



EXPeriment for Liquid On-orbit REfueling

www.explore-rexus.de

ABSTRACT

EXPLORE stands for “EXPeriment for Liquid On-orbit REfueling”. The student experiment investigates the liquid fluid transfer between test chambers under microgravity conditions. It has been selected by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) to fly on the research rocket REXUS 10 in May 2011.

Space exploration missions, in particular human and large cargo flights, will require considerable transportation efforts to future destinations such as Moon and Mars. One option to achieve these payload and crew capabilities is through the refueling of orbital transportation stages. EXPLORE aims at informing the investigation of technologies and processes for these orbital refueling activities through a microgravity experiment.

While storable propellants are already transferred in orbit (e.g. at ISS), the handling of more efficient cryogenic propellants pose specific challenges. A fuel tank is typically pressurized by a gas which then remains in the tank after depletion. Refueling activities then have to ensure best filling of the tank without mixture of the liquid and gaseous phase, while keeping the imposed pressure to avoid propellant boil off. This refueling process shall be reproduced in the EXPLORE experiment to investigate the influence of the filling flow velocity on the propellant flow and final fill level.

EXPLORE uses six transparent test chambers with connected gas reservoirs that will be filled from two central liquid reservoirs. The fuel transfer process is observed visually by a camera and through the recording of pressure and temperature data. The flow velocity profile will be varied for each chamber to identify optimal conditions for maximum chamber filling.

EXPLORE has been initiated and is implemented throughout the year 2010 by six students of aerospace engineering from the University of Stuttgart, Germany.



Das EXPLORE Team sind (von links nach rechts): Andreas Fink, Christine Hill, Juergen Schlutz, Emil Nathanson, Johannes Wepler, Robert Schelling



Forschungsrakete REXUS auf der Startrampe

The EXPLORE Logo shows a stylized image series. The rocket on the left symbolizes the reach for space and the required transportation systems, at the same time it shows the planned launch of the experiment on the REXUS research rocket. Refueling stands between the rocket and distant planets, the targets of future human space exploration. Thus, EXPLORE becomes goal and solution together: it emphasizes the urge for space exploration that is enabled and advanced through the experiment. The images are colored yellow and black, the official colors of the German state of Baden-Württemberg. It underlines the connection of the team with the University of Stuttgart and the local region.

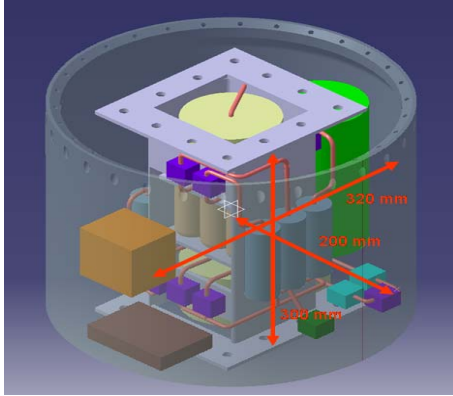


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THE EXPERIMENT

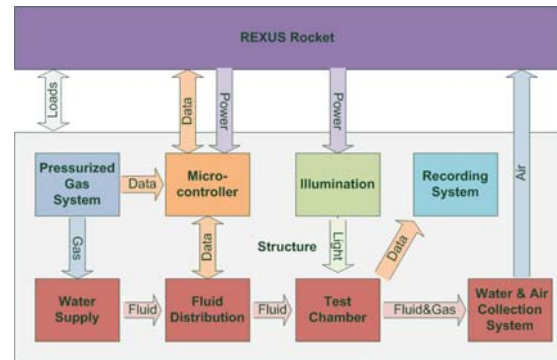
EXPLORE simulates the refueling process under microgravity conditions, i.e. a homogenous and maximized fill level on the receiver tank shall be achieved while varying the mass flow distribution. At the same time, the filling process itself will be recorded and analyzed.



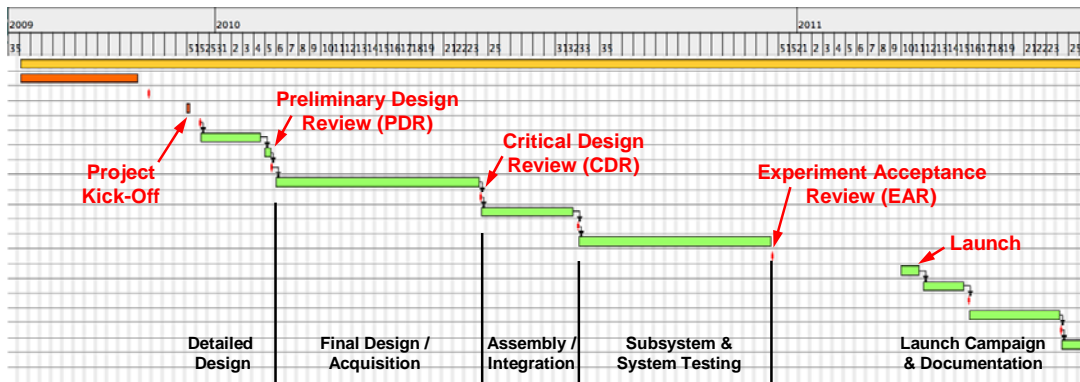
The experiment will be installed in a payload compartment of the REXUS rocket. It comprises the refueling system, the control and measurement electronics, and the structural mounting. The overall mass of the experiment is about 10 kg.

In the refueling system, a central gas pressure tank pressurizes two identical liquid tanks, which again distribute the liquid fuel to the test chambers through mass flow controllers and adequate valves and tubing. The velocity of the fill process is varied as the major parameter for investigation.

The electronic subsystem comprises a microcontroller, which controls the regulators and valves of the refueling system on the one hand, but which also captures and stores all sensor data. Throughout the experiment, pressure, temperature and video data is recorded to characterize the fill process.



In realizing the EXPLORE project, we emphasize the cooperation with non-space-specialized industry to minimize cost and complexity of the hardware. Also, it allows to accentuate the outreach aspects of the student experiment.



The EXPLORE project was conceptualized during fall and winter of 2009 and selected to fly on the REXUS 10 rocket in December 2009. The design phase is finalized throughout spring of the following year, allowing an integration and testing of the components and systems in summer and fall 2010. The delivery of the experiment to DLR and Eurolaunch is scheduled for December 2010, in preparation of a March 2011 launch from Kiruna in Sweden.

Parallel to the technical implementation of the experiment, the EXPLORE team is also driving a outreach campaign which shall communicate the concept and its realization locally and nationwide. This includes a comprehensive web presence as well as presentations, exhibitions, organization of public events and press releases.



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THE TEAM



Christine Hill

Project Management

Christine is responsible for the overall management of the EXPLORE project. She is the main contact person and controls all documentation as well as the project time plan.

Christine is a student of aerospace engineering at the University of Stuttgart in her final year. She specializes in Space Systems and Space Applications.



Andreas Fink

Payload Management

As the payload manager, Andreas oversees the technical design of the EXPLORE experiment. He's also our CAD expert and responsible for all the nice 3D representations.

Andi is a student of aerospace engineering at the University of Stuttgart in his final year. He specializes in Space Systems and Aircraft Design.



Emil Nathanson

Telemetry, Tracking and Command Management

Besides being the TT&C contact person, Emil is mainly responsible for the EXPLORE test campaign. He will manage the test procedures and facilities to make sure our experiment is ready for flight.

Emil is a student of aerospace engineering at the University of Stuttgart in his fourth year.



Jürgen Schlutz

Electric Design Management

Juergen ensures that our experiment has all the power it needs and does the right things at the right time. Furthermore he's our PR and outreach contact. He searches sponsors and communicates with the press.

Juergen is a PhD student of aerospace engineering at the University of Stuttgart. He specialized in Space Systems and Control Systems and currently works on human space exploration missions.



Johannes Wepler

Earth Ground Support Management

Johannes is the EXPLORE hardware manager. He coordinates the selection and manufacture of all hardware items during the project development as well as the required support equipment for the launch campaign.

Johannes is a student of aerospace engineering at the University of Stuttgart. He specializes in Space Systems and Aircraft Design.



Robert Schelling

Mechanical Design Management

Robert is our fluid dynamics expert and responsible for the theoretical foundations of the EXPLORE experiment. His calculations drive the mechanical design and the experiment process flow.

Robert is a student of aerospace engineering at the University of Stuttgart. He specializes in Fluid Dynamics and Aircraft Propulsion Systems.