INTEGRITY MANAGEMENT SYSTEM FOR THE ULTRA DEEPWATER MEDGAZ PIPELINE

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ABSTRACT

The proposed ultra deepwater MEDGAZ pipeline will traverse the Alboran Sea at a water depth of 2160 metres. The 210 km. long subsea pipeline will connect the Algerian gas network to the Spanish gas grid and will be an important future source of gas supply to the Iberian Peninsula. The paper discusses the architecture and implementation of the Medgaz Integrity Management System (MIMS).

In addition to the subsea pipeline, the MEDGAZ system consists of a compression station at the Algerian shoreline and a gas reception terminal at Almería in Spain. The design of this high pressure gas transmission system has required careful assessment of the integrity management challenges posed by the deepwater environment and cross-border operations. Detailed mapping of the seabed terrain has provided the geo-spatial database which will assist integration of the as-laid pipe database generated during the construction phase. The integrated database will also provide the vital reference information for the periodic internal and external inspections and condition monitoring regimes. Coupled with the gas terminal plant maintenance system, the MIMS system is designed to enable the MEDGAZ operations team to provide a low downtime, highly efficient gas transmission operation. System architecture and implementation methods are described.

The construction phase of the MEDGAZ system is planned to commence during 2006; with first gas scheduled for early 2009.
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1 OVERVIEW OF THE MEDGAZ PROJECT

Medgaz project consists of the following segments:

- An onshore compressor station at Beni Saf, Algeria (BSCS)
- A deepwater 24 inch diameter pipeline across the Alboran sea – descending to a maximum depth of 2155 m and an approximate offshore length of 210 kms
- Reception terminal near Almería, Spain (OPRT)

During Phase 1 of the project, it is envisaged that the east offshore pipeline will be constructed to deliver gas transportation capacity of 8 billion m$^3$/year. The capacity could be doubled to a total of 16 billion m$^3$/year through construction of a parallel 24 inch diameter second offshore pipeline at a future date. Schematic of the pipeline routing is illustrated in Fig. 1.

![Fig. 1 - Medgaz Offshore Pipeline Route](image)

Current ownership structure of the project is shown in Fig. 2

![Fig. 2 - Project partnership structure](image)
2 ECONOMIC RATIONALE

- Iberia’s fast growing energy market poses challenges to the existing infrastructure. Spanish gas consumption has grown from 21.4 BCM in year 2002 to 28.3 BCM in year 2004. It is anticipated that in the year 2011 annual demand will exceed 44 BCM (Fig. 3).

- Manufacturing growth and need to switch to ‘Kyoto Protocol’ friendly fuels is increasing gas demand at 18% compound rate.

- Delays in increasing infrastructure capacity could harm the development of the Iberian energy market in the short to medium term and growth potential of the economy.

- During 2005, the gas demand from CCGTs increased by 66% compared to 2004 consumption due to start-up of a number of gas fuelled power stations (Source: Sedigas).

- Spain is dependent on imports for 99.6% of its gas of which 65% is LNG and 35% is via pipeline. LNG costs have a huge significant price penalty due to liquefaction, sea transportation and re-gasification cost elements; when compared against pipeline gas.

![Graph showing Spanish Gas System Capacity](source:CNE, 2004)

**Fig. 3** – Spanish Gas System Capacity (Source: CNE, 2004)

The Long Run Marginal Cost (excluding producing country royalty) for potential gas supply to Spain has been studied extensively by independent energy consultants. The studies indicate clearly the economic benefits of the proposed MEDGAZ gas pipeline, since this is the lowest cost supply option for Spain (Fig. 4).
3 PIPELINE INTEGRITY MANAGEMENT CHALLENGES

Pipeline integrity management is interpreted by Medgaz as cohesive business strategy to ensure defect free long-term performance of the transportation system. The inherent technical challenges to achieve this target are spread over distinct phases:

- Design
- Construction
- Operation

The following subsections describe the approach adapted by Medgaz to deliver integrity of the gas transportation system being planned.

3.1 MANAGING DESIGN INTEGRITY

**Design of the Marine Pipeline**

To ensure design integrity a structured approach is required which will take into account of the following elements:

- Routing alternatives
- Geophysical and geohazard characterization of seabed and underlying strata
- In-service loading
- Construction/installation assessments

The routing alternatives are assessed for the following factors:

- Minimisation of environmental impact
- Protection of marine flora/fauna on the offshore and onshore sections on the Algerian and Spanish sides
- Avoidance of natural obstacles that exist along the route
- Low geological and geotechnical risks
- Minimization of “free-span” risks

Medgaz has developed a Geographical Information System (GIS) database of all survey data to ensure integrity and consistency of bathymetry charts, geophysical and geological characteristics and flora/fauna data. The general bathymorphology of the pipeline route is shown in Fig. 5.

![Fig. 5 - Bathy-Morphological Characteristics of Pipeline Route](image)

The pipeline route and details of the slopes along the route are presented in Fig. 6.

![Fig. 6 - Pipeline route Features and Slopes](image)
Fig. 7 depicts a clip of the video images for the benthic sampling operations being performed in water at a depth of 1300m along the proposed pipeline route.

**Fig 7 - Benthic Sampling at 1300m**

**Geohazard Evaluations**

Based on known characteristics of the pipeline route and information available from surveys, detailed geohazard assessments were performed to ensure the proposed pipeline route avoided significant geological and seismic risks. These assessments included:

- Geophysical interpretation;
- Probabilistic Seismic Hazard Assessment (PSHA);
- Slope stability assessment;
- Probabilistic Fault displacement hazard analysis;
- Numerical runout modeling;

Calculations were performed to assess the integrity of the pipeline under geohazard-type extreme failure events. The events covered included:

- Fault slip - reverse, normal and strike slip, fault movement.
- Slope failure - failure of the steeper slopes resulting in loss of support to the pipeline.
- Mass sediment movements (turbidity flow and mud slide events) - impact of a fast-moving dense flow on the pipeline.

The objective of these calculations was to verify the integrity of the pipeline, thereby ensuring pipeline survival during these extreme events.

**Design Code Governance**

Medgaz pipeline has been designed to comply with the internationally known code DNV OS-F101 which lays down detailed guidelines for assessing loads and response of the pipeline for design, installation, in-service and extreme load scenarios. Extensive material and prototype testing has been performed to demonstrate adequate design safety margin for the various loading scenarios. A typical output from FEA analyses is shown in Fig. 8.
Technical challenges for installing pipelines safely in deepwater environment are vividly illustrated in Fig. 9.
3.2 MANAGING CONSTRUCTION INTEGRITY

After the design integrity has been evaluated, managing construction integrity requires a host of complementary Information Technology systems to enable quality control of the pipeline construction process. Fig. 10 represents the traditional approach undertaken to oversee construction integrity. The traditional systems have posed the following challenges:

- Disjointed survey information and CAD information resulting in lack of simulation and accuracy
- Requirement of manual correlation of data at all stages - planning, construction and maintenance
- Lack of centralized data resulting in sub-optimal collaboration between survey, engineering, construction and repair/maintenance
- Lack of project data flow between various applications from GIS, CAD, ERP, SRM and other applications

Integrated CAD-GIS Applications

To ensure efficient utilization of design data and associated GIS database an integrated CAD-GIS system is being developed for Medgaz application. Fig. 11 and associated Table 1 depict the logic flow in integrated GIS-CAD system.
Table 1 – Sample workflow in MIMS

<table>
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<th>Step</th>
<th>Phase</th>
<th>Data Flow</th>
<th>Key Process</th>
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<td>1</td>
<td>Design</td>
<td>GIS DTM to CAD Model</td>
<td>Conversion of GIS survey data from GIS Application to CAD 3D application</td>
</tr>
<tr>
<td>2</td>
<td>Design</td>
<td>2D GIS and 2D CAD</td>
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<td>Design</td>
<td>3D Pipeline position and positioning simulation in CAD-GIS</td>
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<td>4</td>
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<td>Pipe segment information to Pipeline Data Model (PDM)</td>
<td>Creation of data model and mapping between Euro Pipeline format into Data model of the MIMS PDM database</td>
</tr>
<tr>
<td>5</td>
<td>Design</td>
<td>Integration between CAD/GIS 3D Model and MIMS PDM</td>
<td>Integration of parameters between Pipeline parameters, CAD/GIS 3D model into MIMS PDM database based on the data model in Step 4</td>
</tr>
<tr>
<td>6</td>
<td>Construction</td>
<td>‘As designed’ pipeline layout on seabed</td>
<td>Creation of Construction view with corresponding changes to the CAD/GIS 3D model and MIMS PDM data model parameters</td>
</tr>
<tr>
<td>7</td>
<td>Construction</td>
<td>Pipeline component database</td>
<td>Population of MIMS PDM database with actual construction parameters</td>
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<tr>
<td>8</td>
<td>Construction</td>
<td>‘As built’ database</td>
<td>Re-population of MIMS PDM database with ‘As built’ data</td>
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<td>MIMS update</td>
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**Medgaz Integrity Management System (MIMS)**

MIMS is the central knowledge based information and decision making system that Medgaz will utilize extensively for the construction and operation phases. Fig. 12 depicts the proposed Medgaz integrated dataflow from design to construction and from construction to operation. This data model is being designed to support efficient operations and risk management for the Medgaz transportation system.

![Fig. 12 – Architecture of Medgaz Integrity Management System](image)

### 3.3 LONG TERM OPERATIONAL INTEGRITY

With respect to the long term operational integrity, MIMS data model will have the capability to capture and present different views of pipeline data acquired during all phases of the project to date. This ensures that the Medgaz operations team can use MIMS as a holistic tool to plan inspection strategies and to populate the MIMS database with new data acquired from internal and external pipeline survey campaigns to maximize uptime of the pipeline.
4 OVERALL MEDGAZ IT ARCHITECTURE

The central role of MIMS is shown in the following Fig. 14 depicting the overall IT architecture.
5 DISCUSSIONS

A leading pipeline integrity service provider has claimed that implementing a pipeline integrity data management could lead to operational savings of 10 - 20% on annual pipeline maintenance budget. The planned implementation of MIMS is expected to offer similar savings through guaranteed uptime and risk reduction in the operation of the proposed deepwater pipeline system.

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- Table 1 – Sample workflow in MIMS

6.3 ABBREVIATIONS

BSCS : Beni Saf Compressor Station
OPRT : Offshore Pipeline Receiving Terminal
BCM : Billion Cubic Metres
DnV OS : Det Norske Veritas Offshore
FEED : Front End Engineering Design
EIA : Environmental Impact Assessment
FID : Firm Investment Decision
ROW : Rights of Way
SAWL : Submerged Arc Weld Longitudinal
LP : Low Pressure
HP : High Pressure
LRMC : Long Run Marginal Cost
KP : Kilometre Point
MCM : Million Cubic Metres
MBTU : Million British Thermal Units