European Civil Protection

»With the contribution of the Civil Protection Financial Instrument of the European Union«

WIND RISK

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Precise wind measurement in the scope of WIND RISK project

Wind Risk project is being implemented by four partner institutions from three European countries with the contribution of the Civil Protection Financial Instrument of the European Union. Project aims for several tasks completion: assessment of all wind related risks and vulnerabilities, analysis of current wind related regulations and legislation (especially those related with prevention and protection in the case of high winds), measuring wind related variables with high frequency and precession, comparison of measured data with those predicted by the lawmakers. Final result of the project is expected to be a set of recommendations for improvement of current laws, regulations and norms to better suit measured data.

To accomplish these tasks partners are implementing system for precise three dimensional high frequency measurement of wind variables that will help us understand the phenomenon of high wind and its impact on population, infrastructure, buildings, roads and forests. In this newsletter we are describing the process of engineering such a system for Dalmatia region in Croatia.

➢ Wind measurement

Wind is a natural movement of air in any direction and at any speed due to the differences in pressure and temperature of the surrounding air. Typical variables that are used for quantifying the wind are wind speed and wind direction, but additionally, especially in civil engineering, pressure of wind on buildings is also measured.

It is shown that the movement of the air is not homogenous or continuous. Wind speed and wind direction variables measured at a certain location and in certain moment of time do not describe wind phenomena in a wider area or longer period. Wind speed and wind directions vary significantly in vertical, horizontal and time scale.

Traditionally, wind variables are measured on 10 meters above ground and are averaged over 10 minute periods. Wind is traditionally measured by cup anemometer, by counting impulses of cup turns in certain period of time for wind speed. Wind can be classified using Beaufort scale. In this project we have selected three dimensional ultrasound anemometers for precise, high frequency wind measurement.

Ultrasonic anemometer measures wind speed on the basis of time of flight of sonic pulses between pairs of transducers. If equipped with 3 pair of transducers it can be used for 3D measurement. These anemometers do not have moving parts, which makes them more reliable and able to handle high frequency measurements.

In the scope of Wind Risk project, we are performing measurement on two sites – in the area of Municipality of Ajdovščina in Slovenia and in central Dalmatia in Croatia.

➢ Ultrasonic 3D anemometer

On the market there are several suppliers offering ultrasonic 3d anemometer devices. We will mention two most commonly used: Gill Instruments and Thies Clima. Measurement in Dalmatia is done by using Thies Clima ultrasonic anemometer 3d, while on measuring place in Ajdovščina Gill instruments WindMaster anemometer is installed.

Thies Clima anemometer technical characteristics are:

- measurement of wind direction, wind speed in 3 dimensions X, Y, Z;
- measurement Range: 0 .... 65 m/s;
- temperature Range: - 40 ... +70°C;
- resolution: 1°;
- radius: 0 ... 360°;
- highest precision;
- real time measurement;
- maintenance free / heatable;
- digital/analogue In- /Output Channels.

Anemometer used in Ajdovščina has the following technical characteristics:

- measuring wind speed & direction and acoustic virtual temperature;
- radius 0 ... 359º (no north gap);
- weather resistant in extreme weather conditions;
- 20 Hz or optional 32 Hz data rate;
- optional analog In- and output;
- U, V, W, SOS & Sonic temp output;
- maintenance - free.

➢ Mounting of measurement equipment on location “Bobani”

Selection of location for wind measurement in Dalmatia is determined to ensure micro location homogeneity of the data. In Croatia, location “Bobani” in Split hinterland is selected for following reasons:

- the location is on highest surrounding point;
- the surrounding land is covered with grass and small bush;
- antenna pillar suitable for measurement equipment mounting is located on the site and power supply is available;
- there are no obstacles in direction of two main winds in Dalmatia – bora (bura) and sirocco.

The location on the map is shown in Figure 1.

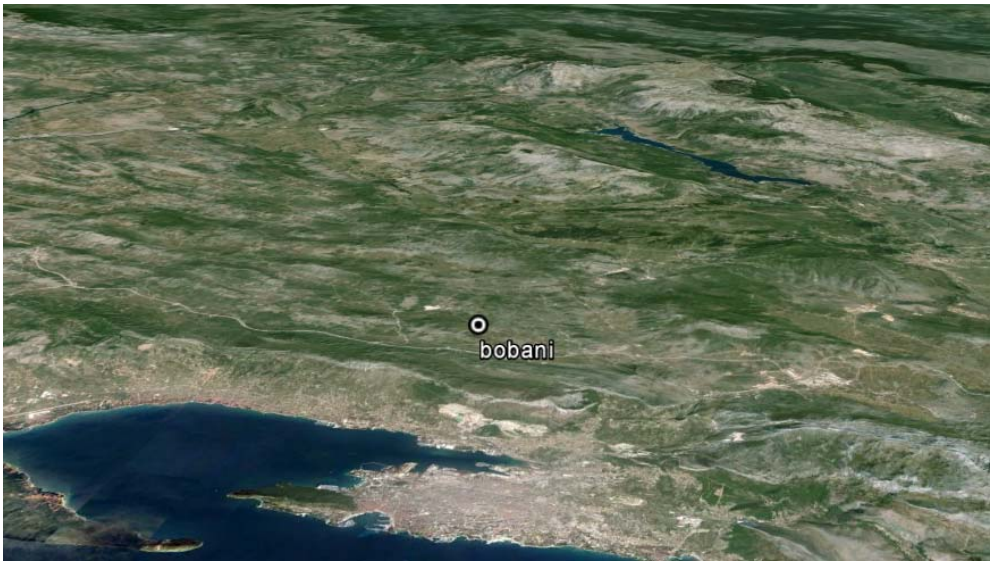

Figure 1: Measurement location in Dalmatia

Thais Clima anemometer is located on the antenna on 10 meters height. It is mounted using a rod so the antenna does not affect surrounded air turbulence. Beside this anemometer, on the same antenna we have 3 *cup anemometers* with used for measuring vertical distribution of the wind.

a)

b)

Figure 2: a) Anemometers mounted on antenna pillar on three heights for wind measurement; b) Thais Clima 3D anemometer

There is also a container for equipment protection placed in the base of the antenna. The container is owned by the same telecom operator as the antenna and holds electronic equipment for antenna functioning. The inside of the container is air conditioned and has permanent power supply thus suitable for electronic equipment placement. All wires from anemometers are brought to the inside of the container. For the purpose of wind measurement streaming we have placed embedded computer inside the container and connected it to anemometer. 3D anemometer wire is connected via RS485/RS232 converter to the embedded computer. The converter is shown in Figure 3.

Figure 3: Connector for 3D ultrasonic anemometer

Location "Bobani" is relatively near Split, but since it is not easily accessed so we wanted to make sure installation will not require frequent maintenance trips. Embedded computers are more appropriate and less expensive for mounting on site of measurement, where one cannot easily access the site. These kinds of computers do not have moving parts so they are more reliable for maintenances and are less expected to fail.

The computer runs custom version of Linux CentOS operating system and is enhanced with scripts and software for reliable work and for network streaming of measured data. The computer is also equipped with USB stick for mobile data traffic and this part is the most vulnerable. Thus, to ensure reliable work and continuous streaming a script for USB device monitoring is installed on the computer.

To ensure remote access to the computer we have implemented VPN (Virtual Private Network) via web server virtual computer.

Figure 4: Embedded Linux computer for the streaming of data measurement

➢ Software for wind data streaming

WindReader software is written in C programming language and compiled for specific operating system. The software continuously reads telegram of data from RS232 port, parses the data and calculates the averages. Periodically, software sends the averaged data to web service for accepting and archiving the wind measurement data.

Additionally, software maintains 3 additional logs locally:

- complete log – verbatim copy of every reading from the meteorological station in raw form with addition of a timestamp at the end of each line. Since the data is sampled at high frequencies a new file is created every hour because of the file size. The name of the file indicates the time period, e.g. WindReaderLog-16.10.2015.-14h.log;
- 3 seconds averages log – logging of 3 second averages for *u, v* and *w* vectors as well as virtual temperature. Timestamp is added at the end of each record. A new file is created every day. The name of the file indicates the date of the logging period;
- 10 minutes averages log – logging of 10 minutes averages for *u, v* and *w* vectors as well as virtual temperature. Timestamp is added at the end of each record. All records are written in the same file.

➢ Web service for wind data archiving

Wind data is archived on the server site on the same virtual machine that runs the web server and web site www.windrisk.eu. We have designed a simple database for data archiving. The database consists of two tables as shown in Figure 5.

The locations for wind measurements are described in table *Locations*. Each location is given unique id and name, as well as geographical coordinates. Measurements are stored in table called *Measurements*. A measurement is given unique id, and is associated with location of measurement by *id_location* foreign key.

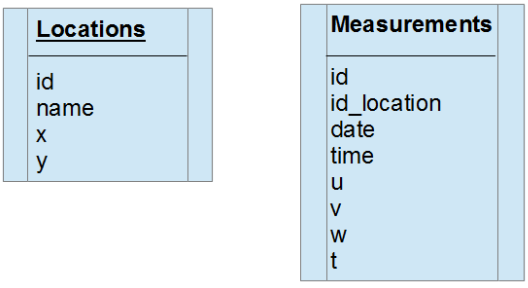

Figure 5: Tables of wind measurement archive database

The service implements "*store data"* functionality, and requires the following parameters:

- location name;
- u, v, w – components of wind measured by anemometer;
- sonic temperature measured by anemometer.

When all necessary parameters are received, the service checks for the location identifier and stores the data with current time and date taken from server system time. New data is given new unique identifier.

➢ Software for data visualization

The archived data can be shown in web interface of wind risk web page. For this purpose we have developed a word press plugin for graphical presentation of wind data fetched from database. The data is fetched from the database and only wind speed is calculated and presented in the JSON format. A part of the wind data series is shown below.

[{"ID":"8827","id_location":"1","time":"02:20:07","date":"2015-12-10","u":"0.34","v":"0.43","w":"0.01","t":"18.54"},
{"ID":"8828","id_location":"1","time":"02:30:07","date":"2015-12-10","u":"0.24","v":"2.12","w":"-0.69","t":"17.89"},
{"ID":"8829","id_location":"1","time":"02:40:07","date":"2015-12-10","u":"1.17","v":"5.33","w":"-0.11","t":"18.62"},
{"ID":"8830","id_location":"1","time":"02:50:07","date":"2015-12-10","u":"-0.37","v":"3.55","w":"-0.22","t":"18.04"},
{"ID":"8831","id_location":"1","time":"03:00:07","date":"2015-12-10","u":"1.12","v":"0.62","w":"-0.23","t":"17.84"},
{"ID":"8832","id_location":"1","time":"03:10:07","date":"2015-12-10","u":"-2.64","v":"1.83","w":"0.07","t":"17.84"},
{"ID":"8833","id_location":"1","time":"03:20:07","date":"2015-12-10","u":"-2.21","v":"3.01","w":"-0.54","t":"17.64"},
{"ID":"8834","id_location":"1","time":"03:30:07","date":"2015-12-10","u":"-1.39","v":"1.7","w":"-1.05","t":"17.38"}]

Figure 6: Part of the wind data fetched from database and presented in JSON format.

➢ System architecture

The overall architecture of measurement and archiving system for measurement in central Dalmatia is shown in Figure 7. Measurements taken by 3D ultrasonic anemometer are transferred via RS485/RS232 converter to RS232 port of embedded computer located at the site. Measurements are logged locally and periodically pushed to web service for wind measurement archiving using wireless mobile network. Web service is responsible for storing data to database. Stored data is then used in analysis and displaying in the form of the graph.

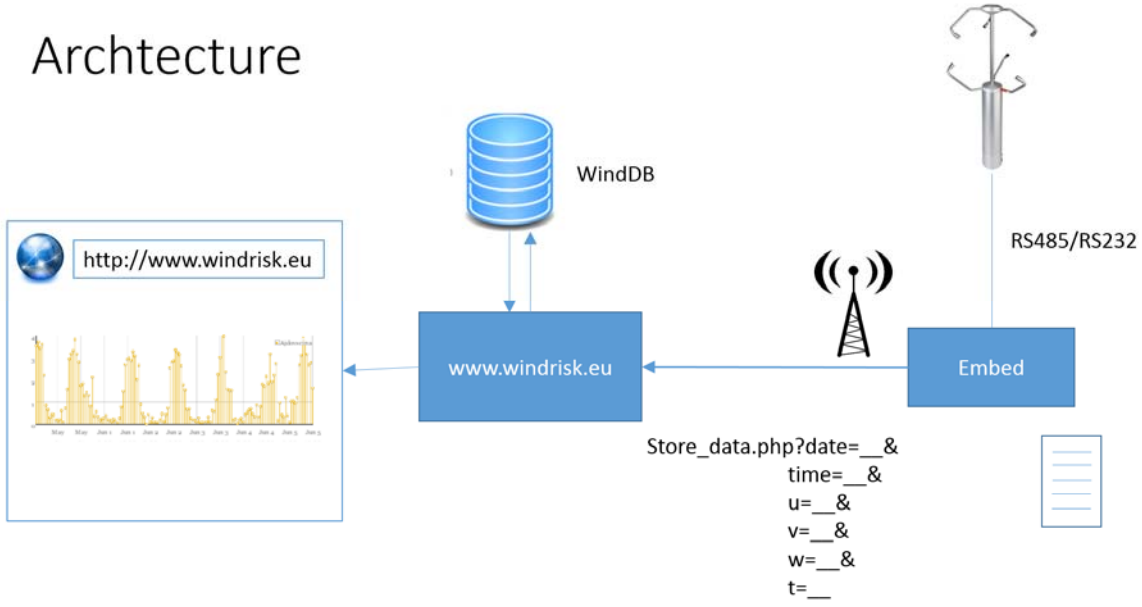

Figure 7: Wind measurement system architecture

➢ Conclusions

As an activity of the Wind Risk project, we have implemented a high frequency precise wind measurement system on two locations – Municipality Ajdovščina and central Dalmatia. In this newsletter we have focused on technical part of measurement system engineering in central Dalmatia. Here we have selected location suitable for Bora and Sirocco measurement that is located in Split hinterland. We have equipped location with anemometer, computer and network.

On the server side we have implemented software in the form of a web service for archiving the data sent by embedded server on the location. Stored data is permanently archived and can be used for data analysis and visualization. The wind graph is displayed in a separate web page that is part of the www.windrisk.eu web portal and is available to the public.