In the pipeline

Meeting the challenges of monitoring a gas pipeline 850m underneath the North Sea.

By **Mike Richardson**.

Located off the coast of Norway, 850m below the surface of the North Sea, the Ormen Lange gas field development project is set provide up to 20% of British gas needs for the next 40years.

The big challenge facing Norwegian oil and gas technologist Bjørge was in overcoming the formidable bulk of the Storegga rockslide located near the continental shelf. The rockslide is more than 800km long – one of the longest on the continental shelf – and a huge mound of rubble has accumulated over thousands of years, creating an extremely rough seabed on which to lay pipelines.

Driven by pressure from the well only, natural gas is streamed to the surface from underwater camps to on shore production facilities. The gas flows in pipelines that pass through the rockslide and are therefore exposed to mechanical vibrations from influences such as the Gulf Stream, water avalanches and water turbulence due to the uneven seabed and pipeline internal flow.

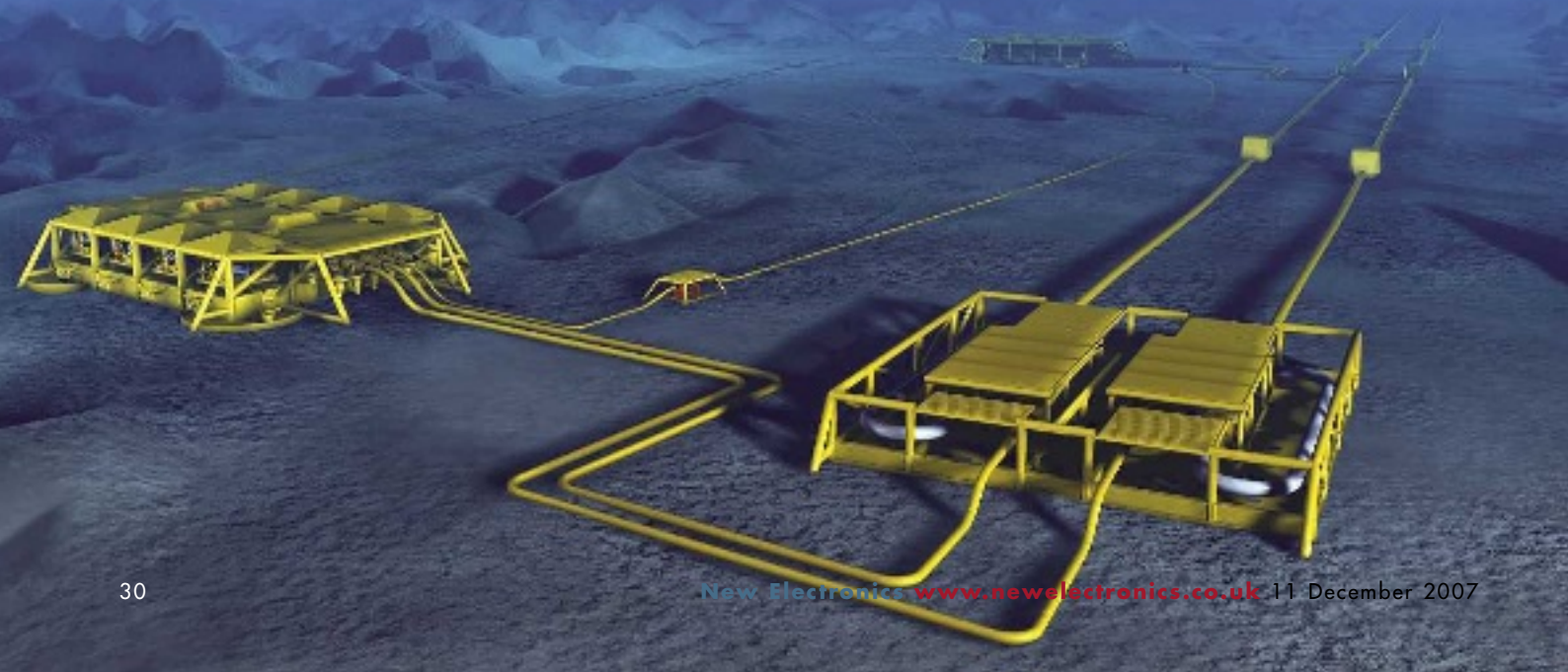
This means the pipeline is monitored continually for vibration, which presents considerable safety risks such as leaks and even pipe breaks. Bjørge has developed a sophisticated monitoring system that uses Naxys technology's hydro acoustics to synchronise multiple sensor nodes, each of which is driven by Analog Devices' Blackfin ADSP-BF533 processor running at 500MHz.

Due to the high demands placed on Bjørge's systems, Naxys is frequently involved in developing electronics and software for its products. However, the short schedule on this project required Bjørge to find a well proven hardware platform and a corresponding programming tool yielding the shortest possible implementation time. Focus was also put on efficient debugging and system testing. The requirements for the hardware and software system to be used on this application provided a challenge that few could meet. Naxys needed to find a platform that was small, could be operated in harsh environments, had low, controllable and deterministic power consumption and which could be programmed in C and LabVIEW.

In at the deep end

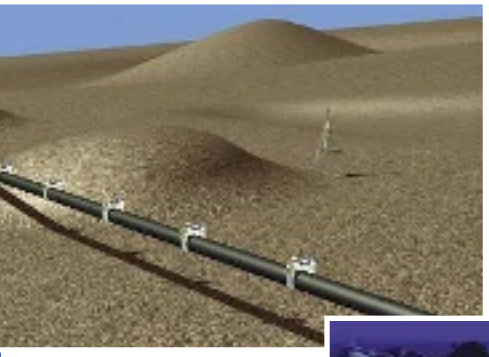
To meet the project schedule, Bjørge selected the low power Zmobile platform from Schmid Engineering, based on the Blackfin processor with mixed signal and communication features. Blackfin provides both mcu and signal processor functionality in a unified core, combining a dual MAC signal processing engine with a risc like microprocessor instruction set and single instruction, multiple data (SIMD) capabilities. This architecture provides the platform for the workload of distributed acoustical processing and analysis.

"The use of embedded electronics is growing as the need for calculation performance and ease of control increases," explained Analog Devices', marketing manager for industrial markets, Anders



Fredricksen. "Customers want to monitor more data whilst consuming the lowest amount of power possible – all at the lowest cost. Embedded processing is starting to appeal to more challenging environments like subsea applications, where divers working in extremely dangerous conditions is time consuming and expensive."

Synchronised measuring points called clamp sensor packages (CSPs) are mounted directly onto the 30in diameter pipeline at regular intervals by a remote operated vehicle (ROV), recording vibrations along three axes of direction. A watertight 'pod' – containing electronics, batteries, sensors and antennas – is then mounted on top using a locking mechanism to enable battery replacement. The CSPs are controlled by an inertial master sensor package (MSP) installed on the seabed. This also records water currents, salinity, temperature and pressure for complete characteristics. The links between CSP and MSP units are wireless through acoustic modems.



Both the MSP and CSP hardware rely on Schmid's Embedded Zbrain system toolbox. This modular solution is based on the Blackfin processor and programmed using LabVIEW Embedded Module for Blackfin. The low power, mixed signal board ZMobile serves as the main platform for the pipeline monitoring system.

"By using a code intelligent metering system of smart sensors positioned every 50 to 100m along the pipeline, Bjørge's system engineers can detect irregular movement and, if necessary, shut off the supply of gas to prevent leakage," continued Fredricksen. "They can program the systems remotely from the surface or from the ROV. The system performs data logging and measures the transfer of gas in the pipeline. If the flow changes between nodes, then there could be leakage at some point. Pipeline movement adds another dimension to the way sophisticated data analysis is performed."

Power management

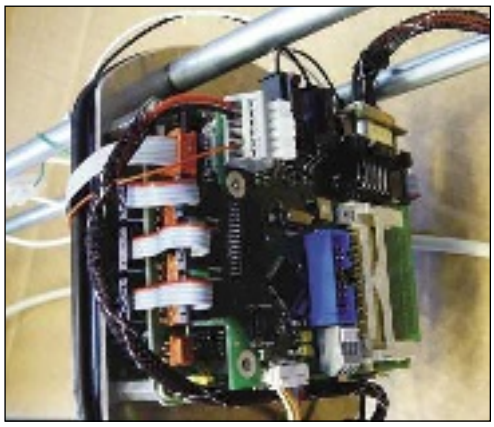
The Blackfin processor's power management capability was another deciding factor for Bjørge as the sensors at the core of its monitoring system are required to perform for up to six months on a single battery charge.

"All the nodes for the measuring systems are battery driven, so reducing power consumption was a big factor," Fredricksen noted. "Each measuring node performs sophisticated analysis on the current flowing through the pipe. In a very short time, the node needs to create a calculation, transmit the data and then switch off or 'sleep' to save power."

Full support for the graphical embedded system design approach, using LabVIEW Embedded was a key requirement as it helped the system engineers to focus on the application, rather than details like device drivers and system services. Therefore, the project presented an opportunity for Schmid Engineering to provide a real life test bench, using its Zbrain board support package (bsp) for LabVIEW. With the ideas, suggestions and test feedback from Naxys, the bsp matured continuously throughout a rapid development time.

"Bjørge wanted a solution where its system engineers could easily monitor and change variables," Fredricksen agreed. "LabVIEW Embedded was chosen to support Blackfin as it provides the high level embedded solution to lock and keep track of the data sets. Each embedded module is linked to the Zbrain bsp for LabVIEW, which meant that from an applications perspective, they had a 'plug and play' methodology to build up a robust and flexible system."

The pipeline monitoring system has a lifetime of several years and will be submerged for at least six months at a time. Therefore, the highest demands are placed on hardware and software reliability, in program error handling and efficient energy management. Fredricksen says the whole development process took less than six months and that Bjørge has now completed successful testing using 50 sensors located on the seabed.



"This development project proves that Blackfin has the power versus cost versus performance to enable users to perform sophisticated measurements."

Anders Fredricksen, **Analog Devices**

"This development project proves that Blackfin has the power versus cost versus performance to enable users to perform sophisticated measurements," Fredricksen concluded. "I have no doubt that Naxys will deploy this technology in other gas fields because it helps to reduce their costs and is more environmentally friendly as it helps to prevent leakage of the process into the sea. I can see measurement systems like this becoming the standard."