sensors used for observation of the meteorological parameters. The fourth section, explains some of the sensor system interactions with humans and with other systems. Conclusions and future works finalyse this article.

2. Structure of a meteorological information system.

Meteorological information systems use the structure of a System Control And Data Acquisition (SCADA), installing the sensors within the airport. These sensors communicate with the CPU of the host computer using dedicated aeronautical communication networks.

From these central units, located in the weather information bureaus of the airports, the information is distributed to the different users in an automatic way or under request.

The display of the information varies and mainly depends on the kind of user who

receives it. For that reason, a special section for the information displays has been dedicated in this article.

3. Observation sensors.

Next some details of the characteristics of most commonly used sensors for observation in airports are presented.

3.1 Anemocinemometer.

The anemocinemometer is an instrument used for the measurement of the wind speed and direction [3]. It has to be placed over a turret of 9 or 10 meters high (in some cases it is possible to install it at 6 meters high) properly marked (painted red and white with electrical obstruction lights driven by photoelectric switch), and folded in direction of the runway axis.

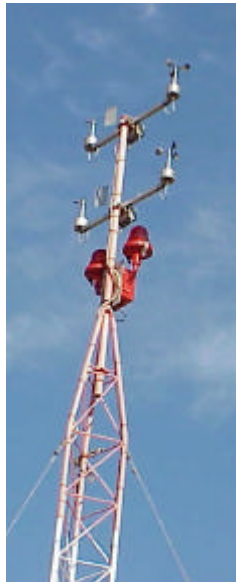


Figure 1.- Double Anemocinemometer.

In the turret, the wind speed sensor (anemometer) and wind direction sensor (vane), the crosspiece of assembly of these sensors and the obstruction lights with the photoelectric cell are installed.

Several methods for redundant wind measurement at the same position have been developed, most of them consisting in the installation of two sets of anemocinemometers at different heights. In last installations, the anemocinemometers are installed at the same height, but separated enough to avoid interference between them.

The connections are made so that it is possible to send the values calculated by the

anemocinemometer to the integrated meteorology system, and remote commutation is possible in case of failure of one of them.

The integrated meteorology system receives the wind data calculated from the communications equipment associated to the wind sensors. The wind equipment sends the information to the displays installed in the air traffic control tower and to the weather bureau.

The most used sensor of wind speed is an anemometer with a system of measurement by interruption of infrared optical connections, with a rank of measurement of very low and very high speed of wind (between 0.4 and 75m/s), and with high accuracy and low sensitivity threshold.

Sensor's operation in extreme conditions of humidity and temperature are demanded, incorporating most of the manufacturers heating to the sensor to avoid the freezing of it in adverse situations.

The most used sensor for wind direction is a vane with optical code GRAY integrated in the sensor, able to measure in ranks of between 0° and 360°, with a threshold of sensitivity of 0,3m/s, and good performances of resolution and precision. Like the speed sensor, the operation in adverse conditions is demanded to this sensor, so most of manufacturers incorporate heating in their models.

The set is completed with a calculating and converter module, that interprets the pulses of the sensors and transmits the calculated parameters to the rest of the system, using optical fiber or cable of twisted pairs.

3.2 Termohigrometer.

An aeronautical termohigrometer is an element able to measure the temperature and the humidity within conditions similar to those found in a runway [3]. It is installed in the wind turret, at 1.5 meters high, over a concrete platform, which has conditions of temperature similar to those of the runway.

The temperature sensor usually is a thermometer of platinum resistance Pt100 type, with measurement between -40°C and +60°C and precision $\pm 0,3$ °C.

The humidity sensor must have a rank of measurement between 0 and 100% and a precision of $\pm 1\%$, a good long term stability and

an insignificant hysteresis, as well as the insensibility to dust and most of chemical agents. A weather and thermal radiation shield must be installed on these sensors, to protect them from the effects of the solar radiation, atmospheric rain, wind and other agents.



Figure 2.- Termohigrometer.

3.3 Double Barotransmitter.

The barotransmitter is in charge of the measurement of the atmospheric pressure in the airport [3]. It is made up of a central unit containing displays, whose main target is the estimation of the atmospheric pressure, calculation of the average arithmetic, compensation by room temperature and presentation of values QNH and QFE. Usually they are installed by pairs in the weather bureau (depending on the country), demanding to them ranks of measurement between 500 and 1060 hPa, with 0.1 resolutions of hPa.

Between each pair of barotransmitters an automatic commutator is installed, so that in case of failure of one equipment, the second enters in operation.

The internal configuration consists as minimum of three elements, independent sealed one to each other, compensated by temperature and controlled by microprocessor, with warning of anomalies.

Serial ports are used for data transmission and presentation of the values of QNH and QFE totally independently in each port. Main display indicates the average value obtained by the three sensors, displaying values as minimum of QNH and QFE.

The operator's terminal can also display values such as transition level, QFF and tendency. Parameters for the correct operation of the equipment, such as the corresponding altitudes, the date and the hour can be remotely introduced.

The installation of the barotransmitter requires a study of the height from the sea level, and of the geodesic reference of the aeronautical weather bureau in which it's installed.

3.4 Visibility and Runway Visual Range (RVR).

The automatic estimation of Runway Visual Range is made using sensors of different kinds, depending on the operative category of the runway they serve. Each manufacturer (although few in the market exist) imposes his installation specifications.

The RVR, according to definition of the International Civil Aviation Organization (ICAO) manuals, is the distance which the pilot can see the runway lights or the paintings in the runway surface [4].

A great amount of subjective parameters



Figure 3. Double barotransmissometer.

influence this value. Some of these are the transmissivity of the windshield of the airship, rain in the windshield, level of illumination of the pilot cabinet, or the physical or psychological conditions of the pilot.

Transmissometers measure the atmospheric transmittance between two points of the space, or the average coefficient of extinction, including factors like dispersion or absorption. ICAO admits configurations of simple and double base transmissometers, measurers of the frontal dispersion or reflecting devices.

3.4.1 Double base Transmissometers.

The systems of transmissometers of double base settle for runways of ICAO CAT II/III. A set of one transmitter and two receivers is used to provide the value of transmittance and MOR (Meteorological Optical Range), facilitating this data to the users of the system [1].

The installation consists of a system of double reference line by means of two receivers, with independent luminous beams, so that the measurement rank includes 0 to 3,000 ms of RVR to be able to operate in runways of CAT IIIB.

There are one transmitter and two receivers. The first receiver is installed at 75 meters from the transmitter and the other at 10 or 15 meters fulfilling the specifications of the manufacturer. The alignment of the optical axis is made so that it is located to 2.5 meters on the level of the runway axis.

Both the transmitter and the receivers have electronic control of the inner temperature and a system of airflow that avoids the contamination of the optical surfaces.

The optical head of the emitter of unidirectional and horizontal light pulses contains the module of flash lamp and the lenses. The receiver of impulses includes the lenses, a photodiode and a signal amplifier.

Those devices must work in extreme conditions of temperature and humidity, as well as being manufactured against corrosion and wind influence. In addition, it is necessary that they fulfill the norms of restriction of obstacles, so they are installed at 90m from the runway axis [5]. Also, the equipment is protected from external lights and uses a system of detection

and automatic compensation of the contamination of the optical surfaces. It's common the use of antibirds systems, to avoid false readings of low values of MOR.



Figure 4.- Double transmissometer.

They also have an internal processor for calculations, control of functions, communications, test of verification and fits.

Once every second, the average value of a minute is obtained. In case that the obtained MOR is high, the sampling cadence is reduced, to increase the life of the instruments.

The rank of measurement comes from 0 to 100% of transmittance with a minimum resolution of 0.02%, and it needs to fulfill the precision required by ICAO (1% of the Bottom of Scale).

In each runway a set of luminancimeter and three sets of transmissometers need to be installed.

3.4.2 Simple base Transmissometer.

The transmissometer of simple base uses only one receiver for the calculation of RVR. In this case, the receiver of 10m is eliminated, that is the one that offers the best precision of the system. In each runway only one set of transmissometers and luminancimeter has to be installed.

3.4.3 Frontal dispersion measurers or forward-scatter.

A measurer of the frontal dispersion measures a small part of the light dispersed from a directed luminous beam towards a relatively narrow band of dispersion angles.

It is constituted of a transmitter and a receiver separated approximately by a meter, able to measure the visibility. Usually encloses a measurer of present time, so that it's possible to identify the types of precipitation and to discern different kind of fogs.



Figure 5.- Frontal dispersion measurer.

Its rank of operation varies from 10 to 50,000 meters of visibility, obtaining inferior precision than those obtained with double base transmissometers. Its precision varies with the rank of visibility, being of +/- 50m for inferior visibility to 500m and a 5% for visibility over 500m.

Its response time is practically zero, being the integrated measurement approximately every three minutes with continuous update.

Systems that avoid the dirt of the optical system are usually installed, as well as systems of heating to avoid the freezing of the optical and protective elements.

3.4.4 Luminacimeters or luminosity sensors.

The sensors of luminosity try to establish the ruling luminosity in the atmosphere. These devices operates in ranks of measurement from 4 to 30,000 cd/m², with a precision of 10%, guaranteeing the linearity in the pick up of light as well as its stability in the changes of temperature. They are usually installed over the transmissometers.

3.4.5 RVR Calculator.

The RVR calculator uses a special calculation software, based in specifics algorithms from the ICAO [2], being the RVR obtained in each location and distributed to the central unit of the meteorology integrated system.

Its main capacity is to obtain the values of RVR, by application of the formulas corresponding to ICAO, from the measures given by the receivers and luminancimeter. The option of manually introduce the data of brightness of runway lights is allowed.

The RVR measurements update at least every 15 seconds, showing as valid the average value of the last minute, and indicating by an alarm the diminution of the value of RVR below an attention value.

The software of this computer must be certified by the manufacturer of the sensors installed, and ICAO certificates for the used algorithm are also necessary.

3.5 Height of clouds sensor or nefobasimeter.

This sensor evaluates the height of one or more cloud layers existing over the airport.

The measuring equipment usually uses laser technology. The transmitter and the receiver use the same lens to the object to obtain better results in the rank from 0 to 300 ft.

Heating, thermostat and automatic cleaners for the control of temperature of the optical and electronic systems, including automatic conditioning of window are also incorporated to the equipment.

It measures from 0 to 25,000 ft, with a minimum precision of +/- 20 ft. or approximately 2%.

For bases smaller or equal to 3000m (10,000 ft) the resolution will be of 30m (1000 ft), and for bases greater than 3,000 the resolution will be of 300m (1,000 ft).

The cycle of measurement has to be programmable between 15 and 120 seconds, having an automatic system such that in case of cloudless sky optimizes the emission of the laser.

They detect simultaneously up to three cloud layers, having two types of ports: a data port with data of height of clouds and status, and another port including all the possibilities of maintenance. Like transmissometers, nefobasimeters have an automatic compensation of the contamination of the lenses (dirt).

The control unit of the sensor allows the presentation of the three layers of simultaneous

clouds, or two cloud layers and vertical visibility, if the lowest layer is not enough defined, including the thickness of the same ones.

The state of the sensor, maximum range of the laser, location of the sensor and other utilities also appears.

3.6 Additional standard sensors.

In addition to the aeronautical sensors previously described, other climatologic sensors are usually installed in the airports. Some of these are termohigrometers in weather huts over natural ground, sensors of minimum temperature next to the ground, extreme thermometers, anemocinometers at several heights, precipitation transmitters, evaporation pans, global radiation, and insulation, among others.

4. Airport's weather data displays.

4.1 Displays of weather data in air traffic control tower.

One of the most important displays used by the air traffic controllers are those used by the meteorological information system, specially the displays of wind data and those of temperature and humidity [1].



Figure 6.- Weather Data Displays in Air Traffic Control Tower.

This data is used during the takeoff and landing of the airships. For that reason, in the older control towers and in the most modern ones, these displays occupy a predominant place, with dedicated displays for them.

There is a tendency to display the information in screens of integrated systems for air traffic controllers information. The controller receives all the necessary information in only one computer-driven display.

Nevertheless, in these towers the actual modular presentation display system has also been preserved, as a backup in case of bad functioning of the integrated system.

The rest of data is exclusively used in adverse conditions, and is presented to the controller in secondary screens of smaller level of use.

The wind, temperature and humidity data appear in wind roses of high luminosity, settling an additional screen to facilitate to the controller the rest of weather data.

In certain towers special presenters arrange themselves to other parameters of great influence in dependency of the usual airport conditions, like individual displays for the RVR.

4.2 Operation terminals.

Additionally, there is a tendency to install operation terminals based on friendly man-machine interfaces which offers the weather data with detailed description and definition than the strictly aeronautical one. These operation terminals are even settled in the control towers, for the use of the air traffic supervisor or to obtain parameters different than those displayed in the controller position [3].



Figure 7.- Supervisor's Terminal.

4.3 Interfaces with other systems.

In certain configurations of airports, interfaces of communication with other systems have been designed to use weather data for calculations. In particular, there are great advances in the communication with the airfield lighting systems, some models even automatically or semiautomatically manipulates

the lights of the airport depending on the meteorological conditions provided by the integrated meteorology system.

5. Conclusions and future work.

This paper describes an airport measure system to obtain important meteorological parameters using embedded systems. It is also described how to integrate those parameters into a single system and to communicate the calculations to external systems. The use of processor-controlled sensor makes possible the calculation of certain parameters and the correction of some errors (i.e., dirt on the lens). The use of classical sensors, without embedded systems, can't afford all the possibilities given today to air traffic controllers and pilots.

Our approach will be to develop a highly integrated meteorological system, to create a most suitable system and to reduce the errors of estimation reducing the human estimations.

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