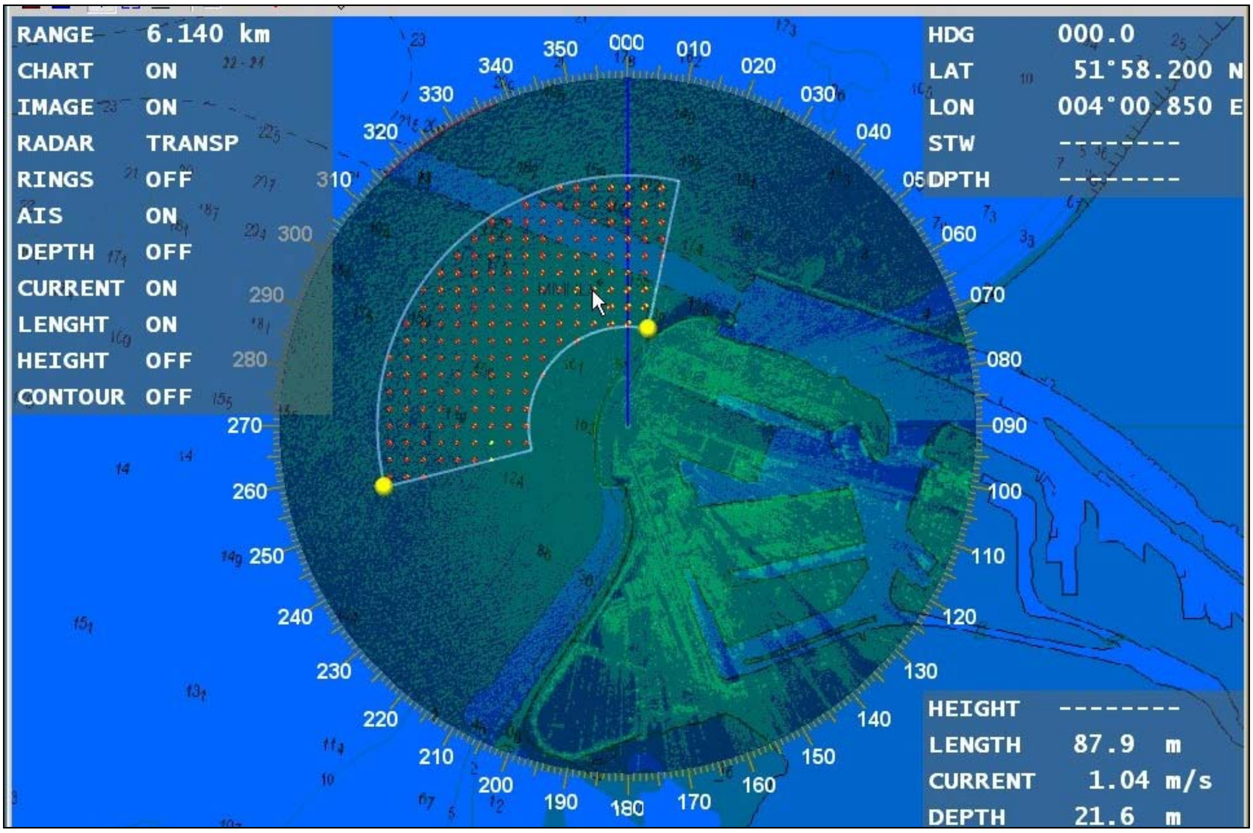
SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

# SeaDarQ Validation Report




**Geert Mosterdijk and Helen Miller**

**November 2008**

This report is a translation of the original report from The Dutch Ministry of Water and Traffic Management, who validated the SeaDarQ system as a tool for measuring hydrographic information to be used during the development and expansion of The Port of Rotterdam (Phase Two). The original report is in Dutch and can be obtained in full from The Port of Rotterdam and The Ministry of Water and Traffic Management.

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

# SeaDarQ Validation Report

Recent and promising developments for the Port of Rotterdam and the Dutch Ministry of Traffic and Water Management are in oil detection and in the measurement of current speed at the entrance of Rotterdam harbour using a SeaDarQ system (Figure 1).

**Figure 1**: HH/VV antenna, Xband radar; ship (The Arca, The Netherlands) with SeaDarQ system installed, and displaying an oil spill image.

There are two parties interested in these developments; The Ministry of Traffic and Water Management and The Port of Rotterdam authorities. The main interest of the Ministry is focused on oil spill detection from a permanent radar site, whereas the Port authorities are primarily interested in using a SeaDarQ system for current speed and direction measurement.

Validation of current speeds and direction using a SeaDarQ system was completed at Radar Post 02 on the Maasvlakte in the Port of Rotterdam (Figure 2). This site is located adjacent to a dredged area (known as Eurogeul) and was chosen because the radar has an unobstructed line of site.

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

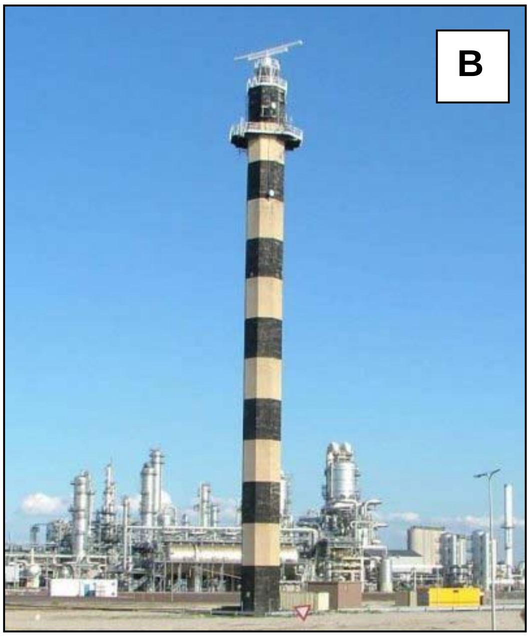




**Figure 2**: (a) Location of Radar Post 02 at Maasvlakte (RP2); (b) Radar Post 02; the height of the tower is 70 m.

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

The turning speed and the pulse length from the land-based radar at Radar Post 02 were adjusted to accommodate for the navigation function and the required range. A faster turning radar than that currently present at Radar Post 02 is considered by SeaDarQ to be more appropriate when measuring the current. For the present and for this validation test, the existing radar was used for measurements at the Port of Rotterdam. Future measurements with a faster turning radar will take place once the radar tower has been adjusted for installation.

The current speed in this validation test was measured in the upper 3 m of the water column. This is because at this particular site, the effects of waves were identified to occur predominantly in this upper zone. A current measurement pole, placed at the centre of the operating range of the radar was used to measure the current. The findings of this current pole are compared to the results of the SeaDarQ system which measured current at the exact same site. At the Port of Rotterdam the function of the current measuring pole will be lost following extension of the harbour. This validation report aims to measure the accuracy and reliability of the SeaDarQ radar system and confirm its validity as a measuring function which may in the future replace the existing current measurement pole.

## Findings of the Validation Test

The initial aim of the validation test was to examine the relationship between wave height (calculated using the SeaDarQ system) and wind speed. The results clearly identified a strong correlation between wave height and wind speed (Figure 3). The operation of the SeaDarQ system is generally dependent on the waves which are detected by the radar, and therefore the effect of wind in generating waves is demonstrated here to be very important.

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

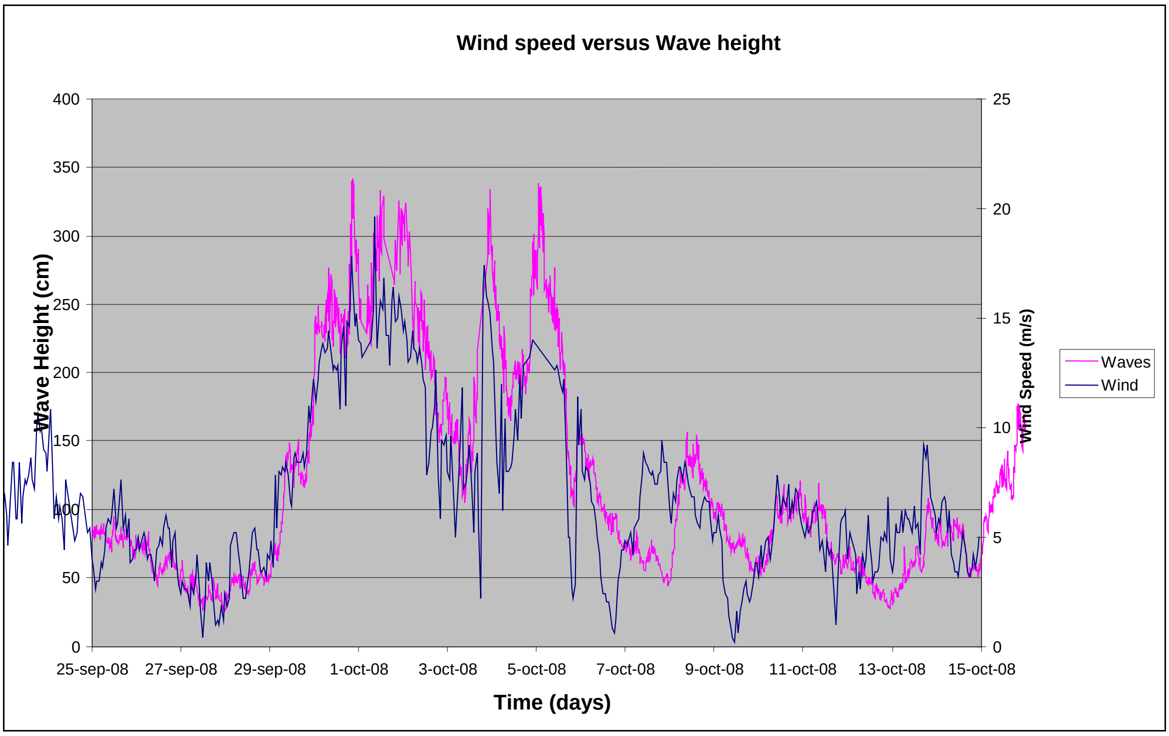



**Figure 3**: Relationship between wind speed and wave height, calculated by the SeaDarQ system.

**Phase One of SeaDarQ validation: Radar set to 200 ns**

The first phase of validation following initial measurements examined current measurements obtained from the current pole and directly compared these to the SeaDarQ measurements of the same parameter. The findings suggest when the radar is set at 200 ns, and at wind speeds lower than 5 Bft (beaufort) there is no correlation and no useful information can be obtained from this correlation (Figure 4).

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

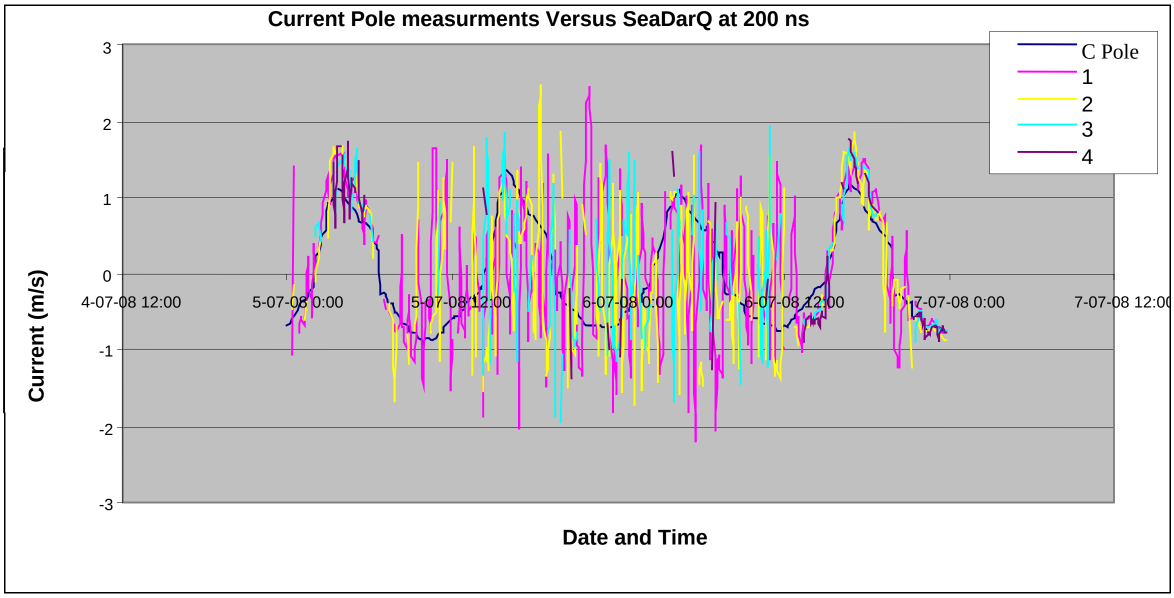



**Figure 4**: Current measurements obtained from the current pole, compared to the four SeaDarQ current measurements around the pole at 200 ns and wind speeds less than 5 Bft. The period of data collection took place between 4th July – 7th July 2008.

At wind speeds greater than 5 Bft (and 200 ns) a clear correlation was evident between the current measurements obtained from the current pole and the SeaDarQ measurements (Figure 5). This correlation demonstrates the SeaDarQ system is capable of accurately measuring current in specific circumstances at this radar setting. However, the availability of wind above 5 Bft in this case is only 35 percent, and thus is considered to be too low and insufficient for reliably calculating current.

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

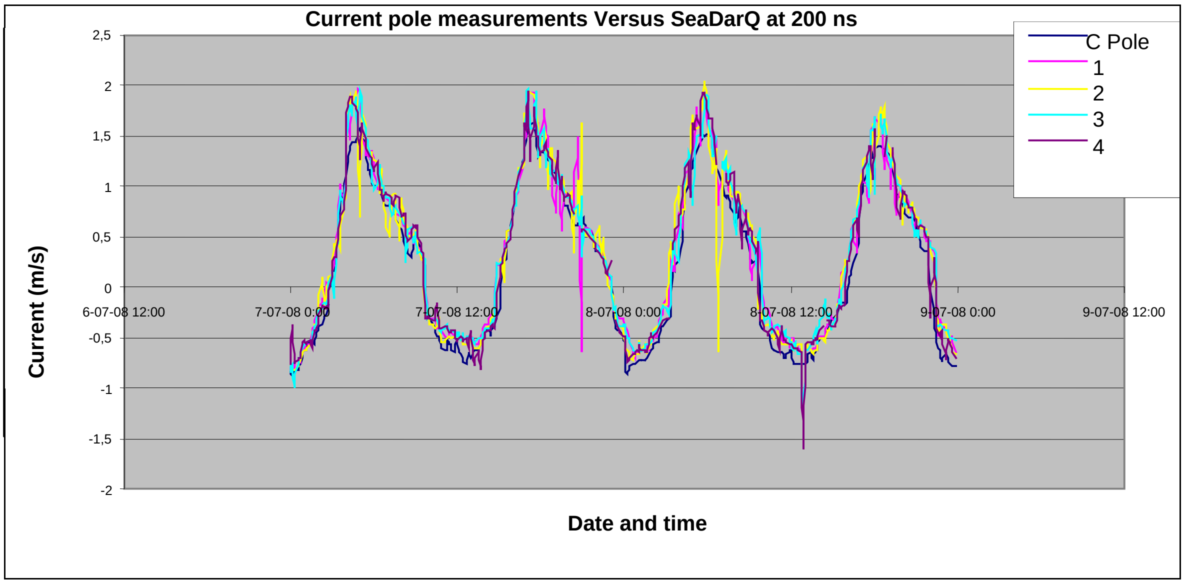



**Figure 5**: Current measurement obtained from the current pole, compared to the four SeaDarQ current measurements around the pole at 200 ns and wind speeds greater than 5 Bft. The period of data collection took place between 6th July – 9th July 2008.

The findings of Phase One of the validation report suggest that at 200 ns, current can be accurately measured only when wind speeds are greater than 5 Bft. This is because the resolution of the radar at 200 ns is poor. In these particular circumstances however, current can be measured to within 0.1 m/s of the findings recorded by the current pole. In addition, the correlation coefficient between the SeaDarQ system and the current pole measurements is greater than 0.96 at 200 ns and wind speeds greater than 5 Bft (Figure 6). While these findings suggest the SeaDarQ system is capable of accurately and reliably measuring current at 200 ns, the specific circumstances required for this limit the applications of a radar set to 200 ns. Phase Two of the validation report therefore investigated the accuracy of the SeaDarQ system when the radar was set to 50 ns.

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

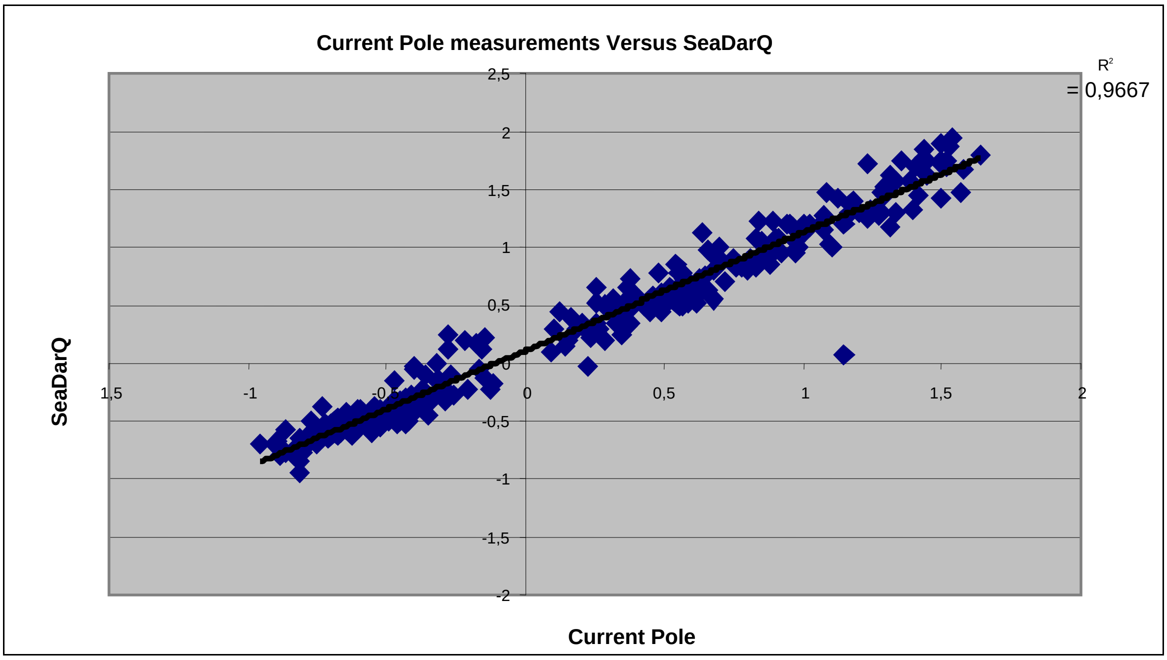



**Figure 6**: Graph comparing current pole measurements versus SeaDarQ current measurements. The period of data collection took place between 7$^{th}$ July – 8$^{th}$ July 2008.

## Phase Two of SeaDarQ validation: Radar set to 50 ns

As previously indicated, the operation of the SeaDarQ system is to a large degree dependent on the radar used, and the waves which are detectable by the radar. Therefore Phase Two of the validation test compared results of the SeaDarQ system with current pole measurements at 50 ns. The findings suggest that at 50 ns, the SeaDarQ system correlates well with the current pole measurements (Figure 7). Wind speed is not an important factor, and does not influence the accuracy of the current measurements. This would suggest that a fast turning, short pulse radar provides the most accurate and reliable current measurements. In addition, when the radar is set to 50 ns, the SeaDarQ system is capable of providing measurements with a range of 6 km, producing an image which displays current measurements and spatial variations for the entire region of Maasvlakte in the Port of Rotterdam (Figure 8).

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

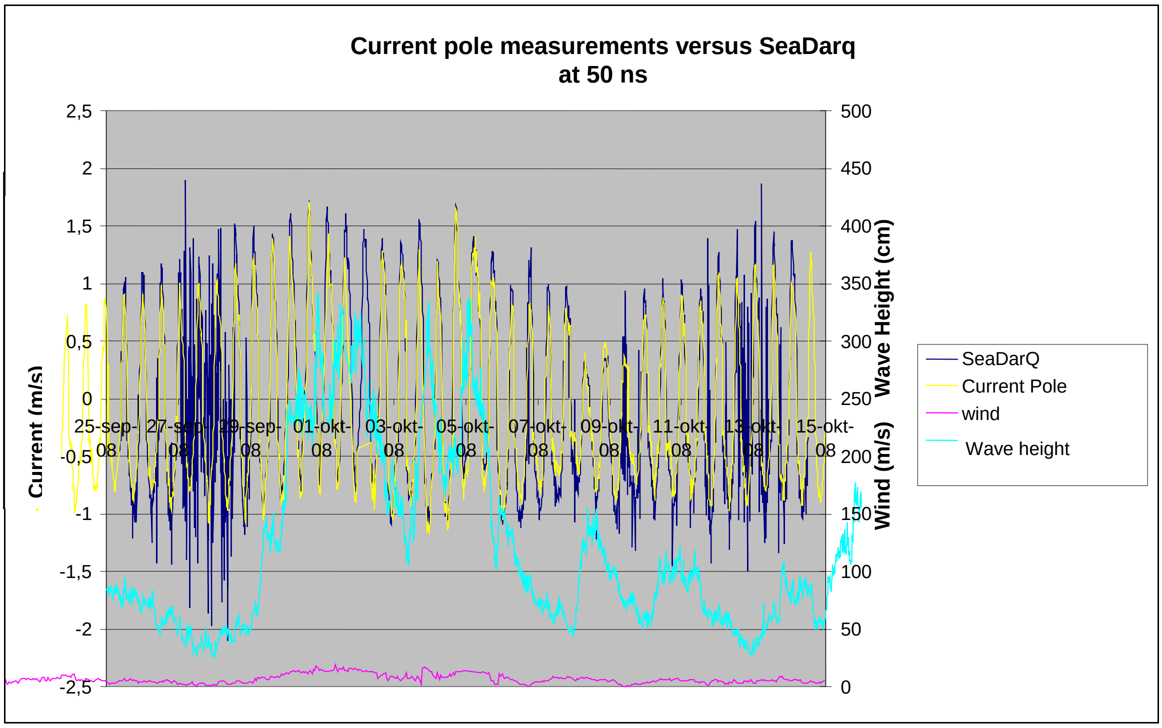



**Figure 7**: Correlation between current measurements obtained from the current pole and the SeaDarQ current measurements at 50 ns. SeaDarQ measurements are the average of four measurements around the current pole. The period of data collection took place between 25th September – 14th October 2008.

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

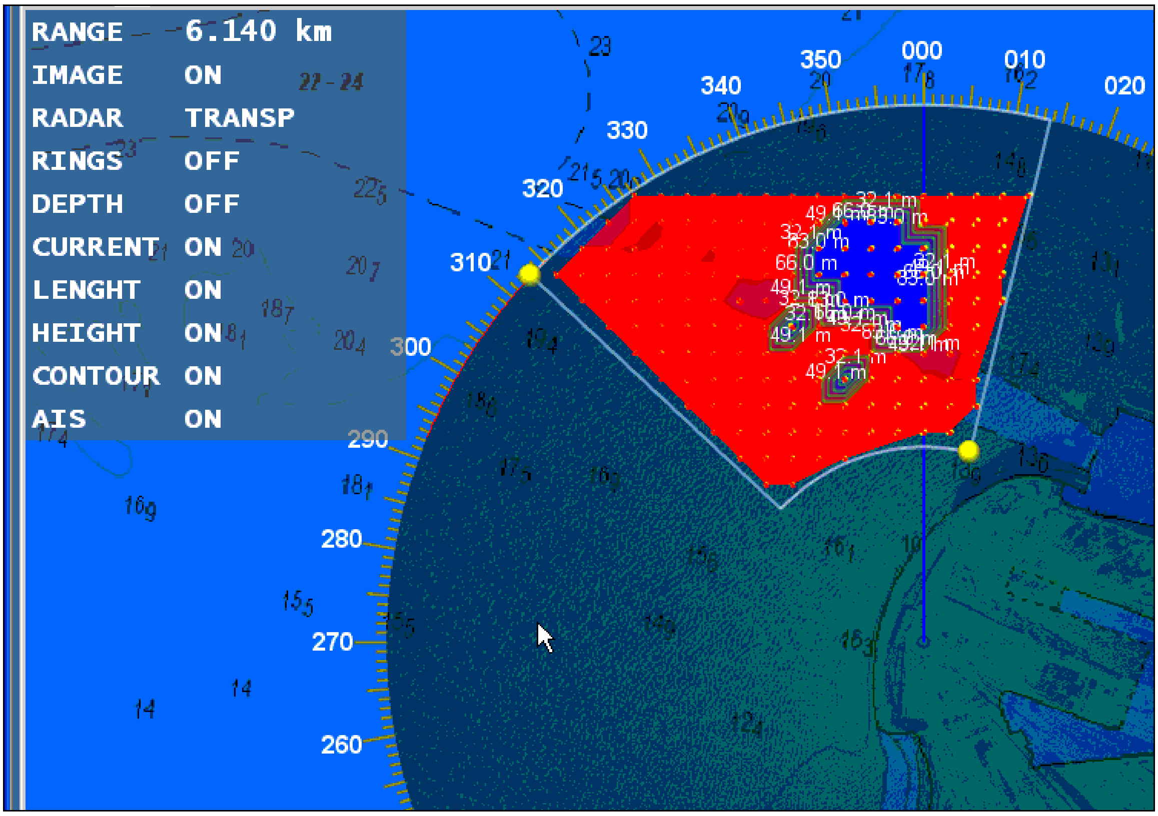



**Figure 8**: Image created by the SeaDarQ system, demonstrating the range of the radar in this case was 6 km when the radar is set to 50 ns.

## Conclusions

- The configuration of the SeaDarQ system in Phase Two (radar set to 50 ns) produced reliable and accurate measurements of current 65 percent of the time. This would suggest a fast turning, short pulse radar is most appropriate.

- The configuration of the SeaDarQ system (Phase Two) produced a range of 6 km.

- The current configuration has been validated as part of the radar chain, and its availability has been proved to be continuous (24/7).

- The present HW/SW configuration gives sufficient confidence to make SeaDarQ operational as part of the monitoring of water currents during the implementation of MV2 (extension of harbour, Phase Two – Maasvlakte).

SeaDarQ B.V.
Nijverheidsstraat 66
3371 XE Hardinxveld-Giessendam
Nederland
Tel. 0184 - 61 55 51
Fax 0184 - 61 54 51
E-mail: info@seadarq.com
www.seadarq.com

**Recommendations**

- To allow this system to become operational at short notice, delegation of responsibilities is required, for example, making part of the organization responsible for the acquisition and performance.

- To make SeaDarQ fully operational and to transform the pilot programme to a project team requires the performance module to be shown on the internet via HMCN. Further research is required to optimise availability and plans should be made to make the data available on the internet in 2009.

- Further research is required examining the confidence level of the direction as well as the correlation between wave height and current speed.

- Multiple radar posts should be connected via the internet to enable the development of an automatic delivery of files from the measuring site to the location of the data processing.

- Further research must be completed to achieve a higher data availability at low wind speeds.