

## Guiding the Construction of 'The World'

# Real-Time Kinematic GPS Positioning

*Just a few kilometers offshore in the sunny waters of the Arabian Gulf, the giant dredging and marine contractor of the Netherlands, Van Oord NV, works on the largest project ever undertaken by a single marine contractor: building 'The World.' This massive job, a multi-billion dollar land reclamation effort, will create a 60-square-kilometer fantasy archipelago of luxury resort islands. One key to making the work cost-effective is high-precision, Real-Time Kinematic (RTK) GPS positioning. RTK dGPS for 'The World' project is enabled by technology from Trimble as well as the Pacific Crest Corporation.*

By Paul Haase and Arjan van der Meer

### A New World

Nothing but open water existed at the offshore site of 'The World' before Van Oord began work in 2003. By the end of 2007 some 300 man-made islands in the shape of the continents have risen a few meters above the sea level, created from massive volumes of relocated sand—more than 300 million cubic meters worth and transported over 30 million metric tons rock.

But unlike islands in nature, these islands won't

be scattered here and there. Rather, when viewed from above, the islands of 'The World' will have the exact shape and precise positioning to create a pointillist-style map of the seven continents and major islands of the earth. It's sure to be an impressive sight even among the Las Vegas-like spectacle of Dubai's tourist fantasyland. Many individual islands sold even before construction began, at prices from 10 USD million up to 35 USD million a piece. Reclamation work to build 'The World' is a

major part of a decades-long program by international Dubai developer Nakheel and Van Oord. The ultimate object: to create substantial new beachfront real estate for Dubai. Dubai has grown remarkably since the early 1970s, evolving from a small trading post into a thriving metropolis and worldwide travel destination.

"By the 1990s, all the beaches were developed," said Nakheel's Hamza Mustafa, General Manager of 'The World' project. "So we decided to build more."



Pacific Crest's machine control product, Sitecom, is installed in Van Oord dredgers to enable high-precision GPS locating and tracking.

## Giant Size

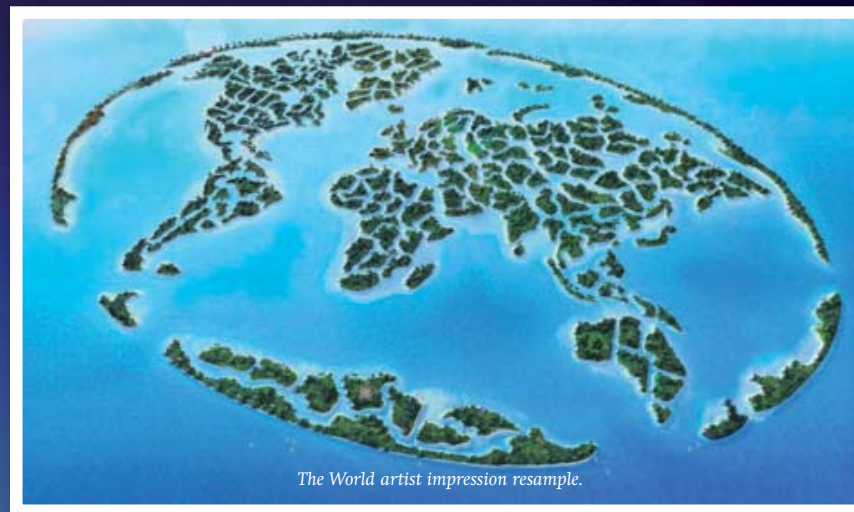
As a large developer owned by the Dubai government, Nakheel did not think small. Their long-term land-building program aims to add more than 1500 kilometers of new beachfront to the emirate's short 70-kilometer coastline. By themselves the beaches of 'The World' islands account for some 200 kilometers.

As such, 'The World' represents a huge construction project. Building it required Van Oord to dredge up hundreds of millions of cubic meters of sand from the bottom of the Arabian Gulf and relocate it into low islands in shallow water 15 to 20 kilometers shoreward. The whole development is surrounded by the longest breakwater in the world formed from 32 million tons of rock to protect the construct from wind and rough waters.

"It's enormous," said Van Oord engineering manager Mark Lindo in a 2004 article by Popular Science magazine about 'The World' project, which was completed in January 2008. "...it would take 10 years of planning and studies to do something like this [elsewhere]."

## Economics of Scale

It's not all about construction records or sheer volume of material at 'The World' development, however; it's about economics. Time, after all, is money. Van Oord is a long-established company with almost 140 years of dredging and marine construction experience, including working in the waters of Dubai itself



*The World artist impression resample.*

for the past decade. To control expenditures at 'The World,' Van Oord pursued the most cost-effective operations possible. And with efficiency refined over the years, the cost for Van Oord to construct the new islands was surprisingly low. The works were finished beginning 2008 after only four years of work by a crew of about 800.

Controlling construction costs at 'The World' required all of Van Oord's expertise, and a big key to efficiency for the company has been investing in reliable survey and machine control systems. In particular, Van Oord relied heavily on RTK dGPS technology as a tool to rigorously guide and track progress at all

stages of construction. Through advanced GPS techniques, RTK provides accurate, sub-centimeter measurements. With such accuracy and precision RTK helped Van Oord guide the movements of a fleet of special-purpose construction vessels working at the jobsite. Among others, these vessels included trailing suction hopper dredgers, side-stone dumping vessels, multi-purpose pontoons, and massive marine cranes. RTK dGPS positioning technology has also been crucial in helping Van Oord track the daily progress of island construction and optimize work to keep this massive reclamation project on budget and on schedule.

## Using RTK DGPS

At 'The World' site, every vessel from crew-tender to jumbo dredger was equipped with Pacific Crest and Trimble positioning technology, ranging from DGPS to RTK dGPS. Each unit could then be matched to the required position. Such precise positioning allowed for safe navigation through the continuously changing seabed at the site in order to guide, record, and optimize the sand mining. These technologies also allowed Van Oord to confidently control the placing of sand and rocks within the specified accuracies and boundaries.

Likewise, hydraulic cranes operating on barges several kilometers offshore were equipped with Trimble MS860 RTK dGPS receivers and Heading systems to guide construction of the protective breakwater around 'The World.' And starting at 7 am each morning, the whole development was patrolled on land and on sea by radio-linked topographic and hydrographic survey teams that carried portable Trimble R7 or Trimble R8 RTK dGPS systems to measure the prior day's progress.

To build 'The World,' large trailing suction hopper dredgers collected sand by sucking it

*Overview of the World project.*



up from the seafloor at designated borrow areas. Once a dredger was loaded it steamed shoreward to the site of a future island, guided by a Trimble DSM 132 DGPS receiver. In the early stages of construction, each ship, after arriving at the exact location, simply dumped its load of sand to the sea bottom from large underwater doors. Once a growing island made the water too shallow for dredgers to get close enough to dump sand, the sand was sprayed or “rainbowed” onto the nascent island using a huge pivoting nozzle mounted in the bow of certain Van Oord dredgers. As with dumping, DGPS guided the rainbowing process.

Overall, dredging-and-filling continued until each new island reached about three meters above sea level. And while island building progressed, large marine cranes that worked under RTK dGPS guidance to place rocks in a breakwater around the seaward edge of the whole project and around the islands to armor and stabilize them.

### Beneath the Surface

Obviously, most of the construction work took place under the ocean’s surface. Nearly all of the relocated sand and rock—almost 90 percent of it—was used to form the new islands’ undersea foundations, where exact positioning and progress cannot easily be observed directly with conventional technologies. It takes at least one hundred shiploads of sand (the vessels vary in size) just to build an island up to sea level and about a dozen more to complete it. Given that ‘The World’ features more than 300 islands, construction ultimately required many tens of thousands of trips by Van Oord’s sand-carrying ships. High accuracy, high precision positioning helped Van Oord guide these trips, not only to ensure that islands are placed to create the complicated design of ‘The World’ but also to optimize construction work. After all, the number of dredger trips needed to complete the project was what drove the economics of the job. As much as possible, Van Oord wanted

to ensure that no trips were wasted, that no sand was placed where it doesn’t contribute to building an island.

“To achieve the required accuracies with the rockwork construction and to optimize the sand-dumping and rainbowing activities efficiently, reliable and, above all, repeatable RTK GPS coverage is essential,” says Frans Pijpers, Van Oord Survey Operations Manager.

In particular, vertical measurement represented a primary focus at ‘The World.’ One dredge-load of sand adds but a few centimeters of height to a growing island. Only RTK technology, with its excellent centimeter-scale performance, can repeatedly and reliably detect such changes (underwater measurements can be made by combining multibeam depth-sounder readings to RTK results of sea level). More than in any other aspect, Van Oord depended on accurate and repeatable vertical RTK GPS readings to monitor and optimize the placement of each rock and load of sand required to complete ‘The World’ islands.

### Real-World Competition

In Dubai, the radio modems that enable RTK positioning at ‘The World’ jobsite played a role out of proportion to their low cost. As on other construction jobs it is possible that tens of millions of dollars of heavy equipment could be idled should a problem develop with a radio worth a few thousand dollars. And



*Land surveyor at work using RTK dGPS from Trimble.*



Close-up of a new island.



Artist impression of the various reclamation projects in Dubai (foreground The World, background the Palm projects).



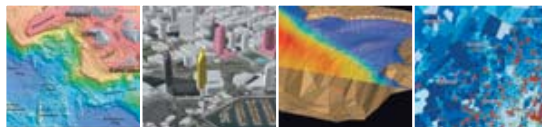


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Trailing Suction Hopper Dredge rainbowing sand.



according to Van Oord, not being able to work because of non-functioning equipment is totally out of the question in the marine construction business.

In order to ensure the maximum RTK dGPS reliability for machine control and surveying at 'The World' project, Van Oord turned to Pacific Crest, the company that developed the original radio modem technology for RTK applications. Specifically Van Oord employed a mix of 15 Pacific Crest Positioning Data Link (PDL) Low-Power Base radio modems and PDL Sitecom radio modems mounted on ships, cranes, backpack handsets, and at reference

stations on land in Dubai.

Van Oord selected Pacific Crest products based not on catalog specifications or experience with a single vendor, but only after real-world competition. The present company was formed from the recent mergers of three of the largest and oldest Dutch dredging concerns, and these mergers brought a diverse mix of state-of-the-art telemetry equipment into the new Van Oord. In the years following the mergers, Pacific Crest's radio modems and RTK telemetry solutions, out of the many systems inherited by the merged company, proved themselves superior. Crews recognized

them as the most reliable and flexible products; they valued the rugged all-weather operation and worldwide compliance of Pacific Crest equipment, as well as the company's easy-to-use turnkey packages that are fully compatible with GPS products from Trimble and other major manufacturers. Consequently, Van Oord has come to use Pacific Crest radio modems and Trimble GPS exclusively for its RTK needs at 'The World' and elsewhere. "The Pacific Crest products provide us with the accuracy and reliability and covering range to execute this project," says Van Oord's Pijpers. "I'm sure many other solutions are possible, but never change a winning team."

*Parts of this article have appeared in American Surveyor and were reproduced with permission from both Trimble Corporation and American Surveyor. Arjan van der Meer from Van Oord has updated the text to reflect the current situation. For more information: [www.theworld.ae](http://www.theworld.ae), [www.vanoord.com](http://www.vanoord.com), [www.trimble.com](http://www.trimble.com), [www.pacificcrest.com](http://www.pacificcrest.com).*