The Balloon Lidar Experiment BOLIDE

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PMC Turbo Mission

- NASA long duration balloon
- Six-day flight from Esrange to Canada in July 2018
- 38 km floating altitude

Scientific payload for high-resolution observations of Noctilucent Clouds (NLC)

- Rayleigh lidar BOLIDE
  - Vertical profiling of the NLC layer (79-86 km)
  - Temperature soundings of gravity waves (45-80 km)

- Seven digital cameras for imaging of the NLC layer
Optical System

Laser
- 4.5 W at 532 nm
- 28 deg off-zenith pointing
- 100 Hz pulse repetition frequency
- 1.5 m pulse length

Receiver
- 50 cm telescope with 160 µrad FOV
- Three cascaded detector channels with 0.3 nm wide filters
- Mechanical chopper and filter wheel with ND filters for ground tests
## Instrument Parameters

<table>
<thead>
<tr>
<th>Dimensions</th>
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</thead>
<tbody>
<tr>
<td>Telescope</td>
<td>55 cm x 55 cm x 140 cm</td>
</tr>
<tr>
<td>Pressure vessel</td>
<td>48 cm x 48 cm x 68 cm</td>
</tr>
<tr>
<td>Radiator</td>
<td>175 cm x 100 cm x 8 cm</td>
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<tr>
<td><strong>Total mass</strong></td>
<td><strong>151 kg</strong></td>
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<tr>
<td><strong>Power</strong></td>
<td>28 VDC, 320 W + 220 W bias heaters</td>
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<tr>
<td><strong>Cooling</strong></td>
<td>Glycol loop with radiator</td>
</tr>
<tr>
<td><strong>Telemetry</strong></td>
<td>8 kbit/s</td>
</tr>
<tr>
<td><strong>Onboard Storage</strong></td>
<td>3x 1 TB (30 day flight)</td>
</tr>
</tbody>
</table>

Rack inside the pressure vessel
Design Challenge: Near-space Environment

- Low atmospheric pressure
- Radiative heating and cooling
- Forced convection during ascent, cold tropopause

Not on the ground, not quite a satellite platform, and flies too long for a suborbital rocket – A thermal engineers‘ nightmare

Key design aspects
- A highly efficient radiator to minimize external influences
- Thermal decoupling of instrument and gondola (insulation, radiation shields)
Radiator Design

Backside of radiator without Insulation

- Aluminum sheet
- Cooling channels
- Support structure

Structure back to front

- Active surface:
  - Optical coating FEP 10 mil with VDA

Back side
Front
Thermal Analysis with ESATAN TMS 2017

Model includes
- Solar radiation
- Albedo
- IR radiation
- Thermal radiation from gondola

Geometric model
- Anti-solar pointing gondola
- 1.6 m² radiator at backside of gondola with 40° inclination
Predicted Performance of the Radiator

Target:
Coolant temperature 17°C

Required heat load

**Cold Case**  470 W  
(Local midnight)

**Hot Case**  320 W  
(Local noon)

Temperature can be controlled by powering additional heaters
Predicted Performance of the Radiator

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In-flight Performance

- Radiator is more efficient than anticipated
- Accurate modeling of heat transfer from liquid to wall is difficult
Lidar Performance

Photon Count Profile

Solar Background
Lidar Performance

Simulated background * 2.5

Photon Count Profile

Solar Background

NLC

Simulated
Sun light scattered off the balloon hits the spider of the telescope and is scattered into the optical path of the receiver

-> 2.5 times larger LIDAR background

**Baffle design is important!**
Fantastic Data

Noctilucent Cloud Backscatter Coefficient

10 Jul 2018
Summary

• BOLIDE is the first mesospheric lidar system onboard a long duration balloon
• The instrument obtained vertical profiles of Noctilucent Clouds and mesospheric temperature at high resolution
• Cooling system was more efficient than predicted
• Lidar performed as expected
• Baffle design is important

Mission was a great success!

Survived landing