The Undersea Malta-Gozo Tunnel Project: geophysical investigations


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Summary

• Malta-Gozo Tunnel

• Targets and Geology

• Activities: MBES bathymetry, HR seismic, MCS, Airborne, VSP

• Data examples
Malta-Gozo Tunnel

• **1972** first preliminary survey report on the link between Malta and Gozo.

• **2012** Economic assessment: existing traffic, traffic projection, socio-economic impact on Malta and Gozo, tolls, etc.

• **2012** The geology of the project area is potentially complex, with evidence of extensive faulting, and is not well documented. A detailed geological and geotechnical investigation is required to determine the optimum tunnel alignment, tunnel form, cost and construction methodology.
Targets

Improvement of the geological model along the projected tunnel alignment

1) Faults:
location, displacement

2) Blue Clay Formation:
location, thickness
Geology of Malta
Offshore study area area
Performed activities

1- Faults mapping:
   Bathymetry (Multibeam - MBES)
   Offshore Very High Resolution Reflection Seismic – (VHRS)
   Offshore Multichannel Reflection Seismic (MCS)
   Airborne survey

2- Blue Clay mapping:
   Offshore Multichannel Reflection Seismic (MCS)
   Onshore seismic (VSP and refraction)
MBES survey

Multibeam Reson Seabat 7125

- Model: Seabat 7125 SV2
- Frequency: 200 & 400 KHz
- Swath: 140° (extended 165°)
- Beam: 512
- Maximum Range: 500 m
- Maximum operative depth: 400 m
- Maximum operative speed: 12 knots
- Maximum Resolution: 6 mm
- Acquisition Software: Reson PDS2000

Motion Reference Unit
TSS MAHRS

DGPS Trimble DSM232

Sound Velocity Probe
Reson SVP71

Software Reson PDS 2000
Data acquisition
## VHRS survey (Boomer)

### AA301 TECHNICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Applied Acoustic Engineering</td>
</tr>
<tr>
<td>Model</td>
<td>AA301</td>
</tr>
<tr>
<td>Frequency Range</td>
<td>400-4000 Hz</td>
</tr>
<tr>
<td>Size</td>
<td>62x52 cm, 25 kg</td>
</tr>
<tr>
<td>Pulse length</td>
<td>200 microS depending on energy setting of CSP</td>
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<tr>
<td>Energization rate</td>
<td>3 Hz</td>
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<tr>
<td>Maximum energy</td>
<td>1050J/s - 350 J/shot</td>
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<tr>
<td>Operating voltage</td>
<td>3600 to 4000 V</td>
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<tr>
<td>Power supply unit</td>
<td>CSP-Nv 2400</td>
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</table>
VHRS data

Acquisition map

Seismic section (time)
# MCS data acquisition

## Acquisition Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
<td>Mini GI-GUN Sercel</td>
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<tr>
<td><strong>Streamer</strong></td>
<td>Geometrics Geoel</td>
</tr>
<tr>
<td><strong>Recording</strong></td>
<td>Geometrics CNT-1</td>
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<tr>
<td><strong>Array</strong></td>
<td>1 x 60 cu.in (11)</td>
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<tr>
<td><strong>Length</strong></td>
<td>300 m</td>
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<tr>
<td><strong>Sampling rate</strong></td>
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<td><strong>Gun Mode</strong></td>
<td>30G+30I Harmonic</td>
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<tr>
<td><strong>Ch. No.</strong></td>
<td>96</td>
</tr>
<tr>
<td><strong>Record length</strong></td>
<td>2 sec</td>
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<tr>
<td><strong>Shot Interval</strong></td>
<td>15.625 m and 18.75 m</td>
</tr>
<tr>
<td><strong>Ch. Dist.</strong></td>
<td>3.125 m</td>
</tr>
<tr>
<td><strong>LC filters</strong></td>
<td>3 Hz (LC)</td>
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<tr>
<td><strong>Depth</strong></td>
<td>1.5 m ± 0.5 m</td>
</tr>
<tr>
<td><strong>Min off.</strong></td>
<td>2 m ± 0.5 m</td>
</tr>
<tr>
<td><strong>HC filters</strong></td>
<td>Antialias</td>
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<tr>
<td><strong>Pressure</strong></td>
<td>140 atm</td>
</tr>
<tr>
<td><strong>Max off.</strong></td>
<td>312.5 m</td>
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<tr>
<td><strong>Controller</strong></td>
<td>RTS Sure Shot</td>
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<tr>
<td><strong>Max fold</strong></td>
<td>9.6</td>
</tr>
<tr>
<td><strong>Aim Point</strong></td>
<td>50 ms delay</td>
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<tr>
<td><strong>Min fold</strong></td>
<td>8</td>
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</table>

## Synchronization

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<td><strong>Controller</strong></td>
<td>RTS Sure Shot</td>
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<td><strong>Max fold</strong></td>
<td>9.6</td>
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<tr>
<td><strong>Aim Point</strong></td>
<td>50 ms delay</td>
</tr>
<tr>
<td><strong>Min fold</strong></td>
<td>8</td>
</tr>
</tbody>
</table>

## Lateral View

- **Stream depth**: 2 m
- **Source depth**: 1.5 m

## Plan View

- **Stream depth**: 2 m
- **Source depth**: 1.5 m

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*Image from TM video*
MCS data acquisition

Lines 106
Spacing 75m
Total kms 236
1) Data Reformatting.
2) Quality control and trace editing.
3) Geometry assignment and water bottom picking.
4) Preliminary velocity analysis -> CDP Sorting -> NMO Correction -> AGC -> Brute stack.
6) Surface Related Multiple Elimination (SRME, water bottom deconvolution).
7) True amplitude recovery.
8) Predictive deconvolution.
9) Final Velocity Analysis.
10) Normal moveout correction.
12) Stack -> FX deconvolution -> Time variant filter -> Amplitude balance -> Final stack output.
13) Post stack time migration -> Time variant filter -> Amplitude balance -> Final migrated stack output.
MCS data example (migrated sections)

Line 106

Line 097
Gas Mapping acquisition

LGR Los Gatos - Ultraportable Greenhouse Gas Analyzer (CH4, CO2, H2O)

Performance Specifications
- Repeatability / Precision (1-sigma):
  - CH4: <2 ppb (1 sec), <0.6 ppb (10 sec), <0.25 ppb (100 sec)
  - CO2: <100 ppb (1 sec), <10 ppb (10 sec), <6 ppb (100 sec)
  - H2O: <100 ppm (1 sec), <35 ppm (10 sec), <15 ppm (100 sec)

- Response Time (flow time through meas. cell):
  - 10 s

- Measurement Range:
  - CH4: 0.01 – 100 ppm
  - CO2: 1 – 20000 ppm
  - H2O: 500 – 70000 ppm

- Operational Range:
  - CH4: 0 – 500 ppm
  - CO2: 0 – 10% (with Extended Range option)
  - H2O: 0 – 70000 ppm

- Outputs:
  - Digital (RS232), Analog, Ethernet, USB

- Data Storage:
  - Internal Solid State Hard Disk Drive

- Ambient Humidity:
  - <80% RH non-condensing

- Operating Temperature:
  - 5 – 45 °C

- Inlet / Outlet Fittings:
  - 1/4” Push-Correct

- Power Requirements:
  - 60 watts (10/30 VDC)
  - 66 watts (115/230 VAC, 50/60 Hz)

- Dimensions:
  - 7” H x 14.5” W x 14” D

- Weight:
  - 15 kg

Off-Axis ICOS (Integrated Cavity Output Spectroscopy)
Gas mapping acquisition
Gas mapping

Survey Area: Flight trajectory

CH4 concentration (ppm)
Target 1: Faults

- Are we able to detect/map faults? 
  Yes

MBES
Bathymetry – sea bottom

HR/boomer
s.b. – 20/50 m below s.b.

Reflection Seismic
s.b. – 500 m below s.b.
Target 2: Blue Clay Formation

- Are we able to detect and estimate the Blue Clay thickness? Yes

Feasibility study: syntethic data

Real data

Blue Clay Formation
Target 2: Blue Clay Formation

- Seismic data need borehole data for validation, calibration and time to depth conversion
Faults mapping – Initial model

Southern sector

Northern sector

From:
Preliminary results – Assessment of road tunnel option between Malta and Gozo
Mott MacDonald, 2012
Real data appear more complex than prognosis!