Boston Barrier

innovative flood defence: leveraging operational forecasting and digital technology

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Environment Agency

The Boston Barrier project is a landmark flood defence scheme located in Boston, Lincolnshire, designed to protect the town from tidal surges and flooding; serving a population of approximately 14,000 homes and businesses. This project is a critical component of the UK's flood risk management efforts. The primary driver for this project is the need to safeguard the town's residents and infrastructure from the increasing threat of flooding due to climate change and rising sea levels. Operational forecasting plays a crucial role in the Boston Barrier project by providing real-time data and predictive models to ensure the barrier operates effectively during flood events. This case study focuses on the technical aspects of the operational forecasting system, its integration with the overall scheme, and the innovations that have been implemented; including the use of advanced digital technology.

Boston Barrier closure - Courtesy of Environment Agency

Project background

The Boston Barrier project was initiated following the severe tidal flooding that occurred in December 2013, which caused extensive damage in Boston, Lincolnshire. This event demonstrated the urgent need for improved flood defences. Boston, situated on the east coast of the United Kingdom, has a history of tidal surges, with significant flooding events also recorded in 1953 and 1978.

In response to the 2013 flooding, the idea for the Boston Barrier was proposed to provide enhanced flood protection. The project received approval in 2017, and construction began shortly after. The barrier is designed to be a state-of-the-art flood defence system, incorporating advanced engineering techniques and advanced technology to offer robust protection against tidal flooding.

The Boston Barrier safeguards ~14,000 properties; including 700 commercial properties. It involved constructing a rising sector gate barrier and associated flood defence walls to protect the town from a 1 in 300-year tidal surge event, even accounting for climate change. The barrier can be raised in just 20 minutes, providing a rapid response to threats from North Sea tidal surges.

This project is a critical component of the UK's flood risk management efforts and is part of the government's long-term investment in flood and coastal defences. The initiative aims to reduce flood risk for hundreds of thousands of homes.

Beyond protecting the town from future flooding events, the Boston Barrier project also supports the long-term strategic aspirations of local authorities. It is intended to contribute to economic regeneration in the town and region.

Engineering & environmental impact: Design & implementation

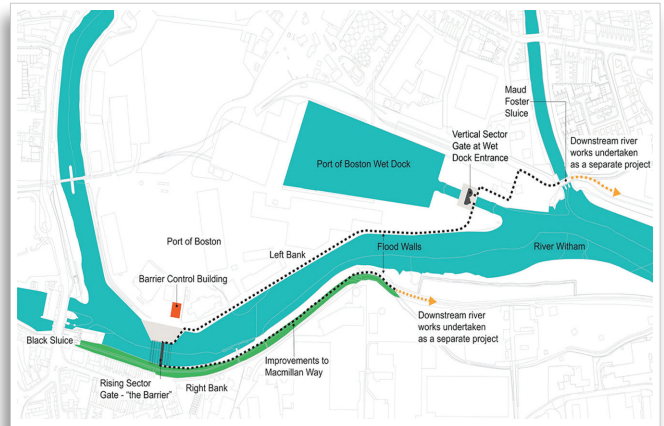
The Boston Barrier Tidal Flood Defence Scheme reduces the risk of tidal surge flooding to properties and businesses in Boston; achieved through the construction of a 28m wide, 11.5m high rising sector flood gate, 7,000 tonnes of sheet piled quay wall, over 2km of flood wall, and a set of 9m wide, 12m high vertical sector gates (VSGs) at the widened entrance to the Port of Boston's Wet Dock.

The project is designed to reduce the risk of tidal flooding against a 1 in 300-year tidal surge event, equating to an annual exceed probability of 0.33% over its 100-year lifespan.

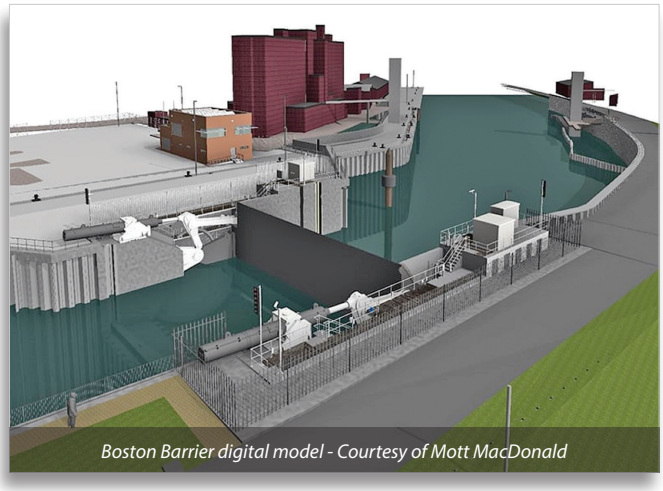
Mott MacDonald acted as the design partner in a design and build joint venture with contracting partner BAM Nuttall. The Boston Barrier Project operated with the construction partner and client on the same collaborative principles as the aims of the Watercare Design Delivery Partner scope. The scheme also showcases services that align extensively with the key services and core competencies required of the Watercare Design Delivery Partner, including design management services, programme management, technical excellence in all engineering disciplines, geotechnical specifications, physical investigations, interpretive reporting, and analysis prior to full detailed design, consent planning, and environmental management and sustainability expertise.

One of the key engineering challenges of the Boston Barrier Project was designing a system that could operate effectively in the dynamic coastal environment. Engineers had to account for factors such as tidal patterns, storm surge behaviour, and sediment transport to ensure the barrier's reliability and longevity. Advanced modelling and simulation techniques were used to optimise the design and predict the barrier's performance under various conditions

In addition to its engineering prowess, the Boston Barrier Project also prioritises environmental sustainability. The location of the barrier was carefully chosen to minimise ecological impact and preserve the natural habitat.



Location of the Boston Barrier project - Courtesy of Mott MacDonald


Boston Barrier digital model - Courtesy of Mott MacDonald


Boston Barrier scheme under construction with digital model support Courtesy of Mott MacDonald & Environment Agency


Boston Barrier scheme under construction with digital model support Courtesy of Mott MacDonald & Environment Agency

Solutions & innovations

Design efficiencies: The development of the overall basis of design was undertaken with full consideration of climate change. This approach informed the design flood levels and ensured the longevity of the design as a whole. Throughout the design process, various efficiencies were identified and incorporated into the final design to improve outcomes for the client, future users, and the wider environment. Some examples include:

- ***Design for manufacture & assembly:*** This method was used in the design and construction of the gate recess for the tidal barrier, result in cost saving, reduced carbon footprint, and simplified temporary works. Additionally, it improved health and safety on site.
- ***Prefabrication of rebar cages:*** Proposed for the tidal barrier structure base, this approach reduced time spent in confined spaces and enhanced the overall quality of the product.

Sustainability considerations: The project leveraged extensive experience in sustainability and sustainable engineering design practices to help the client deliver their first major construction project using the UN Sustainable Development Goals as a framework for monitoring and evaluating the project's broader successes. The client now uses this project as a benchmark for all future projects, demonstrating how a project team can collaborate effectively to achieve sustainable outcomes as a common goal for all project partners.

Technical description

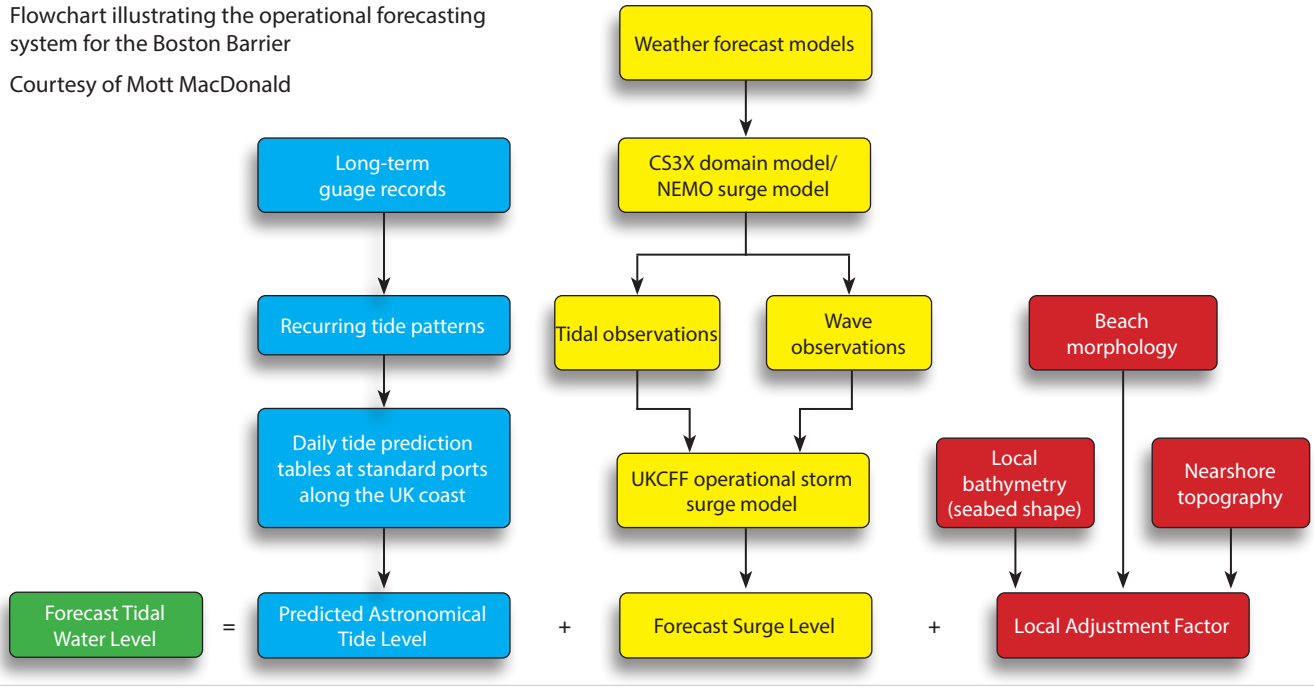
Operational forecasting system: The success of the Boston Barrier project relies heavily on reliable coastal forecasting to determine when to trigger the operation of the barrier. Accurate and timely forecasts are essential to ensure the barrier is raised in response to imminent tidal surges, thereby preventing potential flooding.

Without a robust forecasting system, the effectiveness of the barrier could be compromised, leading to inadequate protection for the community and infrastructure. Thus, it is crucial to develop and maintain a reliable forecasting system to guide the operation of such an important flood defence infrastructure.

This proactive approach not only safeguards lives and properties but also lay the foundation for a resilient and thriving community.

Flowchart illustrating the operational forecasting system for the Boston Barrier

Courtesy of Mott MacDonald



To achieve this, the existing tidal forecast model for Boston was refined and improved to provide the most accurate and timely predictions possible of water levels and flood risks from the sea. This system incorporates advanced numerical models, which are calibrated using historical data and real-time observations. These calibrated models have been integrated into the national Flood Forecasting system, aiming to provide a high level of accuracy and reliability. The flow chart above illustrates the key components and process of the operational forecasting system.

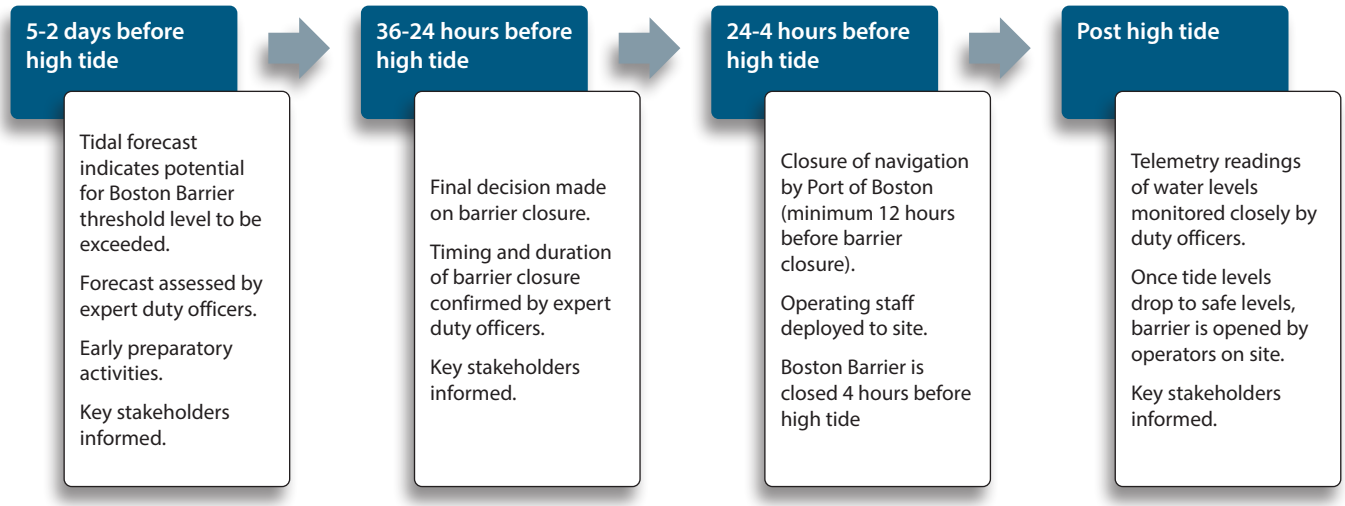
Furthermore, the design includes a robust data management framework to handle the input data and output data generated by the forecasting system. This framework ensures that all relevant information is efficiently processed and utilised to make informed decisions about when to activate the barrier. By leveraging advanced technology and comprehensive data analysis, the operational forecasting system plays a pivotal role in the overall effectiveness of the Boston Barrier project.

In summary, the integration of a sophisticated forecasting system is essential for the successful operation of the Boston Barrier. It not only enhances the barrier's ability to protect the community and infrastructure from tidal surges but also contributes to the long-term resilience and prosperity of the region.

Data collection & analysis: Data collection is a critical component of the operational forecasting system. The project utilises a network of tide gauges and wave buoy stations with recorded water levels, tidal patterns, wave conditions, and associated meteorological conditions. This data is then fed into the multi-regression forecasting models, which analyse the information to predict future water levels in the river Haven, where Boston Barrier is situated, and potential flood events.

Forecasting models: The forecasting models are based on advanced hydrodynamic and statistical techniques. These models simulate the behaviour of tides and surges along the east coast and at Maud Foster Sluice downstream of the Boston Barrier. They take into account various factors such as tide, surge, wind, and local geometry. To ensure their accuracy and reliability, the models were thoroughly tested and verified against 30 years of historical data through both hindcasting and forecasting.

Integration with the operational scheme: The Boston Barrier operational forecasting system is designed to provide accurate predictions of tidal surges and water levels. However, there is no automated response or control system integrated with the barrier's operations. Instead, the operation of the barrier is manual and based on attendance triggered by forecasted conditions.



Indicative timeline of key Environment Agency & contractor activities triggered by the tidal forecast model - Courtesy of Environment Agency

When the forecasting models predict a significant tidal surge and the resulting water level in the Haven is expected to exceed the trigger threshold, personnel are alerted to manually activate the barrier to protect the town from flooding. Since the implementation of the forecasting model, the trigger levels for raising the gate have been further refined and adjusted to reduce the number of unnecessary operations at low levels, thereby enhancing the system's overall effectiveness.

Digital innovations

The Boston Barrier Project is not only an impressive feat of engineering but also a showcase of digital innovation. The project leverages advanced digital tools and methodologies to enhance its effectiveness and efficiency.

One of the key digital innovations is the use of Building Information Modelling (BIM) and a Common Data Environment (CDE). These tools enable seamless collaboration among stakeholders, optimise the integration of existing structures, and streamline the design and construction processes.

The use of precast concrete elements and the integration of permanent and temporary works within the twin wall cofferdam exemplifies how the digital tools, such as the project's CDE and BIM, have contributed to the project's success. These innovations have resulted in significant time, cost, and carbon savings.

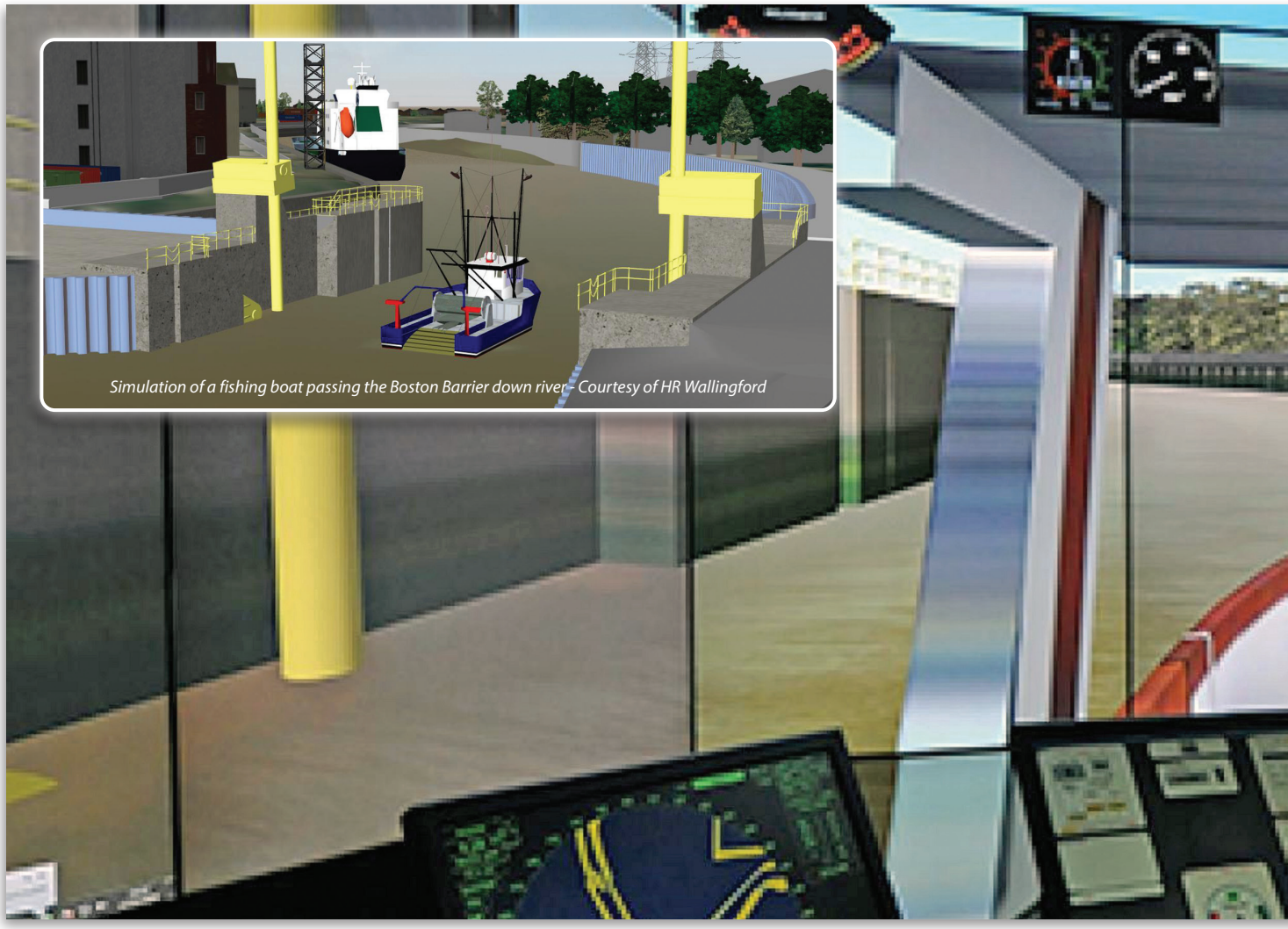
Telemetry-based monitoring & maintenance: The system utilises telemetry feeds to SWANTEL for real-time monitoring and predictive maintenance. Although there is no integration of real-time data from sensors and monitoring systems with the digital model, the telemetry feeds provide valuable insights into the barrier's performance and condition. This setup enhances decision-making capabilities and proactive intervention, ensuring navigation safety and the overall effectiveness of the barrier.

Additionally, the project's hydrodynamic models and BIM model were used to develop flood conditions and virtual navigation simulations for river users even before the scheme was built. This helps identify blind spots and risk areas, ensuring safe navigation through the barrier. By simulating various scenarios, it can highlight potential hazards and provide guidance to mitigate risks, enhancing overall safety for vessels navigating the area around the barrier and the safety of river users.

These benefits demonstrate how the hydrodynamic modelling results not only enhances the operational efficiency and safety of the Boston Barrier but also contributes to the broader goals of flood risk management and community resilience.

Effective communication & community engagement: The work put into the BIM virtual project has ensured that a clear and concise picture is presented to all team members. This approach has unlocked efficiencies, including crucial changes to the design of the control room, hydraulic systems, and future Operation and Maintenance (O&M) ways of working. It has also ensured efficient and effective design to avoid buried obstructions on a well-developed and ever-changing port site.

The BIM model has proven to be a fantastic communication tool, conveying the changes being brought to Boston much better than traditional 2D drawings, especially when communicating with those without engineering knowledge or background. It has been used extensively in both professional presentations and as a key



Simulation of a fishing boat passing the Boston Barrier down river – Courtesy of HR Wallingford

part of the communications package with local interest groups and primary and secondary schools, supporting STEM and community engagement efforts.

Innovations & Benefits of the Boston Barrier Project

The Boston Barrier project incorporates several innovative features and offers numerous benefits that enhance its effectiveness, efficiency, and sustainability. These advancements not only improve the operational performance of the barrier but also contribute to significant cost savings and environmental benefits.

In addition to the previously mentioned advantages, here are the key innovations and benefits of the project in flood forecasting:

- ***Innovative features:*** The project utilises advanced modelling techniques to enhance the accuracy of predictions. By analysing patterns in data and adjusting forecasting models accordingly, it achieves more precise and reliable forecasts.
- ***Carbon reduction:*** The forecasting system improves the efficiency of the barrier's operations by reducing unnecessary activations. This not only lowers the project's overall carbon footprint but also positively impacts the health, safety, and well-being of operators.

These innovations and benefits highlight the Boston Barrier project's commitment to leveraging advanced technology for enhanced performance, cost-effectiveness, and environmental sustainability. By integrating advanced digital tools and methodologies, the project exemplifies a forward-thinking approach to flood defence infrastructure, ensuring long-term resilience and protection for the community and infrastructure.

Conclusions

The Boston Barrier project showcases innovative flood defence through its advanced operational forecasting system, significantly enhanced the barrier's effectiveness, efficiency, and sustainability. The project's success in precise forecasting, cost savings, and carbon reduction highlights importance of advanced digital tools in flood risk management.

Despite the lack of a real-time link between the forecast system and digital monitoring, the project uses telemetry feeds to SWANTEL for real-time monitoring. This setup provides valuable insights into the barrier's performance, enabling informed decision-making during flood events. This proactive approach not only protects the town of Boston from potential flooding but also fosters economic development and community resilience.

The Boston Barrier's achievements offer valuable lessons for future flood defence projects. By focusing on accurate data collection, continuous monitoring and improvement, other initiatives can replicate this project's success, contributing to a safer and more sustainable future.

In summary, the Boston Barrier project exemplifies the power of innovation in flood defence, demonstrating how advanced forecasting and digital technologies can transform community protection against climate change.

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A marine pilot tests the simulation at HR Wallingford for river users to navigate the Boston Barrier - Courtesy of HR Wallingford