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WOLF REXUS Experiment

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Abstract

WObbling controL system for Free falling unit (WOLF) project is closely related to an experiment called SPIDER[1] (Small Payloads for Investigation of Disturbances in Electrojet by Rockets), which was developed under the Swedish National Balloon and Rocket Programme. SPIDER carried a payload of ten Free Flying Units (FFU) which were released from the main rocket at 65 km. The FFU's deployed spherical probes on wire booms to measure turbulence in the auroral electrojet between 95 km and 115 km.Those FFUs experienced a wobble motion, likely induced during the FFU ejection from the rocket. The wobbling motion of the probes may compromise the measurements on the spinning payloads with flexible booms, as the position of the probes cannot be assumed radial. In the worst cases, wobbling can compromise the dynamics of the free flyers. The WOLF REXUS experiment sets out to address this issue, aiming to demonstrate a dynamical system to suppress the wobbling, and ensure flat spin motion on disc-shaped FFUs. The experiment also addresses the questions of the FFU ejection effect on the main rocket attitude dynamics, and develops a more robust recovery and localization system to be used on FFUs of this class. The WOLF experiment was selected for flight onboard RX24 sounding rocket, realized in the framework of the REXUS/BEXUS programme[2]. This contribution describes the setup of the WOLF experiment, and presents the progress up to the Integration Progress Review level.

1. Introduction

Since aircraft and balloons are limited to altitudes of typically less than 40 km and orbital spacecraft have a minimum altitude of well above 100 km, the only viable solution to access the middle atmosphere is the use of sounding rockets. Ejectables probes from sounding rockets can be used to make multi-point insitu measurements. This has been demonstrated, for example, in the successful flight of RAIN on REXUS 11 in November 2012, MUSCAT experiment launched on REXUS 13 in May 2013, or SCRAP[3] launched on REXUS 17 in March 2015. Other REXUS teams as ISAAC[4] or SLED[5] opened the way of SPIDER experiment (Small Payloads for Investigation of Disturbances in Electrojet by Rockets), which was developed under the Swedish National Balloon and Rocket Programme. All the projects mentioned above are designed by students, professors and researchers from KTH Royal Institute of Technology, Sweden.

The outcome of the SPIDER design is a system that measures electromagnetic fields in the ionosphere and characterize plasma's main properties. The main goal of the project is to use multiple Small Payloads for Investigation of Disturbances in Electrojet by Rockets (SPIDER) to probe the multi-scale structure of electrostatic turbulence in the ionospheric E region. The novelty of the experiment lies in the fact that auroral electrojet and pre-breakup auroral arc are studied in situ simultaneously on multiple scales. The auroral electrojet is a current of remarkable strength and persistence that flows between 90 and 130 km height in the ionosphere. It is considered to be the cause of the onset of charge density irregularities. This affects and disturbs propagation of radio waves, as terrestrial TV signals, satellite communication and navigation signals. The presence of the irregularities excited by Farley-Buneman instability is the foundation of the coherent scatter radar operation.

Ten units, called FFUs (Free-Falling Units), cylindrical-shaped with 240 mm in diameter and 94 mm in height are used for the innovative multi-point measurements. Each of them are equipped with eight spherical probes which are deployed by means of wire booms through some holes in the boom deployment unit (BDU) hull and they measure currents and electric fields. The four longer probes are dedicated to electric field measurements, whilst the other four, 1 meter shorter, are biased to provide measures of the plasma trans-characteristic.

2 Experiment Objectives

The primary technical objective of the experiment is:
OBJ 1. To design, build and validate an in-flight wobbling control system for reducing wobble of spinning free-flying units.
Secondary technical objectives are:
OBJ 2. To demonstrate a thin wire boom deployment achieving radial booms
OBJ 3. To acquire high time resolution and high accuracy data on the rocket rotational motion to characterize the ejection process.
OBJ 4. To develop and build a more robust recovery system than the one used in the SPIDER experiment and previous KTH REXUS experiments with large FFUs (such as SCRAP and SLED).

3 Experiment Concept

The experiment consists of one Rocket Mounted Unit (RMU) and two Free Falling Units (FFUs). Each FFU is sub-divided in three other units:

1. Bottom Unit (BU)
2. Boom Deployment Unit (BDU)
3. Common Unit (CU)

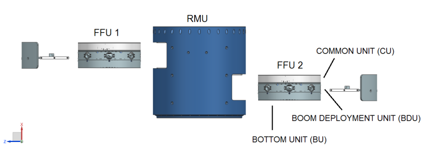

Figure 1: FFUs ejected from RMU.

The two FFUs will be ejected from the RMU, Figure 1 by means of a spring-based ejection system. The FFUs, after ejection from the rocket should spin around the spinning axis (Z axis, Figure 2). The ejection must occur before rocket de-spin such that FFUs retain their spin when they are ejected. The wobble control system will be accomodated in BU and it will damp the lateral angular rates until the FFUs will achieve a flat spin. The centrifugal force created by the spinning of the FFUs will deploy the booms out from BDU.
The purpose of the BDU is to deploy the booms that

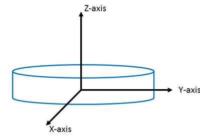

Figure 2: FFU axes.

measure the currents and the electric fields. The CUs record the general flight data for each FFU throughout the experiment. These raw GPS data, acceleration, angular rate, and atmospheric pressure will help to reconstruct the flight trajectories. The CU also houses the recovery system. At approximately 5 km altitude, as determined by the pressure sensor, the parachute is deployed and the FFU's GPS location is transmitted via radio beacon and satellite modem. The bright orange parachute along with 24 hour long location transmission will aid recovery. As all data will be stored on the FFUs, recovery is necessary for any analysis of the experiment.

4. Summary and Conclusions

Following the main objective of the WOLF experiment, we are developing and currently prototyping a reaction wheel-based control system, effectively functioning as active nutation damper. One reaction wheel is used to reduce the undesirable lateral rates. Once validated in REXUS flight, the concept and the design developed during WOLF experiment can be used for other application which require a flat spin of the free falling units.

References

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