Fugro GeoConsulting Limited

Submarine Slope Instability Assessment Using Spatial Analyst Tools

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ESRI Petroleum User Group Conference
Houston, 19th April 2011
Outline

- Background
  - Shallow slope instability geohazard
  - Risk to development

- Shallow slope failure assessment
  - Engineering methods
  - Application over large development areas
  - GIS-based assessment
  - The “Ground Model”

- Results

- Conclusions
Shallow slope instability

- Hazards associated with shallow slope instability
  - Down-slope mass movement impacting facilities
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- Potentially causing...
  - Spanning
  - Buckling
  - Structural Failure (above seabed)
  - Lateral translation and failure of foundation (below seabed surface)
Shallow slope instability…risk?

- Does this geohazard pose a risk to sub-sea facilities?

- Consequences are potentially high:
  - Cost to project
  - Human life
  - Environmental damage

- But, before considering risk management options…
  - Accept
  - Avoid
  - Mitigate
  - Transfer

  …a full understanding of the geohazard is required
Many established methods exist for the quantitative analysis of slope instability likelihood:

- Conventional method of slices (e.g. Bishop)
- Infinite Slope
- Two-wedge model (Nadim et al., 2003)
Slope Stability Analysis – Application
**GIS Slope Stability Analysis - Method Description**

**General Principle**
- Use GIS spatial analysis techniques to perform numerical mapping
- Algebraically combine raster surfaces for different input parameters to calculate result
- Historically, depth variation of mapped input parameters (e.g. soil strength) not modelled
- Develop suite of raster surfaces per parameter, defining layer depths and values
- Use GIS to generate the raster files, using soil province attribute data

![GIS Slope Stability Analysis Diagram](image-url)
GIS Slope Stability Analysis – Ground Model

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**Hence full spatial and depth intelligence of ground model harnessed in analysis**
Results and Conclusions

- Example 1D infinite slope equation
  - Safety factor = f {\( \beta \), soil strength, depth, soil weight, horizontal seismic acceleration}

Extract metrics, e.g. proportion of development area at risk

Rapidly build understanding of sensitivity of instability to various known and unknown inputs

Progress to mapping failure probability by linking this to deterministic safety factor via probabilistic analysis
Conclusions

As a spatial analysis tool, GIS allows:

- Assessment on an **extensive geographical scale** (development-wide / regional)
- Whilst retaining **full data resolution**
- **Rapid screening** using simplified geomechanical models, hence **focus for detailed analysis**
- **Repeatable** and **quantitative** output
- **Cost-effective** assessment, allowing unlimited **parametric modelling**
- Estimation of **slide dimensions**, hence informs **consequence** analysis for seabed equipment vulnerability

As a data management tool, GIS allows:

- All ground model inputs to be **organised** and **managed** in a georeferenced system
- **Sharing** of output in industry standard map format with field development collaborators
Conclusions

- Combined as a spatial analysis tool and a data management tool:
  - GIS allows exploitation of full 3D variability of a spatially resolute and complex engineering geological ground model in submarine slope instability analysis

- Risk
  - This method mitigates the risk of wasting data, or not using the full extent of hard-won data to project's advantage, whilst providing input to estimations of seabed instability risk.