Pebble Tracking using RFID

By Clive Moon and Ted Read

Measuring beach movement is not a precise or static measurement problem. One solution involves installing 2400 tiny radio frequency identifiers in pebbles and tracking them over time.

The Havant, Portsmouth & Gosport Coastal Partnership is a partnership of local maritime authorities responsible for managing coast and flood erosion risk along 136 kilometres of the East Solent coastline in southern England. The partnership is undertaking a long-term study to track the movement of shingle along their coastline. The study, currently covering the open coast on Hayling and Portsea Islands, features the long-term tracking of shingle pebbles that have had a small radio frequency ID (RFID) tag embedded within them. The ultimate purpose of the study is to improve understanding of the movement of beach material along the coastline, which will in turn help to optimise future coastal erosion and flood protection schemes. Of special interest is the performance of the ongoing beach nourishment operations at Eastoke, Hayling Island. SCOPAC, the Standing Conference on Problems Associated with the Coastline, has also contributed financially to the project, recognising the wider benefits of developing a new technique for tracking gravel sized material in the littoral zone.

Pebble Tagging

To accurately simulate the natural beach material, individual pebbles are drilled using high pressure water jets and a small RFID tag is placed in the hole which is then filled with a plastic resin. Where possible the hole is orientated along the short axis of the pebble so that in its natural repose position the majority of tags will be pointing upwards, this being the optimum orientation for RFID detection.

The RFID tags used are passive, meaning that they have no internal power source. The power used by the pebble's microchip tag is supplied by inductive electromagnetic radiation emitted from the RFID reader device. The Texas Instruments tags utilise half duplex (HDX) transmission technology, and operate at a low-frequency of 134.2 kHz. Ultra-high frequency (UHF) tags are not suitable due to the fact that if they are near a conducting material such as metal (or in this case wet salty ground) the range is greatly reduced.

There are three different sizes of RFID tags being used (32 and 23mm glass transponders, and a 12mm plastic wedge transponder). The 32mm tags have the greatest optimum detection range at 1.0m, decreasing to 0.2m for the 12mm tags. Only limited numbers of the 12mm wedge tags will be used initially to test the performance of resin-based artificial pebbles in simulating the movement of smaller sized shingle particles.

RFID equipment

The RFID detection equipment consists of three major components, an RFID control unit, an antenna load tuning box and an external antenna. These components were assembled by Ohmex into two trial units, a portable hand-held unit and a towable large antenna configuration. During August 2010 a field test was organised with Clive Moon (Coastal Engineer, Havant Borough Council) on Hayling Island to trial the two assembled devices. The hand-held antenna has an area of 0.2 × 0.2m, and recorded an optimum read range of 0.4m for a 32mm transponder. The larger antenna was 1.0 × 2.0m and designed to sit in a wooden tray and be towed behind an all-terrain vehicle (ATV). The maximum read range for a 32mm transponder was only 0.2m for this larger antenna.

The optimum read ranges during the initial trial were lower than anticipated and prompted modifications to the design of the equipment. The hand-held antenna was re-wound using heavier gauge wire. During subsequent testing this increased the read range of a 32mm tag to 0.8m, close to the optimum range of 1.0m suggested by the manufacturer.

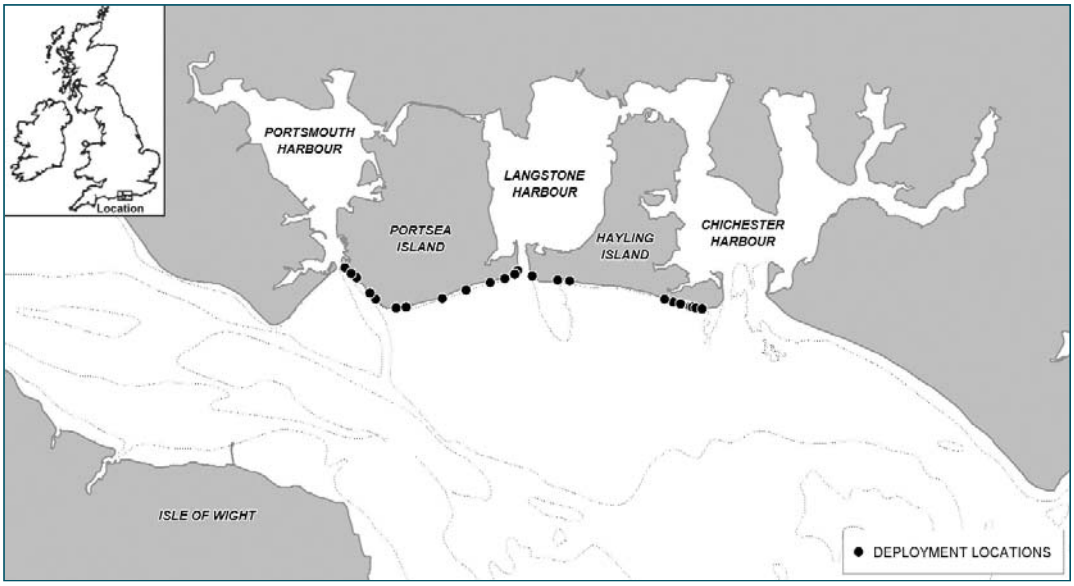

Figure 1: The study area, Hayling and Portsea Island on the South Coast of UK

Figure 2: Tagged pebbles

Figure 3: ATV mounted RFID antenna.

The towed antenna was redesigned to incorporate a multiplexer that can drive up to four antennas, each 1.2 × 0.6m in area, again using heavier gauge wire. The optimum read range for a 32mm tag again increased to 0.8m during subsequent testing. The new array can cover a 3m wide strip of beach, increasing the survey efficiency by 50% compared to the original design.

Further testing is currently underway in which antennas are suspended from the back of an ATV rather than being dragged along the beach surface. If successful this will increase the potential surveying speeds, whilst also reducing wear and tear on the various antenna components. Data from the antenna array is logged and time-stamped using a datalogger. Position data is simultaneously logged using a Trimble R8 GNSS receiver with TSC2 datalogger, using corrections supplied from a Trimble NetR5 base operated as part of the Southeast Strategic Regional Coastal Monitoring Programme. The data is post-processed to combine RFID tag numbers and locations for each of the four antennas.

Initial Results

As part of the ongoing study 2,400 tracers have been deployed around the Hayling and Portsea Island open coast. Sixteen kilometres of beach is being scanned every three months over a 12-month period to build up a picture of the rate and direction of sediment transport. After 12 months, as many tracers as possible will be recovered and re-measured to quantify the rate of attrition of the beach material. This will help the partnership improve the accuracy of long-term volumetric predictions for the fate of beach nourishment material placed along the coastline.

A two-week study of 300 tracers deployed at Eastoke, Hayling Island, in September 2010 yielded good initial results. The average detection rate over the two weeks was 72%, with more than 95% of all the tags detected at least once. After five months deployment the tracers had dispersed along three kilometres of beach, with the mean direction of drift westwards – as anticipated, based on the current understanding of sediment transport in this area. The detection rate had dropped to 17% after five months – a significant drop, but one of the key outputs from the project will be a clearer understanding of the detection rates achievable over longer time periods.

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The day of the RFIDs has arrived

Radio-frequency identification (RFID) is a technology that uses radio waves to transfer data from an electronic tag or label. Attached to objects, the RFID tag enables a reader to identify and track the object. Some RFID tags can be read from several metres away and beyond the line of sight of the reader. Basically there are two types of RFID tag: fixed and mobile. The latter are increasingly used to track vehicles for toll charges while the static have wide application in logistics and stock control as well identifying buried utility services.

The tag's information is stored electronically. The RFID tag includes a small RF transmitter and receiver. An RFID reader transmits an encoded radio signal to interrogate the tag. The tag receives the message and responds with its identification information. Many RFID tags do not use a battery. Instead, the tag uses the radio energy transmitted by the reader as its energy source. The RFID system design includes a method of discriminating several tags that might be within the range of the RFID reader.