***Nortek Technical Note No.: 024***
***Title: Range testing of 190 kHz Continental***
***Last Edited:*** *May 5, 2003*
***Authors:*** *Atle Lohrmann, Nortek AS*
***No. of Pages:*** *3*

# *Range testing and comparison of 190 kHz Continental Current profiler with 300 kHz Workhorse PRELIMINARY*

## 1.0 Introduction

In 2003, Nortek introduced the 190 kHz Continental current profiler based on the 'Paradopp' hardware platform but with redesigned receiver and transmitter. The motivation for the new instrument was to supply the ocean community with a quality sensor for deployment in less than 200-m depth (continental shelf). The single-disk ceramics are large (about 150 mm in diameter) and the mechanical design is based on a combination of plastic housing elements and titanium cups. One person can handle the instrument, which weighs about 20 kg.

***Figure 1 – The 190 kHz 'Continental' current profiler***

As all Nortek current profilers, the Continental uses the robust cross covariance techniques to measure the velocity. The front-end electronics is designed with narrow bandwidth to optimize for range, which is an all-important design parameter if the system is to obtain long profiling range on a consistent basis. The current profiler can be operated in stand-alone mode with internal recorder or in real-time mode using cables or GSM/radio/acoustic modems. To save time in applications where high temporal resolution is required, the transducers are not multiplexed but all transmit at the same time.

## 2.0 Profiling Range

Current profilers rely on acoustic backscattering to operate. When an acoustic pulse is transmitted, a small fraction of the energy comes back to the instrument. This return signal is processed for Doppler shift and the current velocity is calculated.

The amount of energy that comes back to the instrument can be expressed in terms of the 'sonar equation', which contains a large number of terms. One of the terms is the 'backscattering coefficient', which depends on the number of particles (usually biological material) that are suspended in the water column. Unfortunately, for development engineers, this coefficient varies widely in the ocean – both with geographical region and with depth – and it has a significant impact on the profiling range. For example, a current profiler with 50-m range in the open ocean may have 25-m range in the arctic and 75-m range in coastal areas. For this reason, absolute criteria for a successful design are difficult to obtain and the only relevant test is to compare directly with other current profilers.

## 3.0 Comparison

In April of 2003, a 190 kHz Continental was subjected to a direct comparison with a 300 kHz Workhorse manufactured by RD Instruments in the USA. The systems were both mounted on a deployment frame within 1 m of each other and deployed off the West Coast of Sweden. The fieldwork was carried our in cooperation with scientists at the University of Gothenburg, who owns the Workhorse.

The instrument frame was deployed two times in about 200-m of water, each time for about 45 minutes. Both instrument were set to collect average data for 5 minutes and

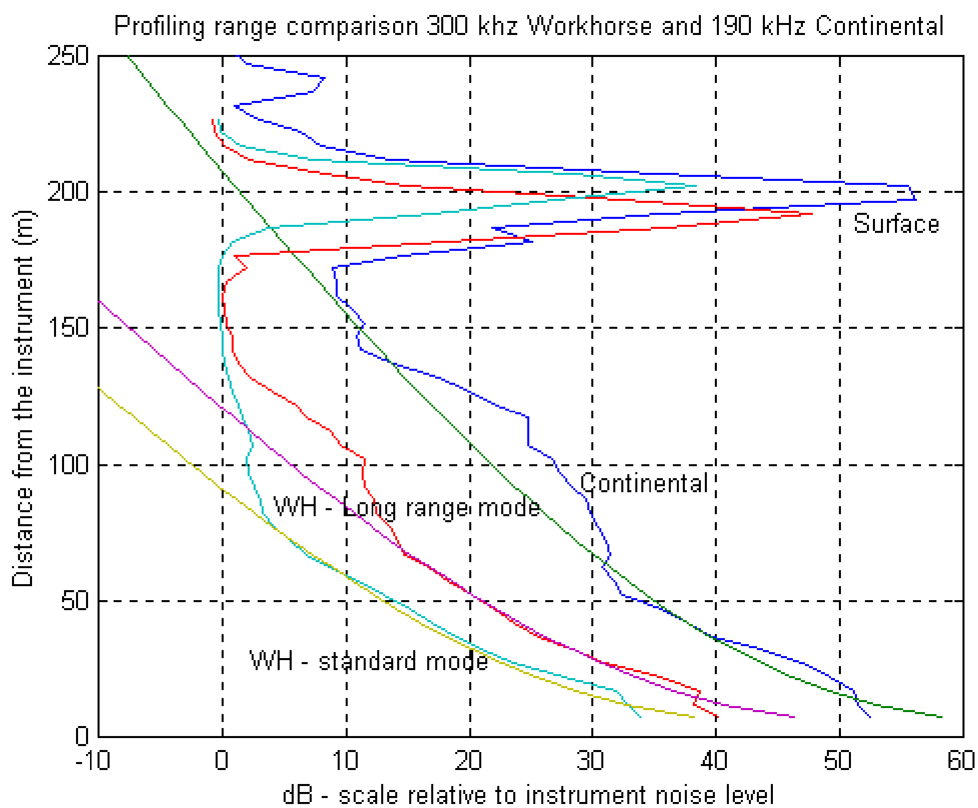


***Figure 2 – The average acoustic echo for the 190 Continental and for the 300 kHz Workhorse operating in standard mode and in long range mode. The analytical curves drawn on top of the data are approximations of the sonar equation using coefficient supplies by the manufacturers. The***

both used 5 m cells. The

Workhorse operated in two modes, 'standard' and 'long range', where the standard mode uses a processing scheme that focus on low standard deviation (high precision). The long-range mode has higher standard deviation than the standard mode and the primary focus in on getting a better profiling range. The Continental only has one operational mode.

### *3.1 Profiling range*

To get a handle on the profiling range for each of the two systems (and for each of the two WH modes), the amplitude data for one of the beams was averaged over the 45-minute deployment period. The amplitude was then converted to SNR curves using conversion coefficients supplied by the manufacturers. The SNR (Signal over Noise) is the relevant number for most signal processing system and a conservative cut-off of +3B is used in the following to determine the actual profiling range. In other words, the cut-off in the range is the point at which the SNR intersects the +3dB line.

Each of the data curves were also modeled and Figure 2 shows a total of 6 curves, three that are derived from the actual data and three that model the sonar equation.

a. The leftmost curve depicts the Workhorse standard mode and shows that the SNR smoothly decays from the bottom up to about 75-m, where the curve makes somewhat of a jump. Using a cut-off of +3dB for the good velocity data, the system has a range of about 125m.

b. The middle curve is the WH in long range mode. It shows the same trend as the standard mode data but the SNR is 8 dB higher. Again, the SNR is smoothly reduced up to 75-m, and then decreases at a much small rate. Using the +3dB criteria, the range is about 145 m.

c. The rightmost curve shows the signal strength profile of the Continental. The SNR curve intersects the surface at about 200-m (sidelobe interference starts around 175 m) so it is not possible to say – from the measured data – exactly what the range is.

A complicating factor in the comparison is the increase in scattering seen between 75 and 150 m. This 'scattering layer' has a backscatter coefficient that is as much as 7dB higher than the bottom and surface water. To make a direct comparison it is necessary to eliminate the effect of the layering. Modeling the data curves using a simplified version of the sonar equation puts the systems on an equal footing.

SNR = Ref. level – 20log10(r) – 2*alpha*r,

where r is the along-beam range and alpha is acoustic water absorption (function of frequency)

For each of three data sets, the Ref. level is established by fitting the model curve to the actual data for the first 50-m of the profiling range. In other words, the curve is fitted to the homogenous data in the relatively clear water close to the bottom. As can be seen, the profiling range would have been significantly reduced in the absence of the scattering layer.

| **System** | **Estimate directly from data** | **Model fit using backscattering level in** |
|---|---|---|

| | | |
|---|---|---|
| | | **bottom 50-m** |
| *WH300 - Standard Mode* | 125 m | 90 m |
| *WH300 – Long Range Mode* | 145 m | 120 m |
| *Continental 190* | 230 m (backscattering layer used to establish Ref. level) | 200 m |

The difference between the range using the data and the model is really the difference between the profiling range in the relatively clear bottom water and in the mid-water scattering layer. This illustrates how sensitive these types of comparison are to the exact conditions and how important it is to compare instruments at exactly the same place and time.

As for the range of the Continental, this data from the coastal area off the coast of Sweden shows that the expectations of a "200-m system" are met and that the range is 60-90% longer than with the 300 kHz WH. As for the difference between the WH standard mode and long range mode, the difference in range of about 20-30 m corresponds well to the difference of 8 dB in SNR.

| | |
|---|---|
| Document no.: TN-024 | Rev.: - |
| Made by: Atle Lohrmann | Date: May 5, 2003 |
| Controlled by: Atle Lohrmann | Staus: Active |