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Geographic Information System Based Multi-Criteria Subsea Pipeline Route Optimisation

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Abstract : The use of GIS as an analysis tool for engineering decision making is now best practice in the offshore industry. GIS enables multidisciplinary data integration, analysis and visualisation which allows the presentation of large and intricate datasets in a simple map-interface accessible to all project stakeholders. Presenting integrated geoscience and geotechnical data in GIS enables decision makers to be well-informed. This paper is a successful case study of how GIS spatial analysis techniques were applied to help select the most favourable pipeline route. Routing a pipeline through any natural environment has numerous obstacles, whether they be topographical, geological, engineering or financial. Where the pipeline is subjected to external hydrostatic water pressure and is carrying pressurised hydrocarbons, the requirement to safely route the pipeline through hazardous terrain becomes absolutely paramount. This study illustrates how the application of modern, GIS-based pipeline routing techniques enabled the identification of a single most-favourable pipeline route crossing of a challenging seabed terrain. Conventional approaches to pipeline route determination focus on manual avoidance of primary constraints whilst endeavouring to minimise route length. Such an approach is qualitative, subjective and is liable to bias towards the discipline and expertise that is involved in the routing process. For very short routes traversing benign seabed topography in shallow water this approach may be sufficient, but for deepwater geohazardous sites, the need for an automated, multi-criteria, and quantitative approach is essential. This study combined multiple routing constraints using modern least-cost-routing algorithms deployed in GIS, hitherto unachievable with conventional approaches. The least-cost-routing procedure begins with the assignment of geocost across the study area. Geocost is defined as a numerical penalty score representing hazard posed by each routing constraint (e.g. slope angle, rugosity, vulnerability to debris flows) to the pipeline. All geocosted routing constraints are combined to generate a composite geocost map that is used to compute the least geocost route between two defined terminals. The analyses were applied to select the most favourable pipeline route for a potential gas development in deep water. The study area is geologically complex with a series of incised, potentially active, canyons carved into a steep escarpment, with evidence of extensive debris flows. A similar debris flow in the future could cause significant damage to a poorly-placed pipeline. Protruding inter-canyon spurs offer lower-gradient options for ascending an escarpment but the vulnerability of periodic failure of these spurs is not well understood. Close collaboration between geoscientists, pipeline engineers, geotechnical engineers and of course the gas export pipeline operator guided the analyses and assignment of geocosts. Shorter route length, less severe slope angles, and geohazard avoidance were the primary drivers in identifying the most favourable route.

Keywords : geocost, geohazard, pipeline route determination, pipeline route optimisation, spatial analysis
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