Factors in Choosing the Right Wind Sensor for your Application

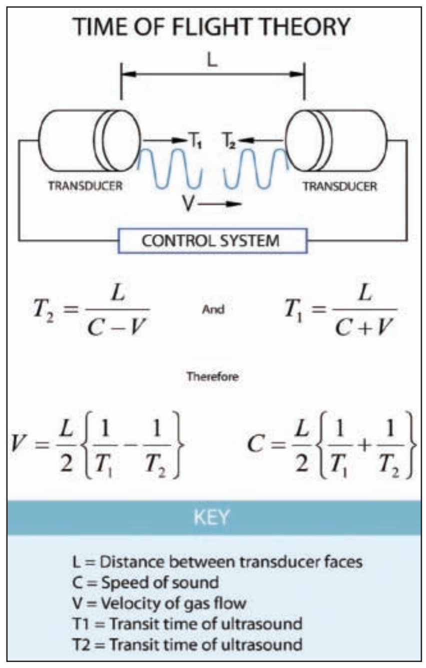
The measurement of wind is one of the most important factors in weather prediction. Wind is the movement of air caused by uneven heating of the earth's surface. It occurs in light breezes that are locally generated due to heating of an immediate landmass, to winds on a grand scale spanning continents caused by solar heating. Besides being used as part of a weather monitoring station there are many other situations where knowledge of the wind condition helps in decision-making such as pollution control, safety of tall structures, control of wind turbines, studies on the effects of wind on crops, manovering of ships and aircraft landing systems. Wind speed is measured with an anemometer; the word anemometer comes from the Greek anemos meaning wind, plus meter.s.

Measurement Systems

For many years mechanical cup and vane anemometers have been used to measure wind speed and direction. These are normally simple but effective tools with the cup measuring the speed and the vane the direction. Variants of the mechanical design also use a small propeller to measure the wind speed and both types of instruments are relatively inexpensive. However there are alternative technologies worthy of consideration. Over the last fifteen years ultrasonic and other solid-state techniques have come on onto the market. Of these the use of ultrasonics is dominant.

Ultrasonic anemometers have the advantage of having no moving parts and therefore they do not suffer bearing wear unlike mechanical devices. With reliable modern day electronics Ultrasonic anemometers are virtually fit and forget. Another advantage is that they have no initial friction to overcome before providing data. Ultrasonic anemometers are available in single axis, two axis and three axis variants. Single axis units will only measure the component of wind speed along the axis in which they are placed, two axis units measure the horizontal wind speed and direction, and three axis units measure three dimensional real time turbulence profiles.

Ultrasonic technology relies on the measurement of sound waves between fixed transducers. A typical two-axis anemometer measures the times taken for an ultrasonic pulse of sound to travel from the North transducer to the South transducer, and compares it with the time for a pulse to travel from S to N transducer. Likewise times are compared between West and East, and E and W transducer. If for example, a North wind is blowing, then the time taken for the pulse to travel from N to S will be faster than from S to N, whereas



the W to E, and E to W times will be the same. The wind speed and direction can then be calculated from the differences in the times of flight on each axis. This calculation is independent of factors such as temperature. Some ultrasonic anemometers also provide Speed of Sound and Sonic temperature outputs, these parameters are important in some research applications.

Another important factor in the use of the ultrasonic technique is that the instruments can provide inherent diagnostic capability. With a mechanical anemometer you do not know if it is not working or if there is no wind if zero wind is reported. With ultrasonic instruments you can provide a health check as part of the output stream.

When first introduced to the market Ultrasonic anemometers were relatively expensive and were used primarily by the research community or where high reliability was critical. However there are a number of two axis instruments available on the market that are comparable in price to professional quality cup and vane /propeller units, and ultrasonic anemometers are rapidly becoming the instrument of choice for all professional measurements. Electronic outputs from both mechanical and ultrasonic anemometers are available in a number of analogue and digital formats and so data can be sent to a wide range of recording instruments such as data loggers, digital displays, chart recorders or directly to a PC for viewing and archiving. Software is available from a number of manufacturers to achieve this. However anemometers will only measure wind speed and direction at the precise point where they are positioned. In some instances it is necessary to make wind measurements higher up in the atmosphere. This can be achieved in a number of ways but traditionally this involved the use of weather balloons and wind finding radar. There are also remote sensing systems now on the market that do not require the use of balloons. These instruments are known as SODARS (SOnic Detection And Ranging). Sodar systems are like radar (radio detection and ranging) systems except that sound waves rather than radio waves are used for detection. Sodar systems operate by sending an acoustic pulse and then analysing the return signals intensity and Doppler (frequency) shift as a function of time (and therefore altitude) to determine the wind speed, wind direction and turbulent character of the atmosphere. Sodar systems typically have maximum ranges varying from a few hundred metres up to several hundred metres or higher. Maximum range is typically achieved at locations that have low ambient noise and moderate to high relative humidity.

Anemometer Applications

There are many different anemometer models on the market and selecting the correct one for your application can be difficult. It is therefore essential to fully understand the environment that exists where you intend to make the measurements. The instrument may need to measure and survive high wind speeds and so needs to be mechanically robust. They may also need to operate in very cold and icy conditions and to achieve this heated variants are available. Corrosion resistance may also be important in offshore and certain industrial applications. There are also instances in potentially hazardous environments such as on oilrigs or within refineries where instruments certified as Intrinsically Safe in accordance with the ATEX directive are required; these instruments are available from certain manufacturers. As well as their use as part of a weather station anemometers are also used to make air

Two axis ultrasonic anemometer.
Picture courtesy of Gill Instruments.

flow measurements to control ventilation in buildings and road tunnels.

Typical array of two axis and three axis anemometers. Picture courtsey of Gill Instruments.

One application has been responsible for an increasing demand for reliable wind speed and direction measuring instruments. With the drive to reduce greenhouse gas emissions from burning fossil fuels thousands of wind turbines have been erected. These are large structures and to produce enough electricity many turbines are placed in close proximity on wind farms. These are intrusive on the local environment and are therefore often placed in fairly remote locations and even offshore. However before erecting a wind farm it is important that the right site is selected. These sites are invariably financed on the basis of a return on investment, and this calculation requires extensive information on how much wind will be available all year round. Errors in this prediction can have an enormous effect on the amount of electricity produced and the viability of the investment. For this reason the potential sites are surveyed for long periods to assess the amount of wind available. Large towers are erected with many anemometers mounted at varying heights to collect data. Consequently selecting the right instrument is paramount, it would be very unfortunate if the wrong instrument was selected and a large amount of data was lost.

Once the site has been selected the anemometers then have another important application. The wind turbines need to be steered into the wind and the blades controlled according to the wind strength. To achieve this task anemometers are placed at the very top of the turbine. In this situation reliability is key, consequently anemometers need to be chosen with the least amount of maintenance necessary.

Earlier in the article it was mentioned that three axis anemometers were available for measuring wind turbulence.

This information needs to be available in a number of situations such as airport landing systems, monitoring around building structures and long bridges. However a little known requirement except among the scientific community relies on the measurement of minute levels of wind turbulence. The measurement of weather not only relies on measurements at particular points but also researchers need to know how these conditions arose. Various techniques used to assist in these studies rely on the measurement of surface fluxes of heat momentum, carbon dioxide and water vapour. The most common technique to measure these fluxes is the Eddy Correlation technique. To make these measurements you need at least an infa-red gas analyser and an anemometer capable of monitoring wind in the vertical and horizontal axis, with a fast response above 20 Hz. Three axis anemometers are available with data rates up to 100Hz,and extensive networks have been set up world wide to study important ecosystems which contribute to the carbon cycle.

These systems are controlled by specially written software that calculates the surface fluxes of momentum, sensible and latent heat and carbon dioxide.

Typical Eddy Correlation site. Picture courtesy of ADC BioScientific.

Conclusion

Selecting the correct anemometer for an application is vital if data is not to be lost. Ensure that you discuss your application with the manufacturer. He can guide you to the correct instrument. What might seem the cheapest instrument may not be the correct choice. Professional/industrial wind speed and direction instruments start from several hundred dollars, rugged versions are more expensive, but a trip to a site in a remote location to fix a problem will far exceed the initial cost. Also think about the through life cost of ownership. Regular calibration and maintenance can also cost more that the initial purchase price, especially if you intend to keep the instrument for up to 10 years

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Ian Bywaters has been involved in the environmental measurement and control industry for the last 25 years. He has a wide experience in engineering design, product specification and sales. He is employed by Gill Instruments as their Sales Manager, responsible for the sales department.
Gill Instruments are the world leaders in Ultrasonic anemometers, which they sell world wide through their extensive sales and distribution network

The LifeFlight Foundation of Maine Selects DigiWx II AWOS

The LifeFlight Foundation has embarked on an ambitious plan to assure the safest operating environment possible for emergency air medical operations. The Foundation has contracted with **Belfort Instrument** (USA) for the purchase and installation of seven DigiWx II Automated Weather Observation Systems (AWOS) at seven locations throughout the State of Maine.

The Belfort DigiWx II is an automated weather system reporting FAA certified altimeter and FAA certified visibility with advisory winds, temperature and humidity and Cloud Height (Ceilometer) The real time report is available on a computer graphic screen, on the Internet, and over the Unicom radio as well as telephone dial-in. The DigiWx II is approved for FAA Part 91 and FAA Part 135 IFR approaches and is specifically designed for General Aviation airports and Heliports. The Foundation is installing a GPS approaches and will use the DigiWx II to support their EMS flight operations.

The new state of the art Belfort systems will improve general aviation safety by improving the weather reporting network in rural areas. "These new systems will serve seven municipal airports in rural Maine. While the new stations will aid us in saving lives, they will benefit all of our pilot colleagues, as well as helicopter and fixed wing operations of the Department of Conservation, the Army's 112 th Air Medical Groups downeast training area, and the U.S. Border Patrol," said Dennis Small, EraMED Lead Pilot and Site Manager for LifeFlight of Maine.

Over the past four years, in a joint effort with the Department of Public Safety, the LifeFlight Foundation has funded numerous hospital helipad and airport improvement projects including installation of over the road fuel systems to serve remote hospitals, instrument approaches, and the installation of new AWOS stations at rural airports.

"After a thorough evaluation process, we are pleased to be working with Belfort Instruments as a partner in implementing cost effective AWOS systems in western, northern, and downeast Maine. Our partnership with our contractors Belfort Instruments and Satellite Technologies Incorporated will quite literally lead to an additional 78 lives saved in Maine each year while making the entire aviation operating environment safer for everyone depending on access to weather," noted Thomas Judge, Executive Director of LifeFlight of Maine.

Installation and FAA commissioning of the DigiWx II is schedule to be completed in summer 2007

Siting Your Weather Station

When you need to monitor weather at your research project, or industrial site, a local weather station of your own is usually the best solution. Not surprisingly, there is often confusion about the best place to install it. Can it be mounted on a nearby building? What height should it be? And so on.

Essentially, there are two main factors that **Envirodata** (Australia) suggest determine where to site a weather station. These are; firstly your intended application, and secondly the impact of the surrounding environment on the relevance of your data. A weather station records the weather exactly at the point it is located. In some applications, we wish to infer that those readings are valid for a radius of 1 to 2 kilometres. This is called a 'microclimate' application, and measures the weather including the effects of the local terrain, including the topography, trees, fences, buildings etc. In other situations, we would like to infer that the readings are valid for up to 25 kilometres. This is called a 'Meso-scale' application and the aim is to measure the weather independently of any immediate effects or local terrain.

Microclimate monitoring is primarily used where the specific conditions and effects of the local environment are of importance. This includes some research trials and many industrial sites and environmental licensing or control situations. The station should be located as close as possible to the area under investigation. It is important to choose a site that is clear of trees or overhangs. Nearby trees or buildings should be no higher than one quarter of their distance away.

Often for microclimate applications, you might consider the roof of a building on your site as an ideal place to locate a weather station. Usually, a roof is a good choice as long as the previous guidelines are followed and the wind sensors are mounted at least 2 metres above the roofline to minimise the eddies caused by the roof edge. Meso-scale siting requirements are more stringent and to achieve optimum results, the following guidelines should be considered. This includes a 10-metre mast for wind speed and direction sensors and radiation sensors, with trees or other obstacles no higher than one tenth of their distance away. The location should be flat and level. These requirements may be difficult to achieve in practice, and therefore some compromise is usually required.

Mounting wind sensors at 10 metres ensures that the effect of the local terrain is minimised, and effectively measures the 'area' wind rather than just the 'local' wind. Typically, this is used for odour, dust and air pollution monitoring, to satisfy Australian EPA licence conditions, and for research trials where localised meso scale data is required.