GIS: THE KEY TO SUCCESS IN SUBMARINE PIPELINE ROUTING

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ABSTRACT

Various tools and techniques are used to ensure the maximum safety of the submarine pipelines. However, the resulting consequence of these tools and techniques is the ever increasing data volumes, with the management and subsequent analysis of the data becoming more and more of an issue. The objective of this paper is to elaborate the implementation of GIS technology for submarine pipeline routing design evaluation. With GIS, various routing criteria could be taken into consideration to identify the Least Cost Path (LCP) of the pipeline analytically, precisely and efficiently. Examples of these criteria are vessel anchoring, discarded objects left on the seabed, seabed irregularities, wave characteristics, subsurface current & pressure, hydrodynamic forces and soil stability.

Keywords: submarine pipeline, routing & GIS

1.0 INTRODUCTION

Submarine pipelines play the important role in offshore hydrocarbon transportation. Various tools and techniques are used to ensure the maximum safety of the submarine pipelines. The resulting consequence of these tools and techniques is the ever increasing data volumes, with the management and subsequent analysis of the data becoming more and more of an issue (Rasmussen, 1998). Pipeline engineers have to take times in order to analyse these datasets for decision making from several separated systems where these datasets are stored in. Evidently, this is inefficient to the industry and even worse is that analysis results may not be accurate as the required information is not integrated.

To overcome this problem, the conventional Database Management Systems (DBMS) are not practical as most of these datasets are geographically references. As the solution, this paper attempts to elaborate the implementation of GIS technology for submarine pipeline routing design evaluation.

2.0 LEAST COST PATH ANALYSIS

The principal objective of submarine pipeline routing design is to maximizing the safety of the pipeline whilst incurring minimum life cycle costs. Ideally, the pipe route should be selected to minimize forces of possible soil movement on the pipeline and avoid any hazardous conditions which may occur along the pipeline route (Mousselli, 1981). To do so, submarine pipeline routing design requires careful examination and analysis of hydrodynamic stability, soils liquefaction, seabed irregularities, vortex-induced oscillations and so forth.

GIS is explicitly designed to determine the most preferred route considering the myriad of complex spatial interactions (Glasgow, et. al., 2004). The Least Cost Path (LPC) analysis is specially created to generate a new grid representing the shortest route between two selected destinations. In general, there are three main steps in LCP analysis, which consists of Discrete Cost Map (DCM), Accumulated Cost Map (ACM) and Optimal Route (OR) as shown in Figure 1.

The first and critical step in LCP analysis is to establish the relative 'goodness' for locating a pipeline at any grid cell in a project area (from SpringField platform to AutumnField platform). The individual map layers are calibrated from the best to the worst conditions for a pipeline routing. In turn, the calibrated maps are weight-averaged to form logical groups of criteria. Finally, the group maps are weight-averaged to derive a Discrete Cost Map (DCM).

In the second step, ACM uses a propagating wave-front from a starting location to determine the least "cost" to access every location from SpringField platform to AutumnField platform. It is analogous to tossing a rock or stick into a pond with the expanding ripples indicating the distance away. In this case however, the computer moves one "ripple" away from the start and incurs the cost indicated on the discrete cost map. As the expanding ripples move across the discrete cost map, an ACM is developed by recording the lowest accumulated cost for each grid cell. In this manner the total "cost" to construct the preferred pipeline from the starting location to everywhere in the project area is quickly calculated.

The bowl-like nature of the accumulated cost map is exploited to determine the Optimal Route (OR*)* from from SpringField platform to AutumnField platform. By simply choosing the steepest downhill path over the surface the path that the wave-front took to reach the end location is retraced. By mathematical fact this route will be the line having the lowest total cost connecting the start and end locations. Note that the route goes through the two important "passes" that were apparent in both the discrete and accumulated cost maps.

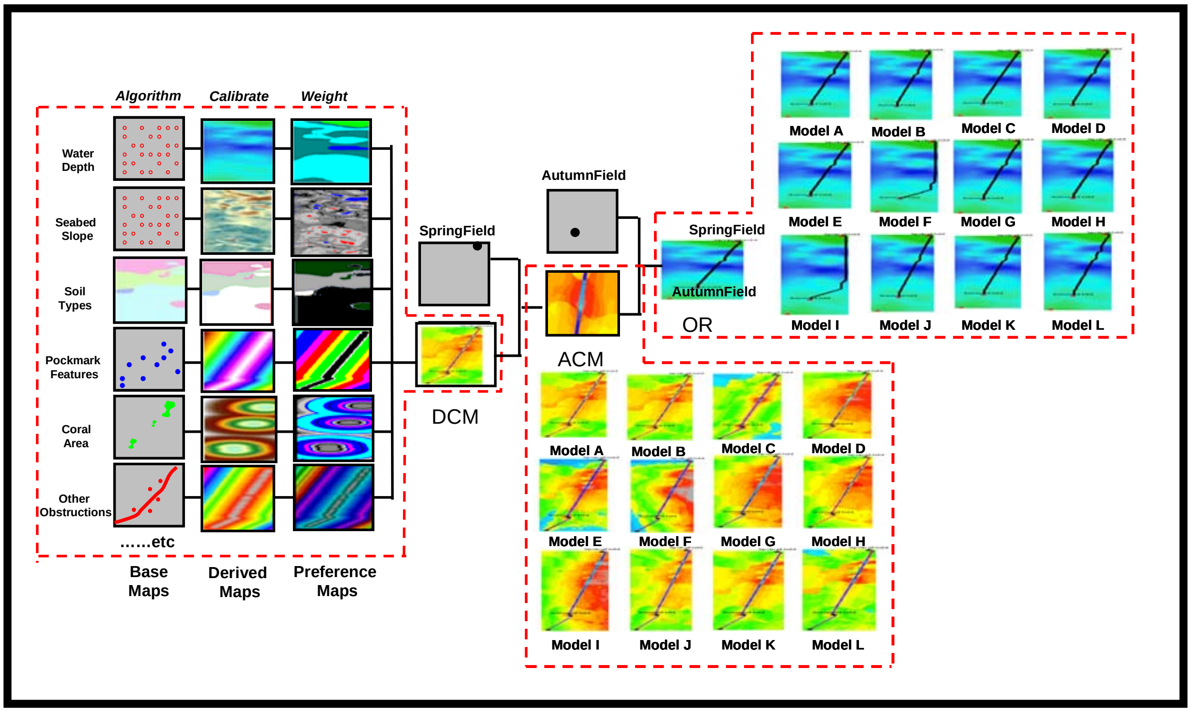

Figure 1 Least Cost Path Analysis

3.0 LCP FINALIZATION

To ensure the maximum safety of the pipeline, various ACM have been generated with its distinct weighting rate. However, only the best route among these proposed LCPs would be selected to install the pipeline in the final stage. Hence, these LCPs would be prudently evaluated with several geoanalytical analysis as illustrated in Figure 2.

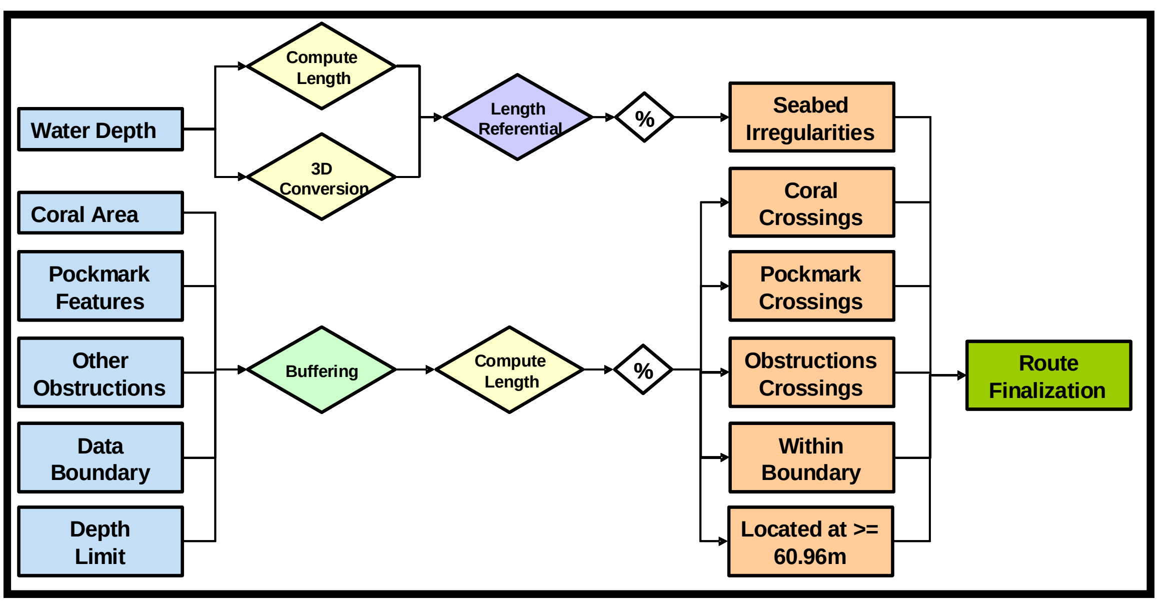

Figure 2 Methodology of LCP Finalization

To precisely finalize the reliability of these LCPs, various buffering are made to the hazardous objects (e.g., coral areas, pockmark features, soil types and so forth) and ‘clipped’ the buffering result with the LCPs, to compute the length of a particular LCP across these harmful objects. The computed lengths are then being classified into a common scale (1 to 10) by giving the highest value (10) to the most suitable LCP.

Table 1 LCP Finalization

Route Name / Crossing Length (%)	Actual Size	Buffer 5m	Buffer 10m	Buffer 50m	Buffer 100m	Buffer 500m	Class
Route A	0.15	0.38	0.65	4.81	9.9	80.7	1
Route B	0.14	0.35	0.6	4.70	9.86	79.1	6
Route C	0.07	0.19	0.39	4.06	10.23	89	7
Route D	0.14	0.35	0.59	4.66	9.58	78	10
Route E	0.14	0.35	0.6	4.61	9.61	79.6	8
Route F	**Excluded**						
Route G	0.14	0.35	0.6	4.74	9.4	78.1	9
Route H	0.14	0.35	0.61	4.69	9.58	79.1	5
Route I	**Excluded**						
Route J	0.14	0.36	0.63	4.76	9.53	80.6	4
Route K	0.14	0.36	0.63	4.76	9.74	80.6	3
Route L	0.17	0.44	0.75	5.87	11.54	75.6	2

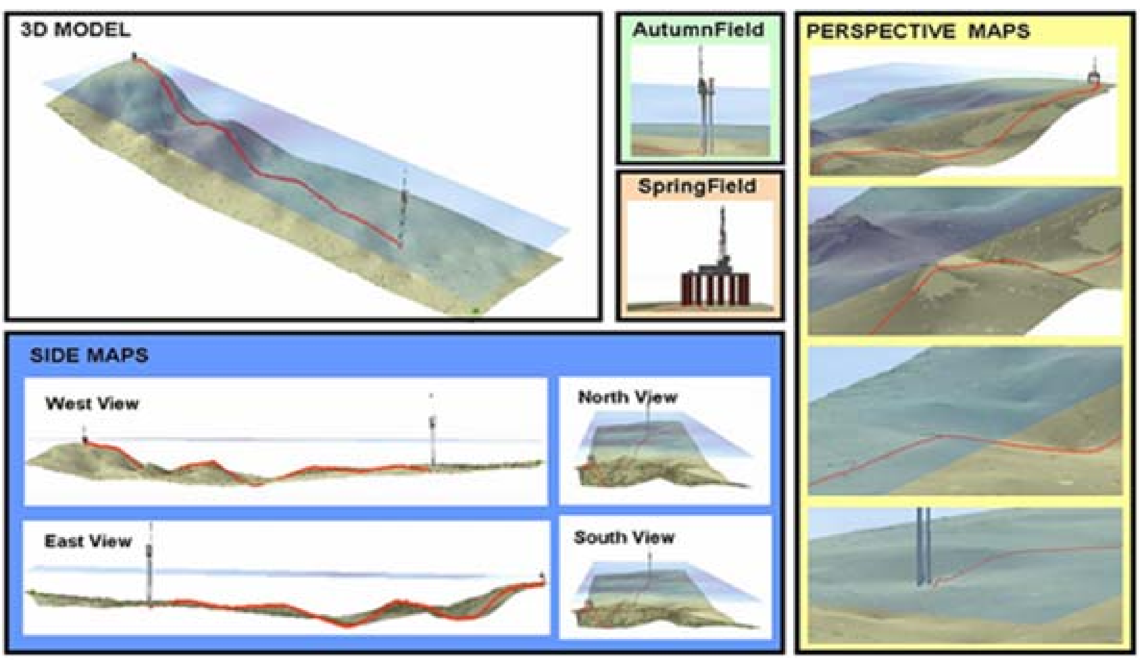

Figure 3 3D Model of the finalized LCP-Route C

Table 1 summaries the route assessment classification for each LCP. The best LCP can be simply identified by total up the classification value from each evaluation factor. The average accumulated value of all LCPs is 53.5 points where Route L has the worst result with the lowest value of 43 points, and Route C holds the highest score for 62 points. Consequently, Route C has been selected as the final path to install the proposed pipeline from SpringField platform to AutumnField platform as illustrated in Figure 3.

4.0 CONCLUSION

Submarine pipeline engineering is a complicated business, which requires high precision assessment of all potential hazardous conditions to ensure the maximum safety of the pipeline during its operation lifetime.

GIS has proved its capabilities as much more valuable tool than merely as a database and mapping platform in submarine pipeline engineering through this study. Efforts should be made so that this valuable tool could bring maximum benefit of Asset Integrity Management (AIM) to the offshore industry. Meanwhile, encouragement should also be made to enhance the application of GIS into other extensibilities in offshore engineering, such as offshore platform and windfarm design.

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