LIFE+11 ENV/IT/000002

CLEAN-ROADS

Action A1:
Experimental data collection campaign during a winter season

D.A1.1

Static RWIS stations

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Table of Contents

1 INTRODUCTION 5

2 ROAD-WEATHER STATION TECHNICAL SHEET 6

2.1 ROAD WEATHER MONITORING STATION 8

2.2.1 Data management unit 8

2.2.2 Temperature and humidity sensors 9

2.2.3 Atmospheric pressure sensors 9

2.2.4 Solar radiation sensor 10

2.2.5 Wind direction and intensity sensors 11

2.2.6 Present weather sensor 11

2.2.7 Traffic sensor 12

2.2.8 Road surface conditions sensor 12

2.2 AIR QUALITY MONITORING STATION 13

2.3 WATER QUALITY MONITORING STATION 13

BIBLIOGRAPHY 14

Table of Figures

Figure 1: Typical configuration of RWIS station. 6
Figure 2: Pyranometer, thermometer and RH detector... 7
Figure 3: Anemometer, wind vane and precipitation detector. 7
Figure 4: Sensors installed on the road surface.. 7
Figure 5: RWIS data management unit.. 8
Figure 6: Air quality monitoring system. 8
Figure 7: MROAD 500 9
Figure 8: Hygroclip S3 line series 9
Figure 9: Atmospheric pressure sensor. 10
Figure 10: Solar radiation sensor, ...10
Figure 11: Wind direction and 11
intensity sensors..11
Figure 12: Precipitation sensor. 11
Figure 13: Non-invasive traffic sensor..12
Figure 14: Road surface conditions sensor. 12
Figure 15: Air quality monitoring station. 13
Figure 16: Receptor models theory at the base of source apportionment methodology [9]. ..13

1 Introduction

Action A1 is one of the two actions expected in the preparatory actions A, which is responsible for the installation of five RWIS (Road Weather Information System) stations in order to collect baseline data to be used to determine quantitatively the benefits and specifically the environmental gain produced by the optimization process that will be tested during the subsequent steps.

The RWIS stations are composed of:

- **atmospheric sensors** such as temperature, relative humidity, wind speed and direction, present and typology of precipitation;
- **temperature sensors** to measure the surface and sub-surface road temperature and to classify the road condition surface in terms of of dry, wet or frozen state;
- **sensors of salt presence** *and concentration* on the road surface.

The collected data will be then matched and analysed with other data coming from:

- meteorological forecasts and bulletins;
- winter road maintenance treatments;
- traffic data;
- environmental data, i.e. air pollution levels and chloride concentrations of run-off waters.

During the measurement campaign it will be evaluated the environmental impact produced by the intense use of salt and gravel on the roads with the aim of (i) comparing it with other reference scientific studies and (ii) estimating the local effects produced on surrounding aquatic systems and vegetation.

It is worth noting that the aim of this document is just to provide an accompanying document for the installed prototype (i.e. the first monitoring site), offering in a synthetic way the reference technical characteristics of its main components. The complete description of the reference monitoring technologies at the base of the different sensors is out of the scope of this document, and will be offered through the deliverable D.A2.2 "*Technological instruments and constraints*". It is finally important to mention that the present report is in light of the delays occurred during the preliminary stage of the project and the following recovery plan, only a preliminary version of this deliverable, which will be possible to fully complete only at the end of Action A1, namely at the end of winter season 2013/2014.

2 Road-weather station technical sheet

Figure 1 shows the typical configuration of a RWIS station; the pole on the left is the standard support for the atmospheric sensors.

Figure 1: Typical configuration of RWIS station.

On the top of the stick, at a height of 5 meters, we can observe the **precipitation detector**, the **anemometer** in charge of measuring the wind speed and the **wind vane** to evaluate its direction (Figure 3). On the same structure (Figure 2), at a height of 2.5 meters, are located the devices responsible for the measurement of the **relative humidity** and **air temperature** as well as for the determination of **global radiation**, which is estimated by means of of a pyranometer.

Figure 3: Anemometer, wind vane and precipitation detector.

Figure 2: Pyranometer, thermometer and RH detector.

On the road, four equidistant invasive road surface conditions sensors measuring (i) the temperature of the first centimetres of the superficial layer and (ii) the saturation level of the liquid film on the surface are installed.

Figure 4: Sensors installed on the road surface

Finally, inside the main cabinet, on the upper left side, the **pressure meter** is located (Figure 5). All the raw data acquired from the different sensors are sent to a **data management unit** stored in this case (easily identifiable in the aforementioned picture) where it is collected, converted, elaborated and stored. This unit can be then connected through a dedicated **communication interface** in order to remotely send the data to a central storage system.

Figure 5: RWIS data management unit.

Figure 6: Air quality monitoring system.

The air quality monitoring system is actually an independent roadside unit installed on the roof of a separated container. The system is capable to evaluate the composition and quantity of particulate matter (PM10), following standard methods and procedures which are used to determine the air quality concentrations requested by the national law (Figure 6).

2.1 Road weather monitoring station

2.2.1 Data management unit

This unit includes the reference technology used in the product MROAD 500, a commercial component capable of collecting, elaborating and storing data acquired by various sensors operating both in the weather and traffic monitoring [1]; images can also be handled by means of an input of a webcam. Data and images can be sent at specific time intervals to a FTP server through the standard protocol TCP/IP.

Main features can be summarized as follows:

Figure 7: MROAD 500

- control of traffic, weather and road surface conditions detectors;
- real-time statistical data output;
- high-communication capacity;
- low energy demand;
- compact and watertight package;
- internal memory: 2GB
- compatible with both digital and analogical inputs;
- operating temperature between -40°C and 80°C
- operation system: Embedded Linux.

2.2.2Temperature and humidity sensors

This versatile probe, based on OEM Hygroclip S3 line series, is capable of measuring relative humidity (RH), temperature and calculates the dew/frost point [2].

Main features can be summarized as follows:

Figure 8: Hygroclip S3 line series

- RH accuracy at 23°C ±5K : ±0.8%
- temperature accuracy at 23°C: ± 0.1 K
- temperature sensor: Pt100 1/3 DIN
- application temperature range between -50°C and 100°C
- application relative humidity range between 0% and 100%
- programmable automatic sensor test with fail safe mode and sensor drift compensation
- excellent long-term stability <1 %RH / year
- response time: <15 sec

2.2.3 Atmospheric pressure sensors

This sensor, produced by Lambrecht, can measure the absolute pressure through a piezoresistive pressure measuring cell in a range from 600 to 1100 hPa [3].

Main features can be summarized as follows:

- cost effectiveness;
- accuracy: ±1 hPa;
- applicable with/ without data loggers in energy-saving mode (e. g. solar operation);
- one instrument capable to make pressure measurement in two different ranges;
- 3 standard outputs;
- operating temperature between -30°C and 60°C;

Figure 9: Atmospheric pressure sensor.

2.2.4 Solar radiation sensor

The determination of global solar radiation is performed through thermal difference measurements by means of a thermopile, which comprise high-quality thermocouples. The glass dome above it protects against cooling effects caused by wind and against soiling [4].

Main features can be summarized as follows:

- operating principle: thermal;
- measuring range from 0 to 1400 W/m^2;
- global radiation range from 315 to 2800 nm;
- operating temperature between -40°C and 80°C;
- response time (95%): <18 s;
- non linearity: ± 2.5%;
- sensitivity: 5... 15 µV/ Wm^2;
- designed in accordance to the international standard ISO 9060.

Figure 10: Solar radiation sensor,

2.2.5 Wind direction and intensity sensors

The anemometer and the wind vane measure respectively the speed and direction of the wind. The optimal heating of the sensor head and minimum power demand of the system are made possible by thermal decoupling of the housing shaft [5].

Main features can be summarized as follows:

- measuring principle: Hall Sensor Array;
- precision, tradition and future reliability;
- large operative measuring and temperature range;
- operating temperature between -30°C and 70°C;
- operating wind intensity between 0.7 and 60 m/s;
- accuracy of the wind vane: ±2%;
- accuracy of the wind : ±2%.

Figure 11: Wind direction and intensity sensors.

2.2.6 Present weather sensor

This sensor detects the type and intensity of precipitations; it can discriminate between snowfall, rainfall, hail and mixed precipitations and classify them according to its level of intensity [6].

Main features can be summarized as follows:

- optical (Laser) barrier technology;
- high reliability;
- immediate detection of any precipitation type and of the correspondent intensity level;
- sensitivity to minimal precipitations levels;
- high reliability even in extreme conditions;
- self-diagnosis functions;
- powered by mains or photovoltaic panelM
- internal heating to avoid condensation or snow accumulation;
- operating temperature between -30°C and 60°C.

Figure 12: Precipitation sensor.

2.2.7 Traffic sensor

This non-invasive sensor can detect stationary and moving vehicles and classify them into different categories with an accuracy similar to that of an induction loop device. It can also gather other essential information for traffic engineers such as vehicles category, distance (quantified in terms of gap or headway), direction, and speed [7].

Main features can be summarized as follows:

- single microwave technology;
- classification of vehicles into 9+1 categories (Italian reference traffic classification standard);
- low-energy consumption;
- powered by mains or photovoltaic panel;
- operating temperature between -20°C and 60°C

Figure 13: Non-invasive traffic sensor.

2.2.8 Road surface conditions sensor

This sensor has been designed to monitor the road surface conditions; it can detect the underground (4 cm depth) and surface temperature and also the saturation level of the liquid film on the road. This technology represent an important instrument for planning the winter road clearance with the possibility to set alarms in case of dangerous conditions [8].

Main features can be summarized as follows:

- thermally passive;
- shielded from solicitations coming from traffic, weather, and anti icing chemicals;
- transducer: three aluminium electrodes and two thermo resistances (class PT100), for a total of four connections;
- classification of road surface condition into 6 different categories;
- typical Accuracy 0.2°C;
- operating temperature between -40°C and 70°C.

Figure 14: Road surface conditions sensor.

2.2 Air quality monitoring station

The equipment used to measure PM10 concentration on ambient air is a gravimetric tool, that represents the official method allowed according to the national law (D.Lgs. 155/2010, All. VI, UNI EN 12341:1999).

This method consists on a gravimetric sampling technique based on a quantitative determination of particulate of a certain diameter based on its mass. In the PM10 sampler, a separating cyclone is able to select the particulate of a size smaller than 10 μm, that is hold on a filter. Therefore the filter is weighed in a laboratory using suitable and standardized weighing equipment.

Figure 15: Air quality monitoring station.

It will be used an automatic outdoor station for continuous atmospheric particulate monitoring using the sampling method on 47mm diameter filter membrane. The sequential substitution system of the filtering membrane and the electronic flow rate controller allow continuous operations.

Therefore, the filter will be analysed chemically in order to identify the main sources of the particulate matters, following the standard source apportionment methodology and using an advanced algorithm called positive matrix factorization (PMF) (Figure 16).

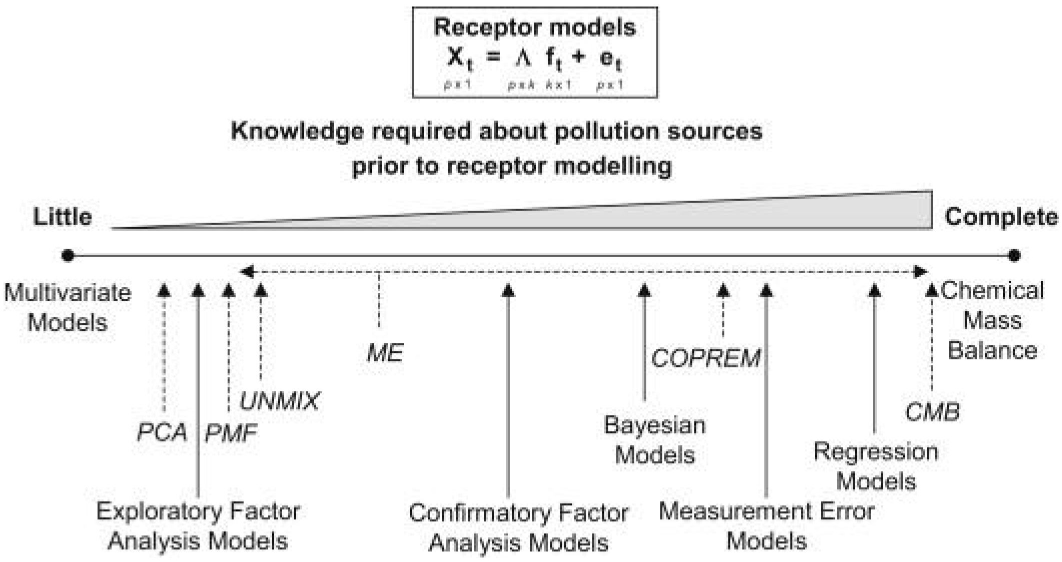

Figure 16: Receptor models theory at the base of source apportionment methodology [9].

2.3 Water quality monitoring station

This part will be completed before the winter season 2013/2014, when the run-off water streams collection and monitoring system will be activated within the case study road.

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