DP POSITIONING - RELATIVE POSITION REFERENCING GOES TARGETLESS

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SUMMARY

This paper discusses RangeGuard Monopole DP, the first local DP reference sensor system for offshore windfarms that operates without dedicated targets. Latest results from the first fully integrated system on the SOV Windea La Cour are presented. This paper follows on from a previous paper "A New Era in Local Position Referencing" which was presented at Design & Construction of Wind Farm Support Vessels, 30-31 March 2016, London, UK[1].

NOMENCLATURE

DGPS	Differential Global Positioning System
DP	Dynamic Positioning
MPDP	Monopole DP
PRS	Position Reference Sensor(s)
PSV	Platform Supply Vessel
SOV	Service Operations Vessel

1. INTRODUCTION

Standard microwave position reference sensors[2] used in offshore oil and gas are not optimised for positioning inside a wind farm. Whereas a platform supply vessel in the oil and gas industry may support just 2-3 platforms, a wind farm service & operations vessel supports as many as 150 wind turbines, each with up to three approach angles. Traditional microwave based PRS require the installation of one or more powered targets at each landing point. The installation and maintenance costs of so many targets makes existing microwave based PRS prohibitively expensive for use in wind farms. This leaves operators dependent on laser and DGPS technology for position holding while deploying a gangway. Laser systems[3] are at risk of false reflections, particularly where personnel in hi-vis jackets are working alongside the reflective targets in the close confines of a wind tower. DGPS can suffer from shadowing, reflections and clock jumps. Under these circumstances there remains a need for a third independent local reference sensor with no common failure mode.

Recently SOVs began utilizing also walk-to-work gangways as DP reference system. A downside is that such a PRS only becomes available for a very short duration once the SOV has reached the final docking position, for approach and departure such a system is not available. While gangway-DP in this form also represents a specific windfarm-application only RangeGuard is available for the entire critical stages of a connection to a wind turbine.

RangeGuard Monopole DP offers a microwave based local reference system that does not require the installation of dedicated targets. This reduces costs and enhances safety.

This paper presents the results of the system when compared to a traditional targeted laser system (CyScan). The trials were conducted on the Bernhard Schulte managed SOV the "Windea La Cour" over the summer of 2016.

Guidance Marine is the only company to offer a local DP PRS solution that removes the requirement for dedicated targets altogether.

2. THE RANGEGUARD MONOPOLE DP SYSTEM

The RangeGuard MPDP system consists of a minimum of two RangeGuard microwave marine range finding sensors mounted onto the side of the vessel, pointing in the direction of the transition piece at the bottom of the wind tower. Simple geometry then determines the range and relative position of the vessel to the transitions piece (as shown in figure 1). The transition piece thus acts as the target to which the system will report range and bearing.

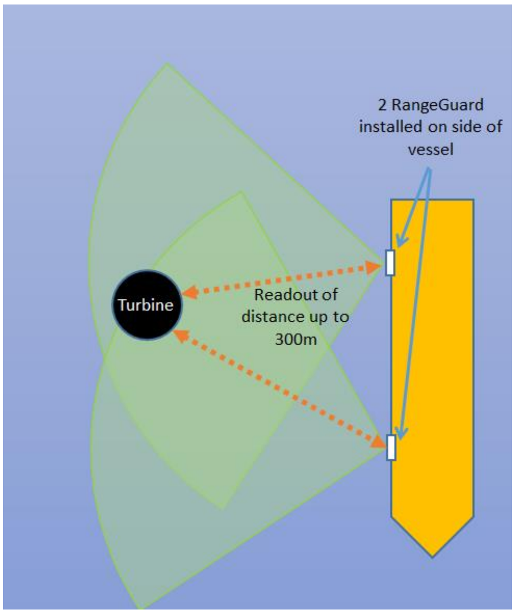

Figure 1: RangeGuard MPDP geometry

The sensors are FMCW radar transceivers operating in the licence free 24GHz band with a maximum working range of 300m[4]. They are configured such that they have an azimuth beam angle of 110º and a vertical beam angle of 11º. Individually each sensor reports the range to the nearest object. Simple Wind tower structures offer a single unambiguous object to which both sensors can measure range. Working in tandem they provide the relative position of the vessel which is displayed on the Guidance Marine Dashboard user interface and can be used in the DP system of the vessel.

3. SEA TRIALS

The first sea trials of the RangeGuard MPDP system were undertaken in August 2015 on board the wind farm service vessel Ocean Zephyr[1] managed by Bernhard Schulte Shipmanagement (Deutschland) GmbH & Co. KG. These successful trials at the Bard 1 offshore wind farm showed that the sensors could accurately report changes to the range and bearing of the vessel relative to the wind turbine where the sensors had clear sight of a simple monopole. Subsequently Bernhard Schulte have installed a full DP enabled system on their SOV Windea La Cour (figure 2) and are in the process of introducing it to the DP PRS weightings.

Figure 2. The Windea La Cour[5]

Sensors were installed on the vessel at the yard on the starboard side of the vessel – the same side as the motion compensated gangway, see figure 3.

Figure 3. Sensor installation on the Windea La Cour.

Guidance Marine accompanied Bernhard Schulte Shipmanagement (Deutschland) on the Windea La Cour commissioning trials during July 2016, prior to its charter. During a 3-week period, the Windea La Cour visited the Gemini offshore windfarm in the North Sea where the vessel has recently commenced long-term employment.

During these trials, the RangeGuard MPDP system was tested in different scenarios at wind turbines, including approach, departure, station keeping, and gangway deployment. Although the sensors were outputting a DP feed to the Marine Technologies DP system, the DP system was not using the data at this stage. This however allowed the Guidance Marine engineers and the crew to view the data in real time and data was collected for later analysis.

The Dashboard user interface allows the position to be calculated relative to any point on the vessel. For the purposes of comparison with the CyScan the reference point was aligned with the CyScan location across the horizontal. In practice the DPO found it particularly useful to use it with the datum point set at the base of the gangway. Figure 4 shows an image of the Dashboard user interface, which will be familiar to a crew who already use CyScan, RadaScan or Artemis.

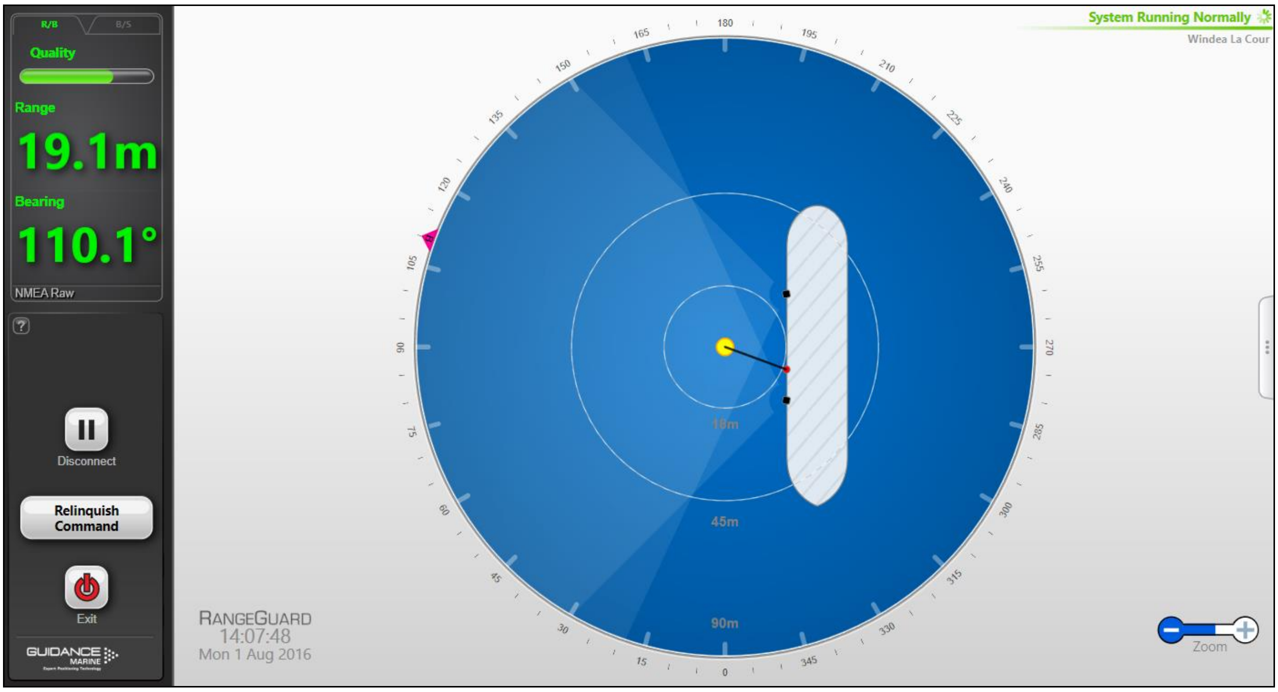

Figure 4. Dashboard user interface. The yellow dot in the centre represents the wind turbine. The black dots show the position of the sensors on the vessel and the red dot shows the position that the range and bearing is measured to. On the left, the range and bearing are displayed.

4. RESULTS

Figure 5 shows the view from the aft senor of a wind turbine transition piece (under construction). It can be seen that the structure is actually more complicated than a simple cylinder. Depending on the angle of approach, the access ladder (to the left of the monopole in this image) may be in view of either one, or both RangeGuard sensors. This introduces the possibility of the sensors first reporting the distance to the ladder but then switching over to the turbine face which would result in jumps in calculated range as the vessel moves.

Figure 5. Aft sensor during sea trial.

After further data analysis, the tracking algorithms have been modified to take into account these features so that a stable range measurement is always reported. It should be noted that for more complicated non-uniform structures, such as an oil platform, this current system could not be used reliably.

During the trials the CyScan laser position reference sensor was also in operation. The CyScan is also mounted on the starboard side of the vessel, figure 6.

Figure 6. CyScan Sensor on the Windea La Cour. The CyScan is slightly higher than the Motion compensated gangway, which is 12-13m higher than the RangeGuard sensors.

Four reflective targets were mounted around the transition piece and position data was collected from the CyScan sensor which selected one of these targets to lock onto. This enabled the CyScan position data to be compared directly to the RangeGuard MPDP position data.

Figure 7 shows the CyScan and RangeGuard MPDP data during a long range approach manoeuvre.

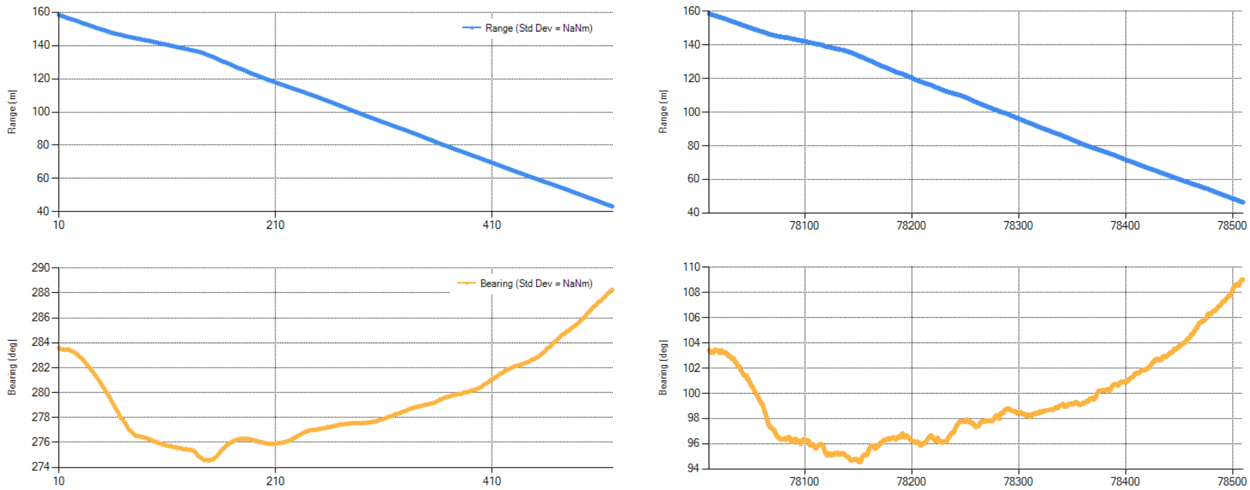

Figure 7. Long range approach manoeuvre. CyScan left, RangeGuard MPDP right, over the same time period. Blue (top) graphs show the range (m) vs time (data counts). Orange (bottom) graphs show the relative bearing (deg) vs time (data counts).

It can be seen that the range curves for the RangeGuard MPDP match very closely to the CyScan data. The bearing curves also match but we can observe that the bearing stability of the RangeGuard MPDP data improves as we move closer in. This is because RangeGuard MPDP uses trilateration to calculate bearing where so noise is greatest where the distance from the target is significantly different to the distance between the sensors. Critically, throughout the approach, the system provides sufficiently accurate positioning data for vessels to meet DP Class out to the 100m DP operation zone.

Figure 8 shows station keeping at the wind turbine, followed by a manoeuvre round to the other side of the turbine (90 degrees from the initial position).

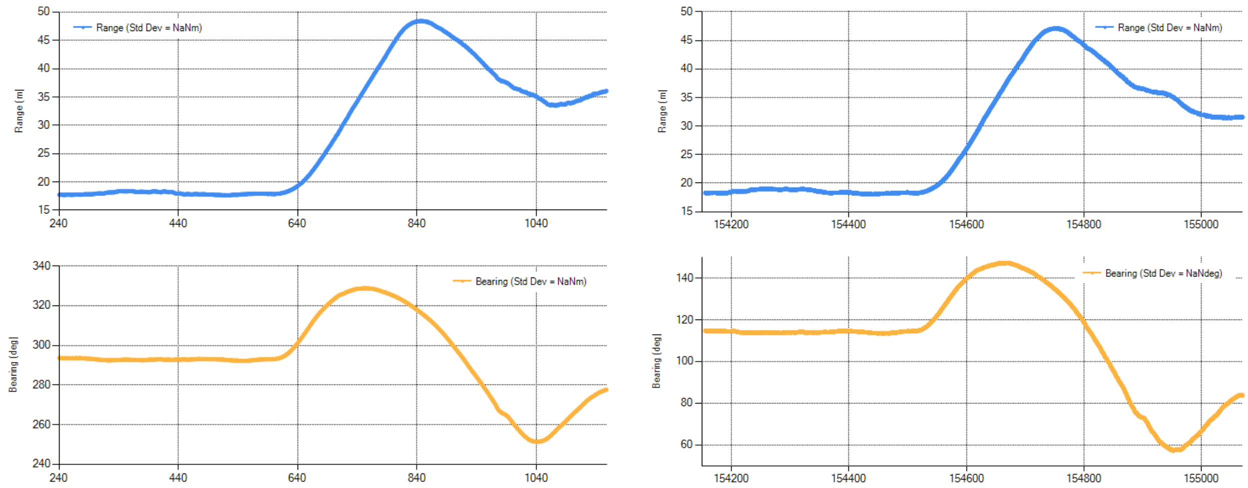

Figure 8. Departure manoeuvre. CyScan on left, RangeGuard MPDP on right for the same time period. Blue (top) graphs show the range (m) vs time (data counts). Orange (bottom) graphs show the relative bearing (deg) vs time (data counts).

Again, there is excellent correlation between the CyScan data and RangeGuard MPDP data. The difference in the range measurement towards the end of the manoeuvre is attributed to the difference in the positions of the targets (CyScan reflector vs. transition piece centre).

Figure 9 shows RangeGuard MPDP and CyScan during station keeping. During this station keeping exercise, the CyScan data and RangeGuard MPDP data match very well.

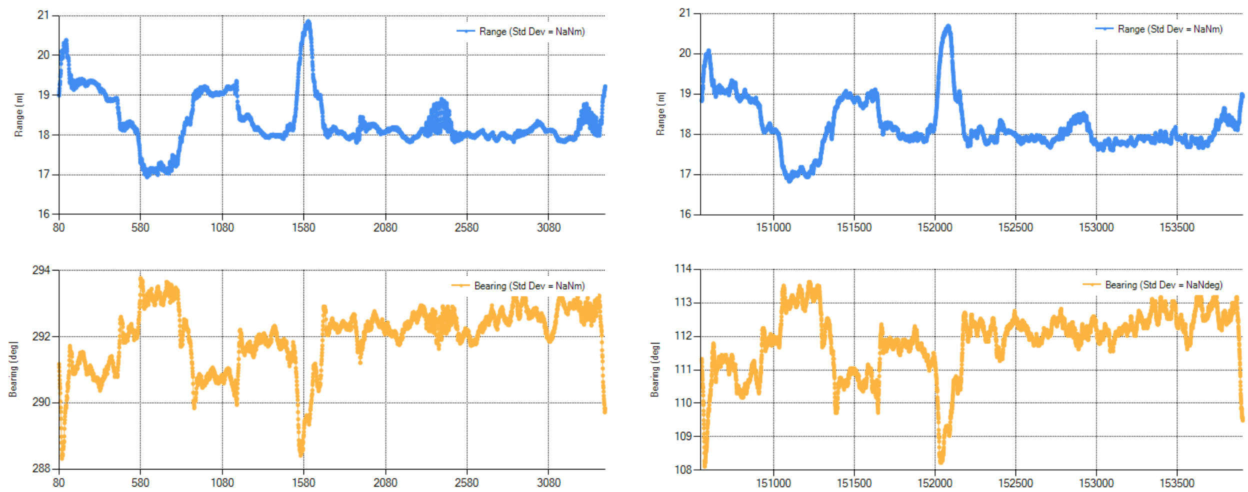

Figure 9. Station keeping. CyScan on left, RangeGuard MPDP on right for the same time period. Blue (top) graphs show the range (m) vs time (data counts). Orange (bottom) graphs show the relative bearing (deg) vs time (data counts).

The x-y position data can also be compared. Figure 10 shows a manoeuvre which includes a period of station keeping.

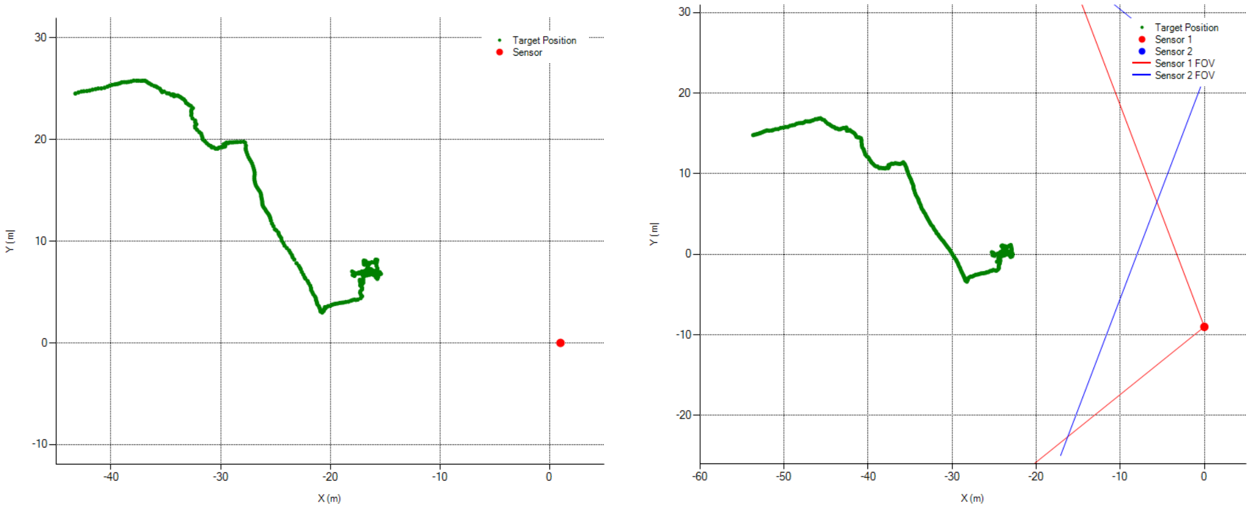

Figure 10. x-y plot (m) showing a manoeuvre which includes period of station keeping. CyScan left, RangeGuard MPDP right. The green line shows target position which correlates to the movement of the vessel in the x-y direction relative to the sensors.

It can be seen that there is little deviation of the relative positions calculated by the RangeGuard MPDP and CyScan. Taking a closer look at the period of station keeping shown figure 11, we see that the CyScan and RangeGuard MPDP traces match very well on the sub meter scale.

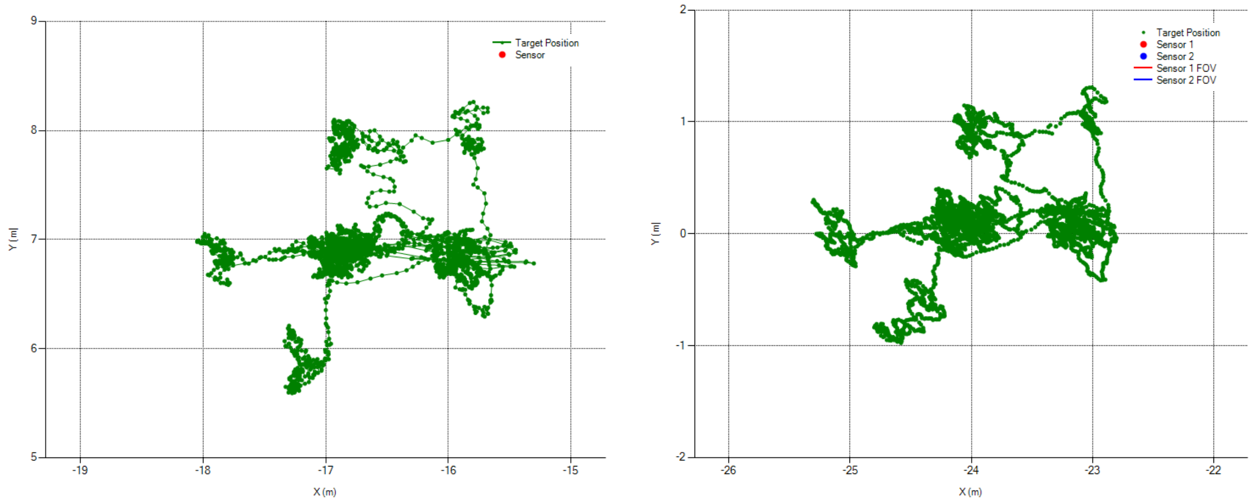

Figure 11. x-y ploy showing the zoomed in period from figure 10 where the vessel was station keeping.

Figure 12 shows a CyScan and RangeGuard MPDP x-y plot data overlaid for another station keeping operation.

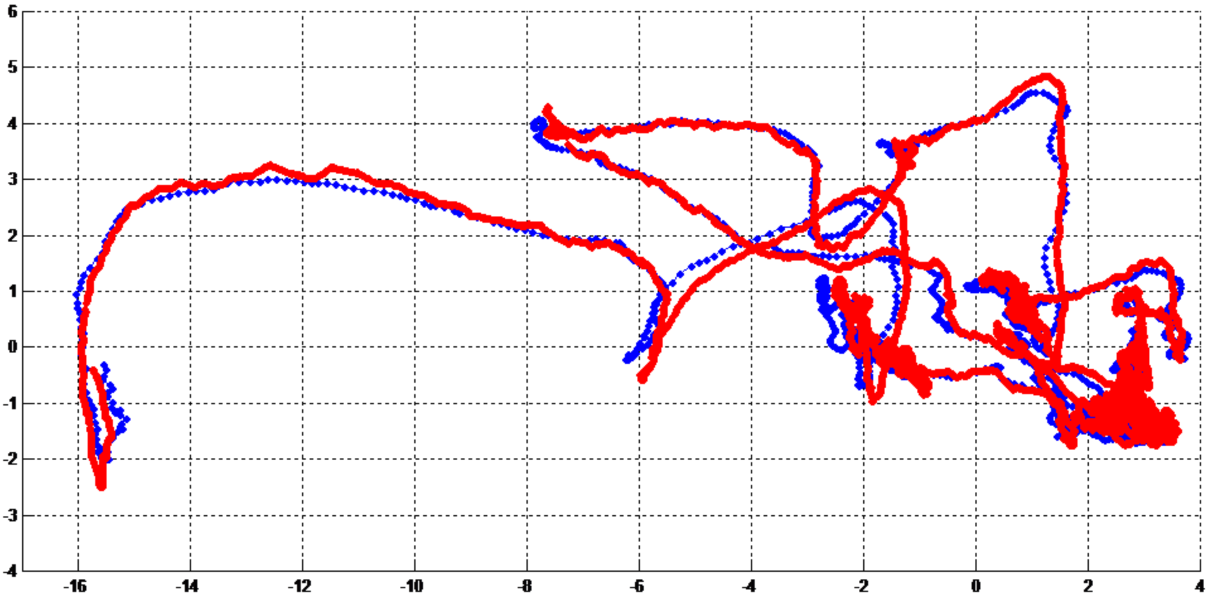

Figure 12. x-y plot (units in m) showing a manoeuvre. The red line represents the RangeGuard MPDP data and the blue line represents the CyScan data.

The slight deviations can be attributed to:

- Vessel motion – there is no motion compensation in these results.
- Errors in RangeGuard MPDP/CyScan measurements – for RangeGuard MPDP this includes range measurement errors caused by the "complex" structure of the transition piece.
- Errors in the model of transition piece – in particular its radius.
- Errors in the mounting position of the RangeGuard sensors relative to system configuration values – for this data set the position of the sensors were estimated from the ship schematics, ideally the position would be derived from survey measurements.

As stated above, the data presented here does not compensate for any roll or pitch of the vessel. These vessel movements can actually be seen in figure 13 which is a zoomed in part of figure 12, squares 0-2 in the x-direction and 1-4 in the y-direction.

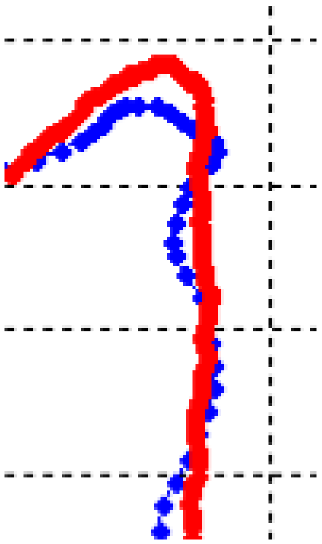

Figure 13. x-y plot (units in m) showing the zoomed in part of figure 12, squares 0-2 in the x direction and 1-4 in the y-direction.

The CyScan data (blue line) in this region is undulating which corresponds to the pitch/roll of the vessel. The RangeGuard MPDP is less affected by this as the sensors are mounted much lower down and closer to the centre of rotation of the vessel. It should be noted that the vessel roll/pitch errors are not only a result of wave motion. For example, they can also be caused by listing of the vessel when the gangway is rotated out over the side of the vessel and when the gangway is pressing up against the transition piece of the wind turbine. This would create a sustained position difference between RangeGuard MPDP and CyScan until the gangway is disengaged/rotated back around rather than the oscillating type error that wave motion causes. These differences are normally corrected in the DP through vessel motion compensation.

5. DISCUSSION

These latest trials demonstrate the viability of using the RangeGuard MPDP PRS against simple unambiguous monopoles. In the coming weeks and months, the team at Guidance Marine will work closely with Marine Technologies and Bernhard Schulte Shipmanagement (Deutschland) to implement the final part of the project and integrate the DP feed into the DP system. This will be a carefully defined process whereby small steps will be taken in order to safely realise the capability of the system. Given the results presented here, the team is in no doubt that the RangeGuard MPDP PRS is capable of performing the same function as existing PRS such as CyScan and RadaScan.

It should be noted the DP string provided is a similar format to all other position reference sensors, outputting range and bearing information. It can therefore be easily adapted to any DP system that accepts laser or radar position reference sensors. It is not limited to the Marine Technologies DP system.

Because this is a completely new type of PRS, Guidance Marine is in discussions with the class societies to ensure that the functionality and capability of the sensor system supports vessel DP classification.

Finally, it should be reiterated that at present the RangeGuard MPDP system is only applicable to an environment where the scene contains a single monopole target.

6. CONCLUSIONS

The Windea La Cour is the first vessel to be equipped with RangeGuard MPDP, a new type of PRS designed specifically for offshore wind DP operations. Based on radar technology it is unique in the fact that it does not require any dedicated targets located on the wind turbine. Instead it uses radar reflections from the environment to measure range to the nearest objects in its field of view. As an additional PRS sensor which complements traditional PRS, this has potential to significantly reduce cost and improve safety during offshore wind operations, as well as providing an additional form of redundancy to the DP system. The common problems that occur with mounted targets are negated and maintenance of targets is no longer required.

Due to the success of the results and collaboration between Guidance Marine and Bernhard Schulte the sister vessel to the Windea La Cour, which is due to sail in 2017, will also have RangeGuard MPDP PRS installed.

7. ACKNOWLEDGEMENTS

Thanks go to the crew of the Windea La Cour who have and continue to cooperate throughout the trials, the Ulstein Shipyard who installed the sensors on the vessel, the team at Bernhard Schulte Shipmanagement (Deutschland) who welcomed us onto the vessel during commissioning and the team at Marine Technologies who are working on implementation of the DP feed into the DP system. Dave Sanderson of Guidance Marine who reviewed the paper. Finally thanks go to the rest of the team at Guidance Marine who have been involved in this project to make the first targetless sensor!

8. REFERENCES

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11. AUTHORS BIOGRAPHY

Andy Knight is a Senior Software Engineer at Guidance Marine and has been the lead Engineer on the RangeGuard MPDP project. He has been with Guidance Ltd since 2007 and his previous experience includes working on RadaScan PRS software, radar/laser signal processing and position estimation for automated guided vehicles.

Sasha Heriot is Business Development Manager at Guidance Marine Ltd. After completing her PhD in Physics at the University of Sheffield in 2003, Sasha worked in the field of polymer physics as a research associate for 4 years. She left the world of academia to work in a spin out company from the University of Leeds specializing in novel surface treatments. She then worked for 3 years in a multinational chemical company as Market Development Manager for a specialist chemical business unit. Sasha started her appointment at Guidance Marine in April 2015 where she is currently introducing innovative technology into new markets and new applications.

Hendrik Busshoff holds the current position of Offshore Marine Superintendent at Bernhard Schulte Ship Management. As a trained Master mariner he is responsible for offshore marine operations and DP. His previous experience includes SDPO on hyperbaric dive support vessel in the North Sea with Technip and sea time as officer and Marine Superintendent with the merchant navy.