SURVEYING THE LONGEST BREAKWATER EVER CONSTRUCTED

Creating 'The World'

Who hasnâ€™t heard of the mega projects currently being executed in Dubai? Land reclamation projects that can be seen from space and skyscrapers that reach 800 meters high are not unusual for the Emirate. Van Oord Dredging and Marine Contractors is working amongst others on the construction of 300 artificial islands that form the map of the world. The configuration measures seven by nine kilometres and is protected by 5 breakwaters with a total length that exceeds 25 kilometres, the longest ever constructed.

'The World' is an archipelago of over 300 artificial islands that forms a map of the continents and is situated four kilometres off the coast of Dubai. The contract was, at the time of award, the largest ever awarded to a single dredging company. Preparation for the project began in August 2003 and when 'The World' is completed (expected by the end of 2007), Van Oord will have transported 32,000,000 tons of rock to build the breakwater and dredged 325,000,000 cubic metres of sand to construct the islands.

The Shamal
The breakwater that spans from (the islands representing) Alaska to Japan is called the Shamal. The name Shamal originates from the Arabic word for â€˜northâ€™, and is a north westerly wind which blows with persistence during the summer from late May to early July over the Arabian Gulf. These winds cause rough seas near the shores of Dubai and the breakwaters are needed to give shelter to the reclaimed islands of â€œThe Worldâ€. For the construction of this breakwater system various materials are used and each requires its own kind of survey.

The Sand
The core of the breakwaters consists of sand which is placed by trailer suction hopper dredgers. In total some 20,000,000 cubic meters of sand is needed to construct the core of the breakwaters. The sand is brought in from allocated sand borrow areas in the vicinity of the project with hopper dredgers ranging in size from 4,000m3 up to 20,000m3 hopper capacity.
Every day the survey vessel will survey the areas where the hopper dredgers have been dumping their cargos, using multi-beam echo sounder system. Multi-beam data is collected and stored in a pre-defined 1m by 1m grid using PDS2000 acquisition software and within a few hours this data is send onboard the dredger and used to update the graphics of the dredgers own survey computer system to enhance safe navigation.
Obstructions like wrecks and pipelines are also made clearly visible on this display to avoid accidents while sailing or dredging. In the areas nearby the project some 250 objects have already been found and charted by the survey team.

Rock Filter Layer
The first layer that will be placed on top of the sand core is the filter rock. The filter aggregate will create a barrier preventing the sand from washing away. The layer thickness should be constant over the cross section with an average minimum layer thickness of 30cm. For placing this tin layer of filter material high positional accuracy is needed from the Side Stone Dumping Vessel (SSDV) as well as from the survey vessel with its onboard multi beam survey system. The SSDV is equipped with dynamic positioning to control position, speed and heading while dumping, plus a survey navigation computer to visually indicate the vessel position with respect to the exact dump locations. An acoustic Doppler current profiler is used to measure currents enabling the crew to calculate and anticipate any displacement of the rock during dumping due to the local current. For all rock layer surveys a smaller grid size than that used by the dredgers is utilised to store the multi-beam data, a minimum hit count of 5 is always maintained.

The Next Layer
The â€˜quarry runâ€™ is the second layer in the rock construction sequence. Instead of using a SSDV, the rocks are dumped directly from the rock barge to allow higher productions.
A very large mooring pontoon (equipped with positioning and heading system) is used as target to position the rock barges at the required position on top of the reef, moving along the reef as required to ensure the rock is placed in the required positions (dump boxes) from the rock barges. Wheeled loaders are used to offload the rocks into the theoretical dump boxes at a higher speed than could be achieved with the SSDV. To obtain an optimal dump result and to minimise the risk of dumping outside the theoretical profile, the total required layer thickness will be dumped in several layers. After each run a survey is carried out over the dumped area, this will show the remaining layer thickness to be dumped. Like the sand and filter layers the quarry run is surveyed with a multi-beam system.

Final Layer
The final armour rock layer is placed with hydraulic excavators.
Two hydraulic excavators will operate from the rock barge and will place the 1 to 4 ton rocks which make up the top layer of the breakwater. The excavators are equipped with the rugged Trimble MS860 positioning system which uses moving baseline techniques and provides centimetre-level positioning together with accurate orientation.
Excavator boom, stick and roll-pitch sensors are interfaced to a Rolloos Digmaster system which determines the relative position of the

grab. This grab position together with the absolute excavator position and heading from the MS860 are interfaced to a special mini computer that is used to run dedicated survey software. To ensure reliability all items are shock mounted on a plate that is installed inside the hydraulic excavator.
The software will visualize a cross section of the reef at the position of the bucket displaying the various stone layers and the latest survey information. This allows the excavator operator to place the exact amount of rock needed to build to the required design level.

Position Checks
The system on the excavator has been calibrated before commencement of the works and is checked on a daily basis against an independent positioning system on the mooring pontoon. During construction, all measurements (heights or depths) are referenced to the client specified Chart Datum.
The position check is done by comparing the easting and northing of the bucket of the excavator against the easting and northing of a known point on board the mooring pontoon. The bucket z-value can be checked against tide level. The simple theory behind the position check is the comparison of two independent positioning systems. Several position checks per day are scheduled for each excavator.

Base Stations
A RTK-GPS base station with back-up was installed to provide all Van Oord equipment with accurate 3D positioning and to ensure correct placement of 32,000,000 tons of rock by the side stone dumping vessels, multipurpose pontoons and hydraulic excavators.
The base station was tied in with the Dubai Virtual Reference System which consists out of 5 GPS monitoring stations spread through the Emirate. The offshore station is closely monitored from the site office and regular baseline measurements ensure the continued accuracy of this station. Tide gauges are installed as close as possible to the base station and working area and real time tidal information is transmitted to all vessels working for the project.

Multi-beam Survey
The day by day progress is measured using a survey vessel which is equipped with a Reson multi-beam echo sounder system. The head is mounted at an angle of 15 degrees and is placed on a retractable bracket. On the same bracket an Octans motion sensor is installed to supply heave, pitch and roll data together with precise heading information. The antenna of the RTK-GPS positioning system is also placed on the same construction. Having all sensors together on one arrangement makes it easy to determine offsets and any misalignment will be measured by the system itself. The multi-beam echo sounder can be lowered with an electrical winch making it easy to carry out shallow water surveys. The slanting position of the head allows more coverage on the slopes in the shallows near the reclaimed islands.

WLAN
Because the work area is relatively large and numerous vessels are working at the project a solution must be found to bring daily survey results on board of each vessel. In the old days a tender vessel was used to distribute floppy discs with survey data to the dredgers and workboats. Wireless LAN is now used on all vessels on the project. By boosting up the signal on both ends it is possible to communicate with ships that are more than 10 kilometres away from the site office. When the survey vessel has finished a certain area the data is immediately transmitted to the office and processed. With little delay the processed data can be send back to the dredgers and rock dumping vessels. The survey systems on board the vessels can be updated instantly. Digital bathymetric charts are also emailed to the vessels and can be viewed or even printed onboard

Still Some Time to Go
It will take another year before the Shamal will be completed and a further year to finish of the smaller reefs on the south side of 'The World'. When completed 'The World' will be a secluded and exclusive community that will accommodated luxury houses, apartments and resorts.