Accurate assessment of the resource at potential wind-energy sites is becoming more critical. The 60m met towers most commonly used for site assessment are decreasingly effective as turbines grow taller. Sodar devices, which measure wind speed and direction at any height up to about 200m, are a potential solution. Although manned sodar products are now common for short-term profiling, they have many shortcomings for long-term assessment. In this article, the author describes the innovations of Second Wind's Triton sonic wind profiler, which was designed to replace met masts for many assessment applications.

By Walter Sass, CEO and Chief Engineer at Second Wind, USA

The Technology of the 200-Metre Met Mast

Rethinking Sodar for Wind Site Profiling

As the wind-energy industry advances, so does the need for more accurate long-term assessment of potential wind sites.

Turbines are growing taller and more productive, but also more expensive. Projects are larger than ever, in terms of money invested as well as megawatts generated. An increasing number of wind farms are 'merchant plants', with no power purchase agreement to guarantee a return.

For developers of wind farms, these factors can combine to slice operating profit margins to a razor's edge, which makes it critical to find a strong and reliable wind resource.

However, the wind prospector's primary assessment tool – a meteorological mast outfitted with anemometers and wind vanes that feed information to a data logger – is becoming less useful as turbines grow taller. Few met masts exceed 60m, because the cost of compliance with aviation and local regulations and permitting makes taller masts impractical for prospecting. The most common height for new turbines today is 80m, which means an anemometer at 60m captures data from less than 20% of the turbine's blade sweep (Figure 1). Developers of wind plants must essentially guess at the viability of the resource above the height of the met masts.

Can Sodar Save the Day?

A technology older than the commercial wind industry has been applied in a limited way to reduce the guesswork. Sodar – for Sound Detection And Ranging – was invented in the early 1960s, predating the development of weather radar. While the latter technology is superior for measuring the upper atmosphere, sodar is ideally suited for measuring the lower 'boundary layer' below the sweep of radar and above the ground.

As the name suggests, sodar employs sound rather than radio waves for measurement. The device sends up at least three focused sonic beams in rapid succession, producing a 'chirp' audible to the human ear. Wind turbulence sends a portion of the sound back towards the ground. By precisely measuring the frequency and time delay of the chirp's echo, the sodar device measures the wind speed and direction at any height up to about 200m. If no unwanted sounds interfere, the measurement of wind speed is exceptionally accurate, based on conceptually straightforward trigonometry.

While radar has been continuously improved for weather measurement, sodar has lacked a sizeable commercial application and the products have changed little over the years. Current sodar products generally require on-site support to operate, and deliver wind data in formats that require expert interpretation. Readings must be carefully analysed to filter out the effect

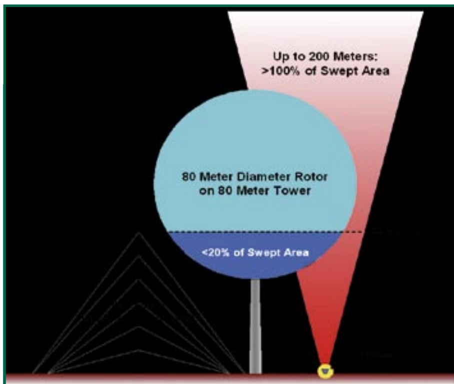

Figure 1. The 60m masts commonly used for long-term assessment are 20m shorter than today's typical wind turbines, which means less than 20% of the turbine's blade sweep area is being measured

Figure 2. The Triton sonic wind profiler was designed using a 'clean-sheet' approach to rethink sodar as a tool for long-term, unattended wind resource assessment

of sound directed sideways, which can be reflected off trees or buildings and muddy the measurement of wind turbulence reflected from the desired upward beams. Most current sodar products also

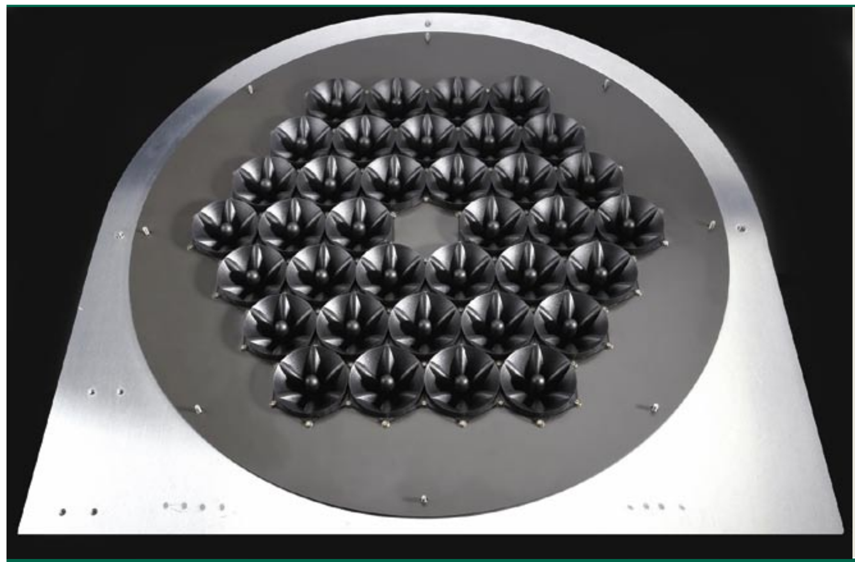

Figure 3. The Triton profiler's six-sided array (patent pending) allows transducers to be spaced more closely than rectangular sodar arrays, producing a more tightly focused sonic beam

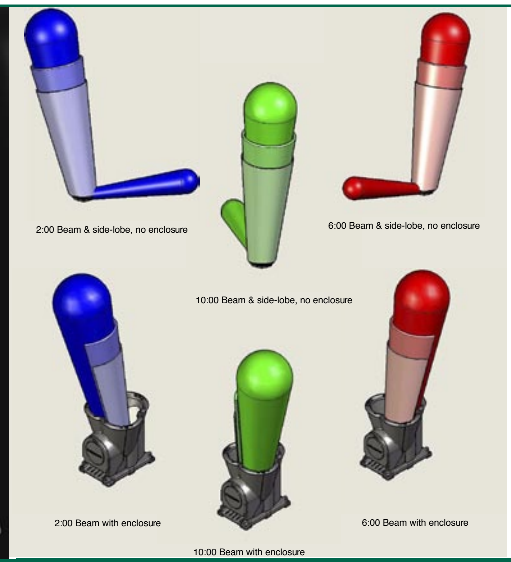

Figure 4. The three-lobed shape of the Triton enclosure baffles side-directed beams that can create unwanted echoes from trees or man-made objects on the groundFigure

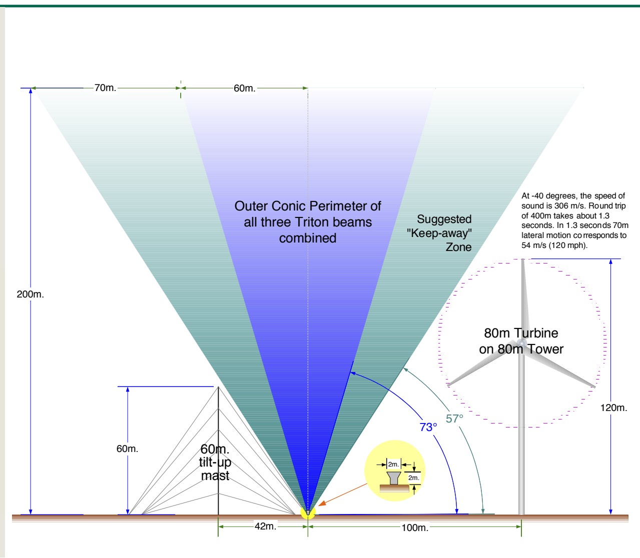

Figure 5. The Triton profiler measures wind speed and direction accurately up to 200m, with a tightly focused sonic beam that minimises the 'keep-away zone' where buildings or trees could create unwanted side echoes

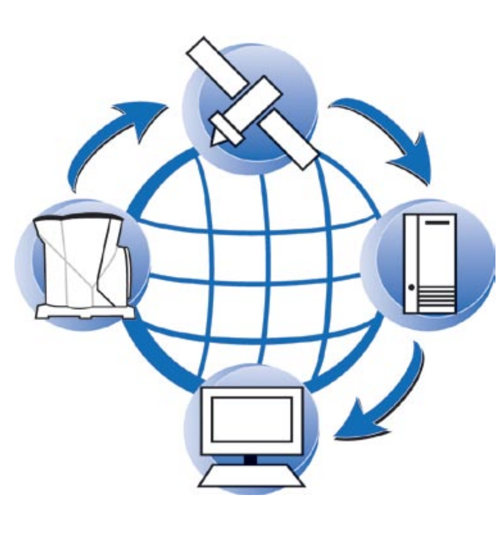

Figure 6. The SkyServe satellite wind data service supplies Triton data every 10 minutes to a secure Second Wind server via the Globalstar satellite network. Users can download the data directly into their analysis systems over the Internet

must be covered during rain or snowstorms to avoid damage to the sensitive transducers required for measurement.

Despite these shortcomings, the use of sodar has become common for 'site profiling' as part of wind assessment. Conventional met masts are placed for a year or more to assess the strength of the wind resource up to 60m; if the resource appears viable, a sodar unit is brought in for days or weeks to verify the resource at turbine heights, and to identify ideal turbine locations.

Rethinking S odar as a Met Mast Replacement

A Second Wind development team took a clean-sheet approach to designing a sodar product for long-term assessment rather than short-term profiling (Figure 2). The goal was not to improve on current products, but to design a sodar device that ultimately could replace the meteorological mast. This required innovations in four areas:

- Improved acoustics that reduce the emission of and sensitivity to side ways sounds, so that the device can be placed nearer to trees or man-made structures.
- All-weather functionality so that users can gather data continuously over time.
- Unattended operation, which requires a self-sustaining power supply, remote communications and the ability to adjust to changing conditions.
- Ready-to-read data that can be used for site analysis by non-experts in sodar, as is possible with conventional anemometry.

Second Wind's four-person development team* reviewed the available literature on sodar, consulted with numerous experts in acoustic technology, and applied the company's own 28-year history in wind meas urement to rethink sodar. The result is the Triton sonic wind profiler. A brief summary of the technologies combined in Triton demonstrates why we believe it reflects not just an enhancement but also a new product category.

A More Accurate 'Big Ear'

Like radio telescopes, sodar devices employ a phased array of transducers that can function as both emitters and receivers. The transducers pulse in rapid sequence to send the upward chirp, and together comprise a 'big ear' that listens to the returning echoes. Second Wind developed several technologies that make the Triton's big ear more accurate than previous sodar products:

- A hexagonal shape for the array, which allows the transducers to be spaced more closely together than the square arrays used in previous sodar products. The spacing must be minimised to create a tightly focused sonic beam (Figure 3).
- A tri-lobed shape for the enclosure, which stands about 2m high and guides the shape of the three upward beams. The shape and height of the enclosure are designed to baffle side-directed beams and potential echoes from objects on the ground that distort the accuracy of desired readings from above (Figures 4 and 5).

All-Weather Operation

Previous sodar products have employed sound-absorbing foam in the enclosure, but the foam deteriorates rapidly with exposure to sunlight and moisture. This has been one reason that sodars often require covering in the rain. To adapt sodar for long-term prospecting, Second Wind worked with a manufacturer to develop a specialised, non-woven polyester for sound absorption. The durable material functions when wet or dry and works as well as conventional acoustic foam. To protect the array from precipitation, it is oriented sideways and the sound beams are reflected off a mirror. Any material that reflects sound could be used, but Second Wind chose aluminium for the mirror and added a heating element behind it. In snow or icy conditions, a propane heater automatically warms the aluminium to keep it clear and functional. A drainage scupper allows moisture to flow out of the unit, as well as leaves or other debris that might enter the enclosure.

Unattended Use

For its sodar to operate unattended in remote locations, Second Wind had to address several challenges besides precipitation. Power consumption is one. Typical sodar units consume 100 watts in average operation, and are powered by banks of batteries. Solar recharging for continuous operation is possible only with very strong sunlight. Second Wind designed and selected every element of its sodar electronics with an eye towards minimising power consumption – including ARM and Blackfin processors that combine high computing speed with low power requirements.

The entire Triton unit operates on less than 10 watts of electricity, allowing it to be powered continuously by a single, rechargeable, car-sized battery and an 80-watt solar panel.

Uneven terrain and changing conditions such as temperature extremes or humidity also can affect the performance of the transducer array. Second Wind outfitted its Triton product with sensors that continuously assess orientation and other variables. A key innovation in the product is supervisory software that adapts it to local conditions. One of the most important is a self-orientation feature – if the sensors detect that the unit is not perfectly level, or is not directionally aligned, firmware adjusts the processing to account for the deviation.

Transmitting data from remote locations is another necessity – and a special challenge in North America, where geography and the lack of a uniform standard makes cellular data transmission unreliable or unavailable in many areas. Second Wind offers the unit with SkyServe (Figure 6), a service that provides reliable data delivery using the Globalstar network of low-earth orbiting satellites. The unit includes a satellite modem and GPS antenna, incorporating time and location stamps with each data feed.

Ready-to-Read Data

Previous sodar products have streamed raw data that require analysis. An expert in sodar technology must decide if the readings are reliable or are being influenced by side lobes and other unwanted artefacts. In our view, the data must be accessible to meteorologists and developers who are experts in wind, but not necessarily in sodar technology. Second Wind spent years in the design process developing software that analyses the data internally, in real time. The result is a stream of continuous data that looks like conventional anemometry – and in beta tests appears to be just as accurate.

Replacing the Met Mast?

The Triton sonic wind profiler is scheduled for commercial availability in late 2007. Our alpha testing indicates that the product functions as well as or better than envisioned. The product is completely new, and sodar itself – though an old technology – is new in its adaptation to wind profiling. So we have no illusions that the Triton profiler will replace the met mast overnight. However, we designed the product with the idea in mind that it would ultimately replace the met mast. And as the product performs beyond expectations in early testing, we expect that to happen eventually.

* The Triton product development team included the author and CEO of Second Wind, Walter Sass, Niels Lawhite (Chief Scientist), Louis Manfredi (Senior Engineer) and Michael Jobin (Industrial Designer).

Biography of the Author

Walter L. Sass is the founder, CEO and Chief Engineer at Second Wind and leads technical marketing for the company. He has successfully brought to market three different wind resource data loggers, multiple generations of turbine monitoring instrumentation, the Phaser power transducer and software applications for wind farm management. Mr Sass holds a BSEE from Tufts University, and undertook graduate study at the University of Massachusetts at Amherst, University of Rhode Island, and Northeastern University.

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