Cardiff Docks as it was then called was the world’s largest coal exporting port. It is also Europe’s largest waterfront development and it has a wealth of leisure activities available both on and off the water. Cardiff bay has been turned into a vast freshwater lake with the introduction of a barrage. Cardiff Bay is home to a number of attractions such as The Welsh Assembly, the brand new Wales Millennium Centre, Craft in the Bay, Butetown History and Arts Centre, Goleulong 2000 Lightship, Techniquest Science Discovery Centre, and the Norwegian Church Arts Centre. The common point of each of these attractions is the constant water level in the bay which requires the smooth and reliable working of the Cardiff Bay Barrage. Behind the scenes everything is done to ensure that the bay is environmentally managed and operated optimally by Cardiff Harbour Authority and uses ABB control technology based upon a long term working relationship.

The harbour at Cardiff Bay experiences one of the world’s greatest tidal ranges up to 14m. In the past this meant that at low tide it was inaccessible for up to 14 hours a day. The barrage eliminates the effect of the tide, which has acted as an inhibitor to development, releasing the potential of the capital city’s greatest asset - its waterfront. The construction of the barrage was one of the largest engineering projects in Europe. Completed in 2000, it has created a 500 acre freshwater lake with 8 miles of waterfront and has stimulated the development of the Bay as a tourist and leisure destination, the 500 acre (200 hectare) lake is no longer influenced by the tide. The impounded lake produces an eight mile (12.8 Km) waterfront, creating the environment for one of Europe’s most exciting and ambitious developments. The National Assembly for Wales asked Cardiff County Council to manage the Barrage and the Bay from April 2000. The Cardiff Harbour Authority was established by the Council to carry this out.

The barrage embankment consists of an 800 metre long embankment constructed from sand and rock and a 300 metre concrete section containing the locks, sluices, fish pass and control building. The inland face is landscaped to provide a linear park and the seaward side is protected with rock stone armour. Five large sluice gates release the flow of the Taff and Ely rivers out of the Bay.
Cardiff’s vital maritime economy is also safeguarded. The effect of the barrage was tested in a ship simulator and structural piers have been provided to assist ships navigating Cardiff Docks, which is close by but not part of the controlled freshwater bay. The barrage itself has three locks which allow access to the safe haven that the bay provides for the many pleasure craft and larger vessels that are moored within.

The environment
Environmental controls at the barrage ensure that the bay’s salinity is tightly controlled. The bay is fed by the Rivers Taff and Ely which have highly variable flow and the passage of vessels in and out of the bay through any of three locks results in some saline water to enter the bay. Added to this inflow and outflow is the fish pass that allows salmon and other migratory fish stock to have free passage to the bay.

Regulation of the impounded fresh water is undertaken by the actuation of up to five hydraulic sluices that are normally shut at high tide. The levels of the bay and the sea, along with numerous flow gauges in the rivers allow a control function to be established for the automation system. The unique nature of the bay has meant that the operators have had a long learning curve to establish a
detailed understanding of water flows and levels in the bay, and thus to determine the consequences of control actions.

The primary focus points throughout the barrage’s development and operation have evolved taking into account the initial socio-economic and newer environment issues. The system records all data such as water levels, flow, salinity etc and this can be readily discussed and shared with the Environmental Agency.

Keeping the control system current
To ensure that the barrage retains its full and in many ways continuously extending functionality the control system is audited annually to ensure that its functionality will meet with new requirements and that there is no inadvertent creeping obsolescence which could become the root cause of a prolonged period of unplanned downtime. To further avoid such operational risks the control system is dual redundant as is the MCC (Motor Control Centre). The control room itself is duplicated in case of a disaster.

A recent upgrade has been to migrate the control system to ABB’s 800xA platform, which is at the core of many ABB run applications and is both strongly supported and widely used. The controllers with 800xA are ABB Compact 800 which is programmed to the IEC 61131 standard. Roger Thorney, Operational Manager, Cardiff Harbour Authority, said, “The barrage is risk managed and a key element of this is ensuring we operate and maintain the systems using the best technology”.

Throughout the last ten years the barrage has been subject to Continuous Improvement, some of which came from changing user requirements, some from operational experience and others from a tightened environmental regime. Work continues on the ABB 800xA migration whilst the barrage remains fully functional. Roger Thorney, “ABB’s annual audit ensures that we have a coherent direction for our continuous improvement and that we are not risking a drift to technological obsolescence, we have a strong relationship with ABB based on their proven technology and expertise.”

Operator Interface
The system provides various screen displays which show the status of equipment and also trends such as water levels onto which the status of sluices and other equipment is superimposed, the result being a highly intuitive display that can be quickly assessed whilst keeping a vigilant eye on public safety from a high level control room. Detailed displays of actual values and trends of Estuary and Bay water levels, Fish Pass levels and flows, River Flow, Salinity, Lock water levels and a host of other information is available. In addition to providing operator information and environmental records the system is capable of controlling many aspects of the bay in automatic operation.

ABB provides extensive backup and support for the system with complete replication at its Stone facility and on-line system access.

Summary
The socio-economic benefits of the barrage are witnessed every day by the thousands of people that work and take leisure around the bay area. These benefits have been expanded to include environmental issues which are well
understood by the barrage supervisors. The next stage of operational evolution involves the reduction of barrage energy usage through metering, monitoring and targeting and also self-generation of energy, possibly by exploiting the water power from within the bay by using water turbines.

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Technology and Continuous Improvement Status

The system which is deployed at the Cardiff Bay Barrage uses many of the technologies which ABB’s Control Technologies’ supply; this is subject to a rolling upgrade to avoid technology obsolescence drift, and to make it readily supportable by the current generation of engineers. The status is a mix of 9x SattCon200 PLC’s which use Dox10 programming, 3x AC800C PLC’s and 8xAC800M PLC’s which is Compact Control Builder IEC 61131 based programming, and a 800xA DCS. The current status is the ongoing phased upgrade of system to Compact 800 solution with 800xA DCS supervisory (800xA used for the redundancy) for which the goal is the modernisation of programming to standard IEC 61131 based Automation System. The migration is phased to replace PLCs one by one. Operation will be maintained 24/7.