SpaceMaster Robotics Team
Expanding the Possibilities for Balloon Experiments
Objectives: Building on experience

- Free fall for Microgravity
- Slow Reeling for Sampling Height
- Balloon payload systems

√ reel.SMRT
√ reel.E
√ Cansat
“To investigate a reel system for use on balloon flights to increase the variety of scientific and engineering objectives achievable through high altitude balloon experiments.”
Objectives

- To achieve near microgravity on a balloon payload in a recoverable manner and perform this multiple times.

- To achieve an increased sampling height range for sensors.

- To educate students about the role and potential of balloon based experiments.
**Microgravity**
- Alternative to rockets and parabolic flights
- Allows for high repetition in stratospheric environment

**Increased Sampling Range**
- Allows study of structures present in the atmosphere
- Better control of environmental variables
- Pushes beyond gondola boundary layer influence
System Design
Mission Phases: Freefall Mode

- Free Fall
- Deceleration
- Recovery

FISH

SMRT Payload

50m

Gravity

20m = 1.6 g’s

Tension

SMRT Payload

Free Fall Mode

SMRT Payload

Deceleration

Recovery

SMRT Payload

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Mission Phases: Slow Reel Mode

- Braked descent
- Deceleration
- Recovery
Mech Design Overview

Materials:
- Aluminium
- Fibre Glass

Reel
Line Guide
Electric Engine
Line
FISH

Dimensions:
- 1m
- 0.4m
The Reel

- Spool
- Brake Mechanism for Deceleration
- Bail: Catch Mechanism

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Line: COTS

**PowerPro Spectra**
- Material: Ultra-High Molecular Weight Polyethylene (UHMWPE)
- Light, extreme temperature resistance (-150°C)

**Key Properties**
- 200m cord, 0.8mm diameter, Mass: 200g
- Strength ~1000N (factor of safety of 200)
F.I.S.H. Design

- **Dynamically Stable**
  - Centre of pressure will be behind the Centre of Gravity
  - No-spin config.
- **Contains:**
  - Sensor elements and batteries
- **Weight:** ~ 0.5g
- **Size:**
  - Diameter: ~80mm
  - Length: 200mm
## Mass Budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Payload</td>
<td>14.5</td>
</tr>
<tr>
<td>Reel</td>
<td>1</td>
</tr>
<tr>
<td>Structure</td>
<td>8</td>
</tr>
<tr>
<td>Electric Motor &amp; Batteries</td>
<td>2</td>
</tr>
<tr>
<td>Magnetic Shielding</td>
<td>3.5</td>
</tr>
<tr>
<td>Line</td>
<td>0.2</td>
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<tr>
<td>F.I.S.H.</td>
<td>0.5</td>
</tr>
<tr>
<td>Sensors</td>
<td>0.15</td>
</tr>
<tr>
<td>Structure</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>~15</strong></td>
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</table>
SMRT Payload
ATMEGA Microprocessor:
- Sensor data collection and processing
- Controls the overall reeling process
- Stores data collected during reeling for post-processing
- Thermal control
- Power control
- Safety:
  - Software with exception handling capability
  - Emergency payload reelup

F.I.S.H.
ATMEGA Microprocessor:
- Sensor data collection during reeling process
- Transfers data to gondola at all times
- Thermal control
- Power control
Software: Communication

F.I.S.H. to SMRT Payload:

- Short range wireless communication (ZigBee)
- Attempted data transfer at all times

SMRT Payload to Ground:

- Use of Bexus' E-Link connection (RS-232)
- Downlink required for status updates
- Uplink signal to manually trigger start of experiments
- Safety mechanism:
  - Stop experiment at any time
### Power Budget F.I.S.H.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Active</th>
<th>Sleep</th>
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<tbody>
<tr>
<td>Voltage [V]</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Current [mA]</td>
<td>62</td>
<td>&gt;1</td>
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<tr>
<td>Time [h]</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Power [mW]</td>
<td>204</td>
<td>4</td>
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#### Saft – LSH 26180

<table>
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<tr>
<th>Type</th>
<th>Li-SOCL₂</th>
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<tbody>
<tr>
<td>Voltage [V]</td>
<td>3.6</td>
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<tr>
<td>Capacity [mAh]</td>
<td>1200</td>
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<tr>
<td>Weight [g]</td>
<td>24</td>
</tr>
<tr>
<td>Dimension [mm]</td>
<td>φ26.2*18.6</td>
</tr>
<tr>
<td>Operating Temp [°C]</td>
<td>-60/+85</td>
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</table>
Motor and Power for Reel System

Maxon
DC Brushed or Brushless motor
Power: 11 W
Voltage: 48 V
Continues Current: 300 mA
Reeling Time: 120 s
Weight 119 g

Torque/ angular velocity adjustable by different gears (up to 1:256)

Battery Requirements (Can supply from own source)
Voltage : 48V
Capacity: 2200mAh
Confirmed Facilities & Support

- **IRV Lab Facilities**
  - Electronics Laboratories
  - Mechanical Workshop
  - Student Project Lab
  - Electronics and Mechanical Hardware

- **LTU Funding** 5,000 sek

- **Supervisors**
  - Ex-Industry Professionals

- **IRF Testing Facilities**
  - Thermal Chambers
  - Vacuum Chambers
### Test Methods and Models

<table>
<thead>
<tr>
<th>Test</th>
<th>Method</th>
</tr>
</thead>
</table>
| Structural Strength under thermal conditions | (1) Wire strength  
(2) Reel System  
(3) Drag System (and calibration)  
(4) Braking force transfer to Gondola interface |
| Aerodynamics                  | Wind tunnel drag test                            |
| Thermal                       | Insulation and heater performance                |
| Electronics                   | (1) Electronics bench test  
(2) Magnetic field shielding                 |
| Software                      | Communications test                              |
| Engineering Model             | System verification tests in Environmental Conditions: standard and emergency modes |

“Test like you fly and fly like you test”

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Cost Breakdown

- Reel - ~800US$ each
- Line - ~30US$/150m
- Manufacturing materials
- Electronics
- Testing
- Travel to conferences and workshops
Management: Structure

Facilitation and Support Level:
- ESA/DLR/SSC
- LTU
- Sponsors

Management Group:
- Manager
- Outreach & Science

Subsystems:
- Mechanical
- Electrical
- Software
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**Management: Schedule**

<table>
<thead>
<tr>
<th>2008</th>
<th>2009</th>
<th>2010</th>
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<tr>
<td>Mai Jun Jul Aug Sep Okt Nov Dez</td>
<td>Jan Feb Mrz Apr Mai Jun Jul Aug Sep Okt Nov Dez</td>
<td>Jan Feb Mrz Apr Mai Jun Jul Aug Sep</td>
</tr>
<tr>
<td>Deadline for Proposals</td>
<td>Preselection / Selection of Experiments</td>
<td>Final Student Report BX</td>
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<td>17.11.08*</td>
<td>19.12.08 / 13.02.09</td>
<td>15.01.10</td>
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<tr>
<td>Call for Proposals</td>
<td>Outreach Programme</td>
<td>Final Student Report RX</td>
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<tr>
<td>03.09.08</td>
<td></td>
<td>30.06.10</td>
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- **Preliminary Design Review:** April 2008
- **Critical Design Review:** May 2008
- **Flight Model:** June 2008
- **Final Report:** October 2008

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Outreach

• Presentations
  • Universities (EU and Australia)
  • Schools (EU and Australia)
  • Austrian Spaceday

• Publications
  • Newspapers
  • Magazines
  • Newsletters

• Webpage
  • reel.SMRT Webpage

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3-5 Feb 2009
Scientific Closure

- Measure the reduction of the effect of gravity on a payload, recover it and perform this multiple times.

- Measure a number of environmental variables over an increased sampling range

- Conduct extensive outreach about the potential of balloon based experiments

- Make available all findings so that others can benefit from the advances made by the SMRT team
We Welcome Your Questions
Additional Slides
High Altitude Lego Extravaganza

- **HALE** was an event that carried nine Lego Mindstorms based payloads into the earth’s stratosphere. Altitude: ~30 km

- The **REEL-E** payload was designed to measure the g-forces under changing conditions in high altitude environments
Electro-Magnetic Interference

Electrical: Own Power Supply
Magnetic:
Ampere law: The magnetic field in space around an electric current is proportional to the electric current \( B = \mu I \)
48V -> 300mA -> lower B
High \( \mu \) material -> shaping the field -> attenuation, selecting the directions of preference
MAGNETIC SHIELDING FOIL
Electromagnetic Shielding (SE) = 14dB (inner/outer)

Notification during design about the magnetic field we are producing
Wireless Communication
ZigBee Xbee OEm RF modules

Microcontroller
ATMega

3-Axis Accelerometer
VTI SCA3000-D03
Sensor List

- Thermistors
- Pressure Sensors
- Gyros
- Accelerometers