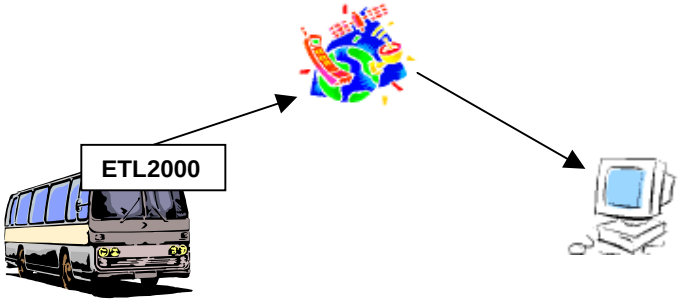
Dynamic air quality monitoring with mobile sensors

Ing. Raffaele Caltabiano - t&t telematica e trasporti S.r.l. Autoporto Pad.A 34170 Gorizia . tel 0481 523874 , fax 0481 523879 , e-mail : t&t.rc@tin.it , web : www.t-t.it



Introduction

The goal of our "**on the move**" air monitoring project is to overcome the limits of conventional monitoring technologies. Traditional air monitoring technologies are based on:

- **a network of fixed control centres** with gas analysers and appropriate equipment consistent with the laws in force
- **movable monitoring stations in fixed points** enhanced with the same equipment of the fixed control centres
- **mathematical models** for simulation and analysis of pollution effects according to the data collected

The **limit** of these technologies consists in the fact that these systems are actually conceived for concentration measurement of air polluting elements in order to alert the public authorities when certain levels are exceeded.

Air pollution testing stations collect precise data in the points where they're located, disregarding completely the characteristics and distribution of the sources of air polluting agents and their spreading mechanism over to the territory.

Furthermore air pollution monitoring stations ignore small areas with localised pollution like traffic light areas, long queues etc

Due to their encumbering dimensions and high supplying and management costs, fixed networks cannot be used for surveying and quantifying areas with extended pollution sources which require many measurements in different locations over the same period of time.

Furthermore they are unable to survey and measure the effects of localised polluting agents in small areas like the ones close to traffic lights, or in the middle of streets where pollution monitoring stations cannot be poisoned.

In the attempt to improve and gain knowledge of the air pollution over the territory, indirect methods like simulative or interpretative **mathematical models** are used on the basis of a previous census carried out on air pollution sources and distribution.

These **models,** that generally yield good results when referred to large homogeneous territories or cities with a large and regular urban structure do not seem to be so reliable when it comes to irregular territories exposed to variable winds or cities with with an inhomogeneous urban layout, growing traffic, increasing traffic light infrastructures etc.

Objectives of the e-MON project

Our project is able to overcome the above mentioned limits through an innovative solution based on **THICK FILM SENSORS** installed on public transportation vehicles, like buses, in order to carry out , on a daily basis, a continuous and systematic monitoring of the entire territory to be surveyed.

Every day, measurements may be carried out simultaneously over different routes and be repeated continuously. In this way it is possible to obtain a bi-dimensional map of the territory through direct testing and deducing the space-time characteristics of various pollution sources and spreading of polluting agents

The data collected may be integrated with:

- **the existing network of fixed control centres** enabling a correlation of polluting agent distribution functions from one point to another of the network
- **mathematical models for simulations** providing continuously the data measured at a ground level in order to improve and test the models.

Thick film sensors

The measurement is realised partly by an analogical circuit and partly by a system composed of an A/D microprocessor converter and uses the proprieties of innovative thick film sensors. **Thick film sensors** are devices based on a technology that utilises the phenomena of electric conduction that takes place on the surface of nanostructured oxide semiconductors (composed of micro-grains with a dimension of 30÷50 nm) heated up to a temperature of (200÷450 °C).

In these conditions the phenomena of oxygen absorbing on the surface of the grains of the semiconductor takes place. The signal obtained from the semiconductor is proportional to concentration of gas in the atmosphere .

An appropriate calibration curve enables to convert “the signal obtained into concentration”.

The sensor is composed of a serigraphy paste on an aluminium plate that measures 2,5 mm per side, under the sensor there’s a heating element that rises the temperature of the sensitive layer to an adequate level.

In the lower part of the aluminium plate there’s a feeler that enables to measure and, through a control circuit, correct the working temperature of the sensor.

In this case a constant working temperature of the sensor is guaranteed so that external temperature variations do not cause changes in the response of the sensitive layer.

The aluminium plate is connected to a circuital element through golden contacts thick 0,3 mm connected via thermo-compression (bonding). The signal obtained passes through a set of filters in order to eliminate possible noises.

Technical description

The innovation of our project is based on two principal elements: the **product** and the **system integration**.

Product innovation is realised using an integrated unit, the ETL2000 Bus, fit for a mobile use, with THICK FILM solid state sensors for the measurement of air polluting agents like CO, NOx, e O3.

The unit is integrated with temperature, humidity and noise measurement. The data collected by the board equipment is processed by the SBX3004 board computer and

integrated with precise space-time coordinates through satellite positioning systems , GPS, and transmitted via GSM to a Monitoring Control Centre.

The system integration implies the integration between:

- The Board equipment: ETL2000, SBX3004 .
- The Data Control Centre that continuously receives and reliably registers the monitored data. The software of the Centre must manage sophisticated functions regarding the analysis and mapping of the territory with the data collected.
- Co-ordination with local authorities (ARPA) for data exchange and integration with the network of fixed control centres.

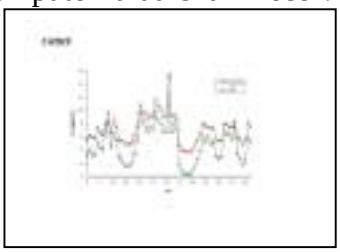
The e-MON Project in Rome

The data collected by the ETL2000 unit long the route followed by the bus is integrated with precise space-time coordinates obtained through satellite positioning systems installed on the bus and transmitted via GSM to a Control centre where the data is registered and processed.

The bus used for public transportation is equipped with an instrumental package including:

- thick film sensors for the measurement of CO, NOx, O_3, sensors for temperature and humidity measurements and a noise sensor;
- a board system for data management and transmission,
- radio-communication and satellite positioning devices

The architecture of the control Centre requires a dedicated computer that shall receive environmental information enhanced with positioning measurement time data from the vehicles while moving along heir routes .



The data collected shall be evaluated and integrated with the data from the network of fixed control centres in collaboration with the local environmental authorities.