



WORLD FROM SAND

IN THE ARABIAN GULF 'THE WORLD' IS SLOWLY BEING RE-CREATED AND RTK GPS POSITIONING IS GUIDING THE CONSTRUCTION AS IT TAKES SHAPE. PAUL HAASE DESCRIBES THE PROJECT AND THE TECHNOLOGY THAT IS BEING USED.

Just a few kilometers offshore in the sunny waters of the Arabian Gulf, the giant dredging combine 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 GPS for 'The World' project is enabled by technology from the Pacific Crest Corporation, a leading supplier of wireless data communication systems for positioning and environmental monitoring applications.

"It took Van Oord less than Euro 40,000 worth of radio modems and software to make RTK available throughout 'The World' jobsite," says Aldert Kluit, Sales Manager for Pacific Crest. "The savings in time and money that RTK delivers for this giant project are immense."

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 will have risen a few meters above the sea, created from massive volumes of relocated sand—more than 300 million cubic meters worth, or about ten quintillion individual grains—and transported rock.

KCS TraceME

GPS/GPRS/SMS Module



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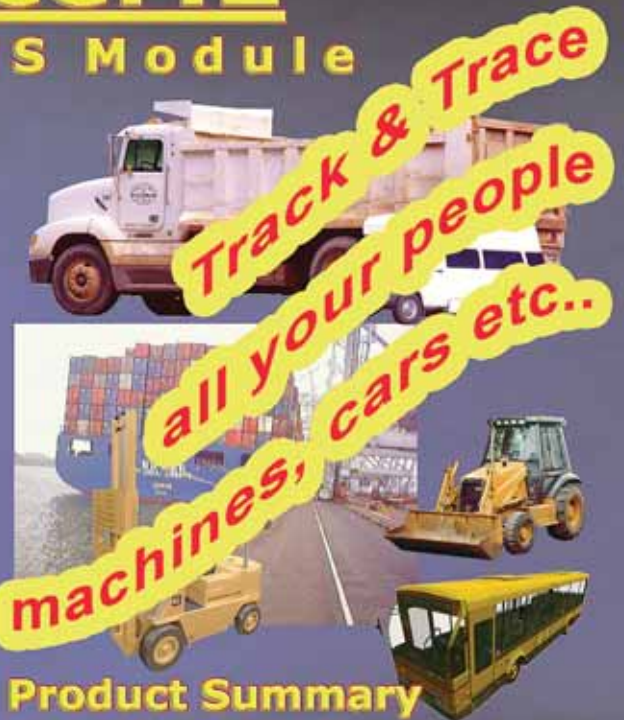
The KCS TraceME/TrackME GPRS/GPS Module enables you to remotely track & trace a variety of objects, e.g. cars, trucks, containers or ships. Its small, lightweight aluminum design makes it easy to install and together with the extended position logging, it's ideal for use in fleet management, anti-theft and M2M applications.

Furthermore, the numerous I/O connections allow monitoring and control of a range of external hardware. For surveillance and security purposes, a tiny camera is available, so you can see what's going on at a glance... anywhere, anytime!

Key Features

- Extremely small and lightweight
- Ultra low power consumption
 - Car/truck battery
 - Solar panel with small battery
 - Power supply
- Excellent GPS accuracy
 - Autonomous, MS-A or MS Assisted A-GPS
- Versatile interfacing
 - More than 25 I/O lines
- Maximum flexibility
 - Remotely configurable to fit any application
- Integrated SIM card reader
- Wide operating temperature range
- Ruggedized aluminum enclosure designed for rough environments
- Fully EMI shielded

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Product Summary

Equipped with a state-of-the-art GPS receiver, the KCS TraceME/TrackME Module provides reliable and accurate navigational data. All communication is handled rapidly and effectively by a GPRS/GSM modem (dual/tri-band version available) through a GPRS network or, if not available, by means of a GSM network. In areas with no GPRS/GSM coverage, position-data and events are stored in memory. As soon as communication is restored, all information is transmitted.

A unique feature is the user-configuration menu, which controls events like sending position-information and switching of external hardware. Changing this configuration is possible remotely or on-site. Virtually every parameter can be controlled, to adjust the TraceME/TrackME Module exactly to your needs!

Applications

- Fleet management
- Public transport
- Railway industry
- Logistics
- M2M
- Security and surveillance
- Remote control and diagnostics
- Vehicle immobilisation

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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 up to Euro 30 million apiece.



Reclamation work to build 'The World' is a major part of a decades-long program by international 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."

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 will account for some 200 kilometers.

As such, 'The World' represents a huge construction project. Building it will require 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 will be surrounded by a double breakwater formed from 32 million tons of rock to protect the construct from wind and rough waters.

Such volumes dwarf those of the typical construction project, whether on land or sea. Indeed they rank among the largest construction jobs ever undertaken. For example, the gigantic Three Gorges Dam

project nearing completion in China involves excavating some 100 million cubic meters of earth and pouring roughly 30 million cubic meters of concrete, amounts that almost double the records set when the Itaipu Dam was built between Brazil and Paraguay in the 1970s and 1980s.

"It's enormous," said Van Oord engineering manager Mark Lindo in a 2004 article by *Popular Science* magazine about 'The World' project, which is on a fast track for completion by Nakheel and Dubai. "...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 for the past decade. To control expenditures at 'The World,' Van Oord pursues the most cost-effective operations possible. In fact, they expect to conclude

dredge-and-fill activities in 2007, after four years work by a crew of about 800. Although the jobs don't compare directly, it's illustrative to consider that the Three Gorges project in China will require at least 15 years and 250,000 workers.

Despite this incredible efficiency, controlling construction costs at 'The World' requires 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 relies heavily on RTK GPS 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 (see Sidebar: "RTK GPS and Communications"). With such accuracy and precision, differential GPS (DGPS) and RTK help Van Oord guide the movements of a fleet of special-purpose construction vessels working at the jobsite. Among others, these vessels include trailing suction hopper dredgers, side-stone dumping vessels, multi-purpose pontoons, and massive marine cranes. RTK GPS 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.

"RTK enables sub-centimeter positioning from autonomous GPS receivers, which otherwise position only to 10 or 15 meters," says Rick Gosalvez, Product Marketing Manager for Pacific Crest. "By fitting GPS receivers with radio modems and software to communicate with a fixed reference station, you can survey a site or guide the position of equipment down to the centimeter; whether it's a backpack receiver, a backhoe, or a 100,000 ton ship."

Island Building 101

At 'The World' site, every vessel from crew-tender to jumbo dredger is equipped with Pacific Crest and Trimble positioning technology, ranging from DGPS to RTK GPS. Each unit can then be matched to the required position. Such precise positioning allows for safe navigation through the continuously changing seabed at the site in order to guide, record, and optimize the sand-winning. These technologies also allow 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 are equipped with Trimble MS860 RTK GPS receivers and Heading systems to guide construction of the protective breakwater around 'The World.' And starting at 7 am each morning, the whole development is patrolled on land and on sea by radio-linked topographic and hydrographic survey teams

that carry portable Trimble R7 or Trimble R8 RTK GPS systems to measure the prior day's progress.

What the survey team monitors is sand, which, after all, is the currency of 'The World' reclamation effort. Sand forms the luxury beaches—as well as all the surrounding islands—and every granule of it must be gathered and moved from somewhere else.

"Every grain of sand is utilized for beach," says Nakheel's Mustafa.

To build 'The World,' large trailing suction hopper dredgers collect sand by sucking it up from the seafloor at designated borrow areas. Once a dredger is loaded it steams 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 dumps its load of sand to the sea bottom from large underwater doors. Once a growing island makes the water too shallow for dredgers to get close enough to dump sand, the sand is 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 guides the rainbowing process.

Overall, dredging-and-filling continues until each new island reaches about three meters above sea level. And while island-building progresses, large marine cranes work under RTK GPS 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 takes place under the ocean's surface. Nearly all of the relocated sand and rock—almost 90 percent of it—goes 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 will require many tens of thousands of trips by Van Oord's sand-carrying ships.

High accuracy, high precision positioning helps 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 is what drives the economics of the job. As much as possible, Van Oord wants to ensure that no trips are wasted, that no sand is 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 represents 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 depends 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 play a role out of proportion to their low cost. It's 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 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 GPS reliability for machine control and surveying at 'The World' project, Van Oord turned to Pacific Crest, the company that developed the original radio modem

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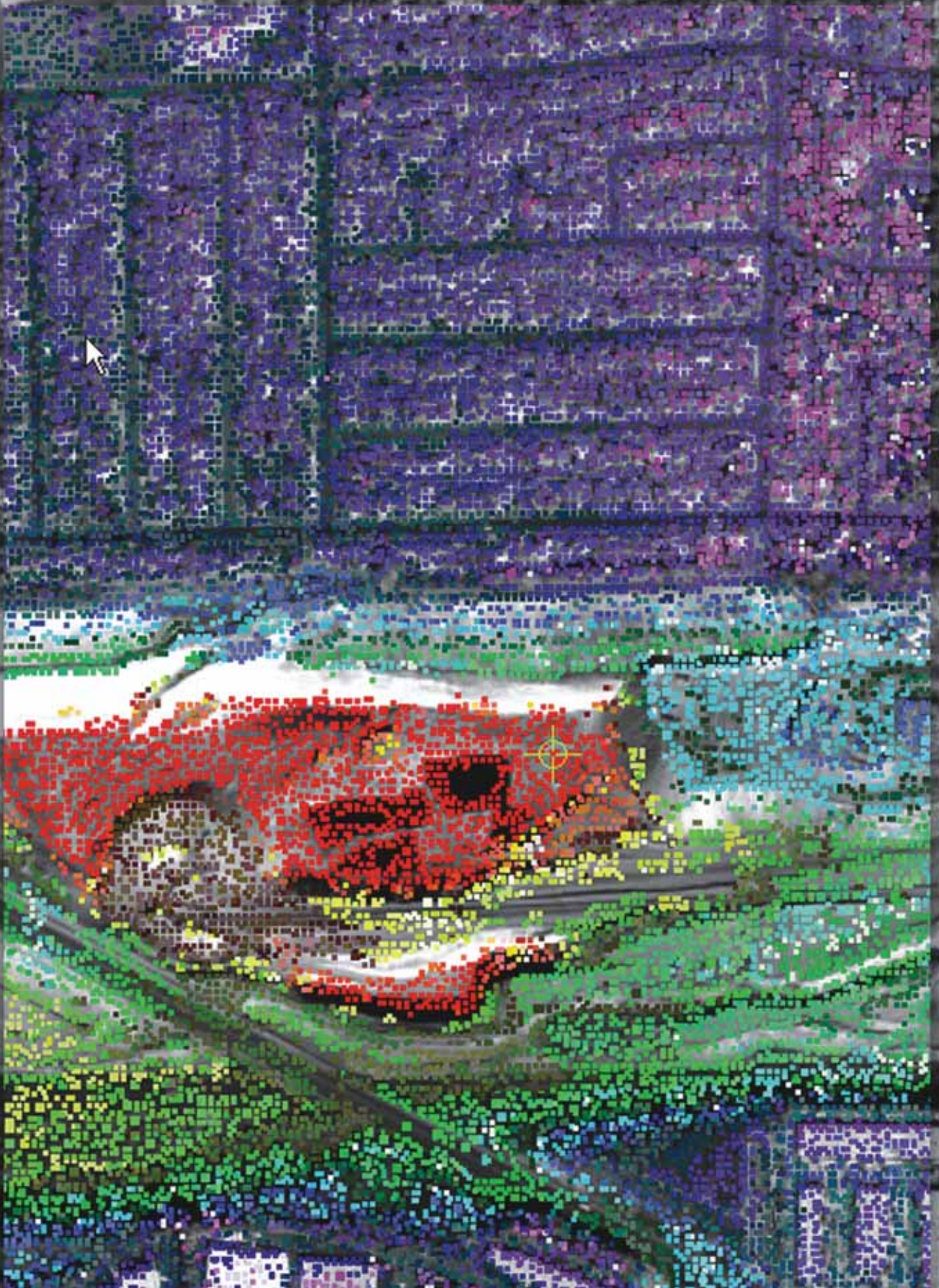
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EDITOR'S CHOICE: Do you have an image you would like to share? It can be on any topic and using any technology. It must be 300 dpi or greater resolution.

IMAGE OF THE MONTH: The image featured shows terrain points generated from an IKONOS® one-meter panchromatic stereo pair using BAE Systems' innovative Next Generation Automatic Terrain Extraction (NGATE) software. The resulting point cloud is thinned so that smooth areas have low densities. Further algorithms have been refined to remove trees and buildings, i.e., to create the "bare earth" digital terrain model or DEM from the initial points (DSM).



technology for RTK applications. Specifically Van Oord employs 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."

Beyond 'The World'

Construction of 'The World' now nears completion. After almost 30 months on the job, RTK GPS technology and related products from Pacific Crest have proven to be reliable in helping Van Oord to get another job done right.

And as companies such as Pacific Crest develop radio modems and other data communications solutions that are highly reliable and easy to use, RTK technology is coming to serve others beyond the heavy construction and surveying industries. Whether used for agriculture, science, transportation control, surveying, or dredging and building islands, RTK technol-

ogy and RTK-based radios have been proven in the field to save valuable time and resources for a customer.

"We design our RTK support products to work easily and reliably as part of a system, so that anyone can accomplish a task involving highly-precise positioning without worrying about the science of it," says Gosalvez of Pacific Crest.

Paul Hasse is a researcher at Pacific Crest.

RTK GPS AND COMMUNICATIONS

Real-Time Kinematic (RTK) GPS technology provides centimeter-level positioning from survey GPS receivers through a highly refined form of differential GPS (DGPS). GPS receivers identify position based on satellite signals, but these signals contain errors that limit accuracy and precision to about 10 meters. DGPS improves accuracy to a meter or two by filtering out the positioning and signal errors of GPS receivers which compare the satellite signals and location among one or more mobile receivers in the field and a fixed reference receiver of known location. The reference receiver monitors the system errors and formats correction messages that are transmitted to the other GPS user equipment in the network. For RTK GPS, sophisticated communications equipment enables higher accuracy corrections to improve GPS accuracy and precision

to a centimeter or less.

RTK can be highly cost-effective because all it requires is a dedicated GPS receiver to serve as a reference station and a telemetry network to transmit the correction messages among the reference station and mobile GPS receivers at a jobsite. Typically the telemetry is provided wirelessly through a system of inexpensive radio modems, such as the Positioning Data Link (PDL) products pioneered for RTK by Pacific Crest Corporation. But no matter what telemetry system is used, reliability and ease-of-use remain critical: if RTK telemetry at a jobsite isn't working, accurate high-precision positioning isn't possible there either—and millions of Euro worth of heavy equipment and crews could be idled. And that's not what RTK is all about.