Testing of the Beagle2 Instrument Arm

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The Beagle2 Mission

- Launch is on Mars Express in June 2003
- Enters Martian atmosphere after 6 months cruise & 5 days coast
- Arrives on Martian surface following parachute decent, airbag bounce and final drop onto the surface
- Target operational life is 180 sols in the ISIDIS basin 11°N, 270°W
- Beagle2 will search for evidence of life on Mars (past & present)
Stowed Configuration
Beagle2 Instrument Arm
Test Environments

- **Vibration Testing**
  - Random vibration - launch on Mars Express
  - Long Duration Shock - air bag bounce
  - Medium Duration Shock - final drop from airbags

- **Thermal Testing**
  - To simulate the extremes of Martian environment

- **Dust Testing**
  - To simulate wind and dust present on Mars

- **Arm Calibration**
  - Arm Calibration
  - DEM generation
  - End to end testing
Vibration Testing
Random Vibration

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>20- 80 Hz</td>
<td>+12dB/oct</td>
</tr>
<tr>
<td>80-120Hz</td>
<td>1.8g^2/Hz</td>
</tr>
<tr>
<td>133-380Hz</td>
<td>0.15g^2/Hz</td>
</tr>
<tr>
<td>400-800Hz</td>
<td>0.030g^2/Hz</td>
</tr>
<tr>
<td>820Hz</td>
<td>0.058g^2/Hz</td>
</tr>
<tr>
<td>820-2000Hz</td>
<td>-3dB/oct</td>
</tr>
<tr>
<td>Overall</td>
<td>13.63g_{rms}</td>
</tr>
</tbody>
</table>
Medium Duration Shock

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-100 Hz</td>
<td>+6dB/oct</td>
</tr>
<tr>
<td>100-1000Hz</td>
<td>400g</td>
</tr>
<tr>
<td>1000-4000Hz</td>
<td>-3dB/oct</td>
</tr>
<tr>
<td>4000-10000Hz</td>
<td>200g</td>
</tr>
</tbody>
</table>
# Long Duration Shock

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>99.9-100 Hz</td>
<td>81g</td>
</tr>
<tr>
<td>Sweep rate</td>
<td>2 oct/min</td>
</tr>
<tr>
<td>No. of cycles</td>
<td>5</td>
</tr>
</tbody>
</table>
# Vibration Testing (normal modes comparison)

<table>
<thead>
<tr>
<th>Mode Number</th>
<th>PFM (test) (Hz)</th>
<th>FEM (Hz)</th>
<th>PFM/FEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>192</td>
<td>194</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>290</td>
<td>273</td>
<td>1.06</td>
</tr>
<tr>
<td>3</td>
<td>322</td>
<td>302</td>
<td>1.07</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>340</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>395</td>
<td>401</td>
<td>0.98</td>
</tr>
<tr>
<td>6</td>
<td>495</td>
<td>476</td>
<td>1.04</td>
</tr>
<tr>
<td>7</td>
<td>549</td>
<td>541</td>
<td>1.02</td>
</tr>
</tbody>
</table>
Thermal Testing
Thermal Testing

4 Thermal Cycles

- Tmax = +30 deg C
- Tmin = -100 deg C
- Functional Test, Amb. Temp
- Functional Test, -40 deg C
- Functional Test, -50 deg C
Thermal Testing Results

FM_Axis2_PositiveDirection

Current (mA)

Functional test @ -50deg C
Functional test @ -40deg C
Functional test @ +20deg C

Angle (º)
Dust Testing

• Pressure = 6.8 to 8.1 mbar CO$_2$
• Wind speed = 4.5 m/s
• Turbulence = 14%
• Dust dose = 63 sol
• Dust accumulation = 18 mg
Dust Testing

Location:
Institute for Physis and Astronomy
Aarhus University
Aarhus 8000C
Denmark
Calibration for Operation on Mars

- Repeatability ± 1mm
- Accuracy to GAP inlet =± 1mm
- DEM generated
- End to end test conducted

(discussed in greater detail by Dave Barnes in another session)
Summary and current status of Beagle2 Instrument Arm

- Vibration tested to cover: launch, airbag bounce, and final drop onto the Martian surface
- Thermal tested to operational and non-operational extremes on Mars
- Dust tested to simulate the typical exposure on the Martian surface
- Calibrated ready for use
- End to end testing completed to cover operation on the surface
- IA sterilised ready for fitment to the lander