



Digital twin provides resilience to coastal change

North Norfolk's 72km coastline is changing fast due to cliff erosion and collapse, leaving low-lying areas at risk from storm surge inundation. The 2013 North Sea storm surge event had a major impact on the North Norfolk District Council frontage, and threatened the Bacton gas terminal.

Development of a custom-built digital twin

The Bacton gas terminal, one of the UK's largest gas terminals, is located on the Norfolk coast; it was at risk of cliff erosion and needed protection. Downdrift of the terminal, sea defences at the villages of Bacton and Walcott were expected to fail within ten years. Sustaining the defences was not affordable, and there was no mechanism or funding to support the communities' adaptation.

North Norfolk District Council recognised that private investment in the emerging coast protection scheme at the gas terminal created the opportunity to also benefit the two villages by extending the life of their defences and enhancing the viability of their communities.

However, using "hard" defences in front of the terminal site would have retained sand, and prevented it reaching Bacton and Walcott – where beach levels were already falling – leading to the eventual failure of the sea wall, promenade and road.

An integrated scheme with a custom-built digital twin was therefore developed to protect the gas terminal, while also extending this protection towards the two villages. The Bacton to Walcott Monitoring and Integrity Management Plan uses an innovative "sandscaping" approach to build up the beach, with

its progress in the coming years monitored by a digital twin, which could predict its long-term viability. This is a UK first; its only international parallel being the Dutch sand engine (zandmotor) scheme, north of Rotterdam.

A Development Agreement was signed to take forward an integrated coastal management scheme, with the gas companies meeting two thirds of the costs and the remaining third financed from public sector sources.

Recognising the public good which would be delivered through the scheme, North Norfolk District Council became its accountable body in terms of project management, contract award and securing the necessary funding package. The contract value approached £19M, with £6.5M being met through public funding sources including an Environment Agency grant, the New Anglia Local Enterprise Partnership, Norfolk Business Rates Pool and North Norfolk District Council.

Digital twin implementation

The sandscaping scheme, designed by Royal HaskoningDHV, saw 1.8 million cubic metres of sand delivered and placed on the beach along a frontage of 6.5km, providing protection for the gas terminal and 298 residential and business properties. As a result, the beach grew in height by between three and seven metres, and by around 100 metres in width in front of the terminal.

With the sandscaping completed, Royal HaskoningDHV started work on the next major component of the scheme: monitoring the beach and foreshore – and the conditions that affect them – to assess the how the new frontage behaves over time.

To achieve this, the team built a digital twin of the new defences, which automates a sequence of monitoring tasks including data collection and modelling for sand conditions, weather, and tidal patterns. The twin then takes that data and combines it with topography and bathymetry data collected by coastal monitoring experts SHORE and applying predictive analysis models to estimate how long the current solution will last.

A graphic interface shows decisionmakers at Bacton Terminal Companies and North Norfolk District Council detailed visualisations of analysts' surveys, helping them understand how different factors affect the sand, and how long they can expect the new defences to hold. This detailed knowledge is helping leaders make more informed decisions about their next steps.

Based on current insight, the digital twin predicts that the next set of defences will need to be built in 2034, a full 15 years after the initial sandscaping was completed.

Engaging the public

The project has delivered an innovative coastal management scheme to a vulnerable length of the coast, protecting the critical national infrastructure of the Bacton gas terminal and providing additional protection for two low-lying communities which had experienced significant storm surge inundation twice in four years.

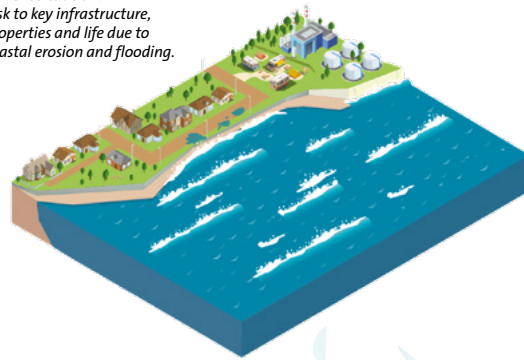
However, other benefits have been realised through the delivery of the digital twin.

During the construction period significant numbers of visitors were attracted to the area to watch the engineering works on the beach delivering positive business outcomes from increased visitor numbers and spend to local shops, cafés, and tourist businesses.

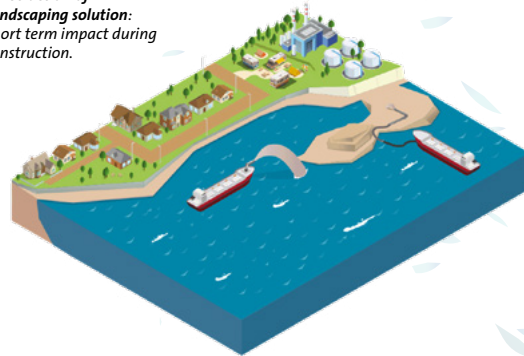
Team Van Oord staffed a public exhibition vehicle on the Walcott seafront to explain the sandscaping scheme, which received an average of 120 visitors per day while the works were underway.

In anticipation of the increased numbers of visitors and confidence in the newly restored beach attracting new tourist visitors, the local council has refurbished

Current situation:
Risk to key infrastructure, properties and life due to coastal erosion and flooding.



Construction of sandscaping solution:
Short term impact during construction.



5 years after construction:
Natural shaping of new beach by coastal processes.



20 years after construction:
Long term and adaptable protection with benefits for key infrastructure, local communities, the environment and tourism.



facilities and is looking into a new public car park. It is hoped the changes will boost the profile and accessibility of the area's beach for years to come.

The contract also delivered the first social value outcomes for North Norfolk District Council, through a £25,000 small grant funds for local community projects. This included offering student placements, allowing contractor staff to volunteer for community projects for up to a day, and making £20,000 of improvements to the Norfolk Coast Path which passes through the two villages.

Throughout the project there were opportunities for input and involvement from the local communities. Key local representatives formed a liaison group to enable two-way discussion with the community, enabling local input and providing a sounding board for the project as it was delivered. The group was invaluable in identifying potential local concerns so that these could be considered and mitigated.

Development and delivery of the scheme also achieved strong engagement and partnership working between the North Norfolk District Council, the Environment Agency and private sector energy companies, which make a significant contribution to UK energy security and the transition to a zero-carbon economy by 2050.

The future of coastal management

The project will explore the significant potential to apply the digital twin model more widely for other beach management schemes, as well as for use by broader groups (e.g. beach users, fisheries, habitats). For example, the Bacton digital twin's monitoring capabilities could be expanded to predict safe areas to swim based on weather and tidal conditions, supporting local tourism and helping support public safety on the beaches.

As a result of the scheme's success, Royal HaskoningDHV is now working with The Crown Estate to refresh the list of sites with high potential for sandscaping in England and Wales, which was first established in 2015. Together, we'll define next steps to take the identified sites forward for a more in-depth feasibility assessment.


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