

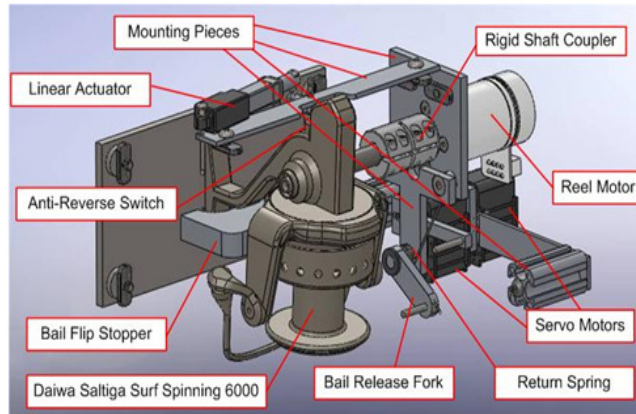
### 3. System Modes

#### Drop Mode

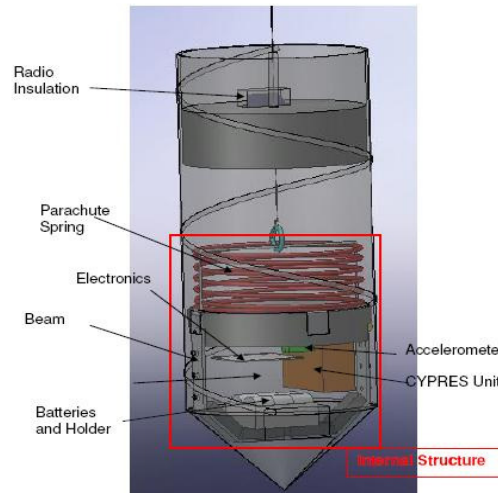
The drop mode has three phases: free-fall, deceleration and recovery. In free-fall, the FISH begins inside the MAIN Payload. The line guide is then unlocked and the bail mechanism is opened, enabling the FISH to fall under gravity as the line spools off the reel. During the drop, all feedback sensors are monitored and if a malfunction occurs the emergency recovery using the line guide is activated, where the line guide is turned to slow down the FISH. Once 50m is reached, which is determined by the length of time that has passed, the bail mechanism shall be shut by turning the motor on the reel handle and forcing it past the bail close mechanism (solid protrusion). In the deceleration phase, the brake is applied automatically by the bail closing and the FISH is decelerated to a halt over approximately 20m. In the recovery phase, the FISH is reeled up into the MAIN Payload. At the end of each drop, the FISH and MAIN Payload transfer accelerometer and gyro data via Xbee connection. If necessary, the line guide will be used to lock the line in place between drops.

#### Slow Reel Mode

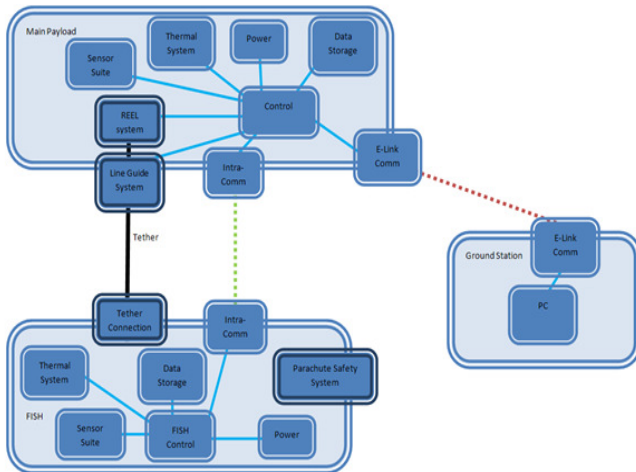
In the slow reel mode the bail remains closed. The FISH is lowered in a controlled manner using a motor to reel down the line by rotating the fishing reel handle forward. In this way, the speed of the unreeling and the line tension can be varied. This mode can be used to obtain information about the perturbation effects and stability of the FISH at the end of a long tether in addition to scientific applications.



reel.SMRT Reel Mechanism



The internal design of the FISH (free-falling system & instrument housing)



reel.SMRT System Diagram

### 4. Future Development

The reel.SMRT Team aims to investigate the feasibility of their concept of a balloon-borne low gravity system. This project is intended as the first step to realising such a capability. The Team further presents a number of extensions and recommendations for further development, including:

- A tether capable of power transmission.
- A custom reel that ‘drops’ the tether (akin to ‘pinching-in’ the lip of the reel), with a larger diameter for longer drops. This would negate the limitation of unreeling speed.
- Installing actuators for a 3DOF FISH, such as three reaction wheels, as well as a payload bay for experiments.

### The reel.SMRT Mission

... to investigate the feasibility of producing a reduced gravity environment on a balloon payload in a recoverable manner and perform this multiple times.

## 1. The Concept

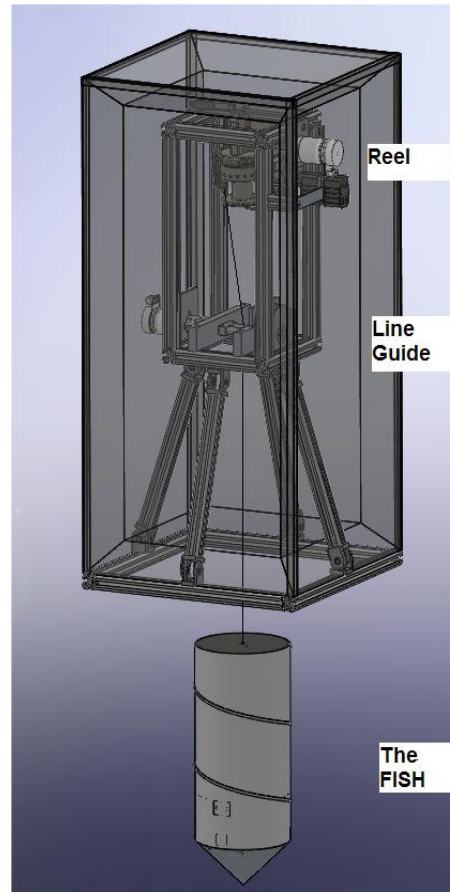
A balloon that can drop, reel down and reel back up a payload and perform this multiple times, would significantly expand the scope of balloon-based experimentation.

The reel.SMRT Project is a mission that shall be launched on a Stratospheric Balloon in October 2009 following an 8 month development period as part of BEXUS-9 (Balloon-borne Experiments for University Students). Through this programme, reel.SMRT investigates the feasibility of a balloon-based low gravity platform, capable of multiple tests in a single mission. The vision is that the platform may be ultimately up-scaled to provide a viable and more cost-effective alternative to parabolic flights and drop towers. It has the potential to drastically increase the maximum drop lengths and versatility of such systems, along with more frequent drops and a greater number of drops in a single mission. The reel.SMRT system also has secondary applications for balloon experimentation; by controlled lowering of a capsule, it is possible to take measurement further from the gondola, increasing the sampling range for sensors. Other advantages of an up-scaled system would include: capability for large payloads such as antenna deployment; multiple drops to gain more test data; and variable gravity to simulate Martian or Lunar conditions. Additionally, the tether has applications as a safety line for UAV experimentation, or for lowering a sensor or object to near the surface for a low-altitude mission (such as in Martian exploration). Our simulations have shown that with minimal tension, milligravity performance is limited only by air drag after kilometers of drop distance.

For this feasibility analysis, the system has a 50m drop length (70m total reel length) and 5G braking force, to demonstrate the quality of the low gravity environment for a dropped payload without actuators, using COTS components including standard fishing tackle and line as the reeling mechanism.

Parabolic Flight	Drop Tower	reel.SMRT Concept
<b>Advantages</b>		
<ul style="list-style-type: none"> <li>Interaction during tests</li> <li>Interaction between tests</li> <li>No extreme temp or pressure</li> <li>Fun and Public Outreach</li> <li>Variable gravity conditions</li> <li>Transportable</li> </ul>	<ul style="list-style-type: none"> <li>High quality reduced gravity</li> <li>Interaction between tests</li> <li>Proven and respected</li> </ul>	<ul style="list-style-type: none"> <li>Payload Versatility</li> <li>Multiple drops</li> <li>Potentially relatively low-cost</li> <li>Many potential operators</li> <li>Variable gravity conditions</li> <li>Transportable</li> <li>Vacuum &amp; thermal enviro.</li> <li>Versatile system: modes</li> <li>Transferable tech: space expl.</li> <li>Very large drop time</li> </ul>
<b>Disadvantages</b>		
<ul style="list-style-type: none"> <li>Low quality reduced gravity</li> <li>Variable gravity quality</li> <li>Cost</li> </ul>	<ul style="list-style-type: none"> <li>Impact forces</li> <li>Vacuum environment</li> <li>Fixed location</li> <li>Power and Mass Budgets</li> <li>Cost and application time</li> </ul>	<ul style="list-style-type: none"> <li>Unknown quality of gravity</li> <li>Vacuum and thermal environ.</li> <li>No physical interaction</li> <li>Power and Mass Budgets limited by balloon capacity</li> </ul>

## 2. Implementation



A 3D model of the reel.SMRT system depicting the MAIN Payload within its insulation box. The MAIN Payload is 85cm tall with a 40x40cm base.

### System Summary

The reel.SMRT system consists of three primary segments: a ground station, the MAIN Payload and the dropped payload called the 'FISH'. Each of these systems is electrically independent and communicates wirelessly. The MAIN Payload sits in the gondola over a hole cut into the floor and the FISH is a 1.8kg vessel with its own power, thermal system, data storage, sensor suite and parachute.

When dropped, the FISH falls while tethered to the fishing reel and collects acceleration data to the accuracy of 1 milliG using pre-calibrated accelerometers and gyroscopes. This data is both stored and transmitted to the MAIN Payload for back-up storage. Safety is paramount for this system, with redundancy implemented wherever practicable. The line guide is a key safety system that can brake and reel up the FISH independently of the reel.

## REXUSBEXUS

The REXUSBEXUS programme allows university students across Europe to perform experiments on sounding rockets and balloons. Each year, 2 rockets and 2 balloons are launched, carrying up to 20 experiments designed and built by student teams. BEXUS experiments are lifted by a balloon with a volume of 12000m<sup>3</sup> to a max. altitude of 35km over 2-5hrs. The programme is realised under a bilateral Agency Agreement between DLR and the SNSB and is also supported by ESA.



The team is grateful to all of the REXUSBEXUS team for their expertise, encouragement and this incredible opportunity.



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The team are all students of the Erasmus Mundus Joint European Master in Space Science and Technology 'SpaceMaster'.

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