USING GIS TO FIND TRANSPONDER SITES ALONG PIPELINE ROUTES

LBL Array for Hostile Topography

The unique seabed topography of oil & gas field 'Ormen Lange', in the North Sea near Norway makes it very difficult to design pipeline routes and associated structures in compliance with the strain and fatigue criteria governed by physical properties of construction materials, installation method and their interaction with the seabed. Despite substantial pre-lay intervention the pipelay corridor remained very narrow and positioning accuracies were required beyond the capabilities of vessel-borne (aided) sub-surface positioning systems.

The installation tolerance described above, in combination with rugged terrain, presents a special challenge to the planning of sites for any acoustic positioning transponder which must be 'seen' from the pipeline routes. In the five-year project 'Norsk Hydro Ormen Lange' (2003 to 2008) four companies, Hydro ASA, Campus Marine, Aquadyne and iSURVEY, are using their combined resources to use GIS to design Long Baseline arrays for the pipe-route intervention sites and template areas. GIS is also being used to provide survey and construction vessels with the information they need to make decisions about positioning operations. Designing an LBL array requires a compromise between maximising survey accuracy and minimising installation cost. Given a flat seabed, other complicating factors are water depth, acoustic range, varying sound velocity and position update rates. For Ormen Lange, finding any line-of-sight over a practical distance is the primary challenge.

Nearshore Work
BjÃ¸rnsund is characterised by a narrow, 250-metre wide, steep-sided gap with 120-metre high walls, through which all seven pipe-routes will run. Hydro ASA has a comprehensive high-resolution DTM model of the seabed topography along the pipeline routes. A preliminary estimate of how many acoustic positioning devices were required was made with the help of paper charts. Seabed topography was shown as shaded relief image, together with planned pipeline routes and depth contours. Positioning solutions for BjÃ¸rnsund were given high priority due to work starting early in the 2004 season. Array planning went ahead using the DTM model and Golden Softwareâ€™s graphic software, Surfer. The positioning challenge in BjÃ¸rnsund was often repeated in the deepwater area: in places where cross-line accuracy was critical, corridor restrictions made it impossible to find transponder sites far enough away from either side of the route to give good angles of cut.

Acoustic Gates
A succession of positioning 'gates' with a pair of transponders either side of the routes were planned for BjÃ¸rnsund. The maximum distance between transponders was 600m, based on the range of EHF acoustics. This meant that four transponder sites could be calibrated and adjacent sets of four had at least one common 'gate'. Surfer's general-purpose software was adequate for planning on this basis, but the product did not have enough mapping tools to make the process efficient. At this time, proposed sites were being passed on to Hydro ASA, who used ESRI's ArcGis to perform more advanced analyses using ArcGis 3D Analyst, Spatial Analyst and ArcScene to present the information and illustrate potential 'coverage' of the pipe routes. During deployment of the transponders at the designated sites it was found that the current in BjÃ¸rnsund had swept the rocks free of sediment and a smooth 'mound', as shown in the high-resolution DTM data, could represent untenable boulders or rock outcrop. This phenomenon also occurred with the large, sharp slide-blocks found in the deepwater area. It created the additional challenge of finding a feasible location in the immediate vicinity using the marginally suited optical sensors fitted to the ROV. How this problem, first experienced in the BjÃ¸rnsund area, was remedied is further detailed in the paragraph headed 'Year of the Users'.

Deepwater Lessons
The Storegga slide area is characterised by a series of 'steps' descending from 220 metres to 630-metre depth along 4,000 metres of the route. The array-design challenge here was to minimise the number of transponders in the LBL arrays in areas where seabed topography dictated narrow pipeline routes, while still being able to measure two-way ranges between transponders for calibration purposes. Sonardyne International Ltd assisted by planning the first LBL arrays in the slide area; this allowed survey vessels to install the transponders and find out what practical problems were involved. Sonardyne also worked with ArcGIS. The most useful util-ity within ArcGIS was found to be the application called Viewshed, designed to calculate best sites for mobile phone base stations. This utility

utilises DTM data to calculate which parts of the DTM model can be 'seen' from one or more observation sites. The areas in view (coverage) can be visualised by colour-coded layers and overlaid on a surface-relief map. In the Ormen Lange application an observation site can be a point on a pipeline route or a transponder location.

Template Installation

The defining event of 2005 was the successful installation of three structures (Templates A & B and a PLET bottom structure) in the deep water at the gas field. LBL Acoustics accomplished positioning to high tolerance. Azimuth control was by gyros backed up by LBL acoustic transponder baselines on each structure, one transponder in each corner. Each corner of the structures could 'see' at least three transponders. The transponder array diameter was reduced to around 350 metres because the installation site is situated on a topographical 'dome'. LBL positioning commenced when the structures were 30 metres above the seabed and continued until full penetration was achieved. A PLET structure was installed after Template B, so some of the array transponders lay in the 'shadow' of Template B as seen from the PLET.

The Viewshet application allowed for detailed pre-installation analysis of the site and these graphical expressions came into general use during array planning, as the GIS was used to model transponder visibility at different stages of the operation. During this process it was found that extensions would have to be made to raise the transponders on the structures by one metre. This allowed acoustic line-of-sight to extend at least 10Â° below the horizontal, clearing the outlying parts of the structure to enable ranging to the nearest transponders, even at 30 metres above touch-down. Installation and calibration techniques were reviewed with the aid of the DTM model. At Template B, inter-visibility among all array transponders was impossible due to the 'dome' topography. A proposal was accepted to install temporary transponder sites to link smaller arrays together by common baselines.

Year of the Users

Experience of transponder installation in 2005 showed that the planned transponder positions were not always ideal. Relocating the transponder using ROV visual had been time-consuming and the sight nearby would not necessarily fit with the rest of the array. At the start of 2006, survey installation vessels used results of the GIS analysis to aid the selection of alternative sites, should the planned site prove untenable. In some deepwater areas (600 to 800 metres depth) planned pipeline routes often could not avoid passing over slide-blocks that needed excavation or rock-dumping intervention. Consequently installation tolerances of Â±2.5m cross-line accuracy were specified at the intervention sites without the ability to install redundant LBL coverage.

iSURVEY surveyors used Grontmij's MOVE3 network-analysis software and recent experience of position-line propagation within the arrays to work out what accuracy could be expected at each observation point using a sparse array. The graphical error ellipses from this analysis were overlaid on the GIS illustrations. The iSURVEY/Aquadyne/Campus team now used the GIS to batch-produce illustrations of array coverage and predicted positioning accuracy at 50-metre observation points along the routes. The information was included in the 'Contractors' Work Instructions to Surveyors' on the array-installation and pipe-laying vessels. The online surveyor has advance warning of poor positioning accuracy and, using a GIS read-only package, he or she can get an instant view of the geometry of the LBL array around any selected observation point.

Future Plans

Swath data is now routinely collect-ed as part of pre-route and shallow seismic surveys and is therefore more widely available to enable this kind of pre-planning of LBL operations. Pre-planning can be viewed as a low-cost risk reduction exercise; it ensures optimal deployment and subsequent operation of LBL systems. The fact that a GIS can import files from most graphics packages, store data attributes, apply advanced geostatical analysis and build up layers of information meant that users in different workplaces could add information to a common database. In this project, team members contributed from London, Oslo, offshore North Sea and Perth (WA) so that work could meet required deadlines. It is also possible to transfer to the GIS and attach to existing positional details of sites technical information concerning hardware populating transponder sites. Three-dimensional surface visualisation files from the individual observation points can be merged so that a user can click on any point on the pipeline route and bring up information about all transponder sites in view. Users of the Ormen Lange project are now able to use a web-based server to display all relevant information available in the database.