SED

Student Experiment Documentation

Document ID: BX28_IRISC_SEDv1-0_16Jan19

Mission: BEXUS 28

Team Name: IRISC

Experiment Title: InfraRed Imaging of astronomical targets with a Stabilized Camera

Team	**Name**
Student Team Leader:	Diego Octavio Talavera Maya
Team Members:	Anja Möslinger
	Eligius Franciscus Maria Weterings
	Kimberly Tuija Steele
	Veronika Haberle
	Adam Smialek
	Ajith Kumar Baskar
	Harald Magnusson
	Niklas Ulfvarson
	Sabina Björk
	William Eriksson
University:	Luleå University of Technology

Version:	Issue Date:	Document Type:	Valid from
1.0	**January 16, 2019**	**Spec**	**January 16, 2019**

Issued by:

The IRISC Team

Approved by:

Dr. Thomas Kuhn

CHANGE RECORD

Version	Date	Changed chapter	Remarks
0	2018-12-06	New Version	
1-0		All	PDR

Abstract:

Keywords:

Contents

PREFACE

The Rocket and Balloon Experiments for University Students (REXUS/BEXUS) programme is realized under a bilateral Agency Agreement between the German Aerospace Center (DLR) and the Swedish National Space Board (SNSB). The Swedish share of the payload has been made available to students from other European countries through a collaboration with the European Space Agency (ESA).

EuroLaunch, a cooperation between the Esrange Space Center of SSC and the Mobile Rocket Base (MORABA) of DLR, is responsible for the campaign management and operations of the launch vehicles. Experts from DLR, SSC, ZARM, and ESA provide technical support to the student teams throughout the project.

The Student Experiment Documentation (SED) is a continuously updating document regarding the BEXUS student experiment IRISC - InfraRed Imaging of astronomical targets with a Stabilized Camera and will undergo reviews during the preliminary design review, the critical design review, the integration progress review, and final experiment report.

Acknowledgements

1 Introduction

1.1 Scientific Background

The universe hides a plethora of information across the entire electromagnetic spectrum. Infrared light is unique as compared to other wavelengths of light in that it can permeate interstellar dust, and corresponds to typically "cold" astronomical phenomena, such as star formation, some nebulae, and older, colder stars, to name a few [**?**]. Here on the surface of the earth, both visible light and radio waves exhibit near-total transmission through the atmosphere for observation, and experience fewer ill effects from atmospheric interference than other wavelengths, including infrared light, that cannot penetrate the atmosphere at all. The infrared regime lies between visible and microwave radiation, and in an astronomical context this usually corresponds to wavelengths between 0.75 and 300 microns. Within this range, a number of cosmological phenomena can be explored, however only parts of this spectral range are capable of penetrating the earth's atmosphere for observation.

Factors affecting infrared transmission through the atmosphere include molecular absorption (in particular absorption by carbon monoxide, carbon dioxide, water vapour, and oxygen, among others), scattering by dust and other molecules, and distortion of the light by small-scale perturbations in the atmosphere such as pressure and temperature gradients [**?**]. As with visible light, infrared observations are also not possible on cloudy or overcast nights. To minimise these problems, infrared telescopes are usually situated at very high altitudes, such as the Tokyo Atacama Observatory (TAO) at 5,600 m above sea level [**?**]. Better still, the Stratospheric Observatory for Infrared Astronomy (SOFIA) is an airborne observatory that flies at an altitude of 13-14 km, thus getting above 99.8% of atmospheric water vapour absorption [**?**], as well as the majority of scattering and distortion.

1.2 Mission Statement

Studying astronomical targets in the infrared from ground-based observatories is hampered by atmospheric distortion and extinction, limiting the amount and kind of infrared research that can be done. Therefore, having a telescope make observations from above the majority of interfering atmosphere will negate these effects, and improve the SNR and therefore scientific quality of the obtained images. Establishing a functional, low-cost system for performing infrared observations from a stratospheric balloon will help to push the boundaries of infrared astronomy.

1.3 Experiment Objectives

The primary objectives of the experiment can be split into a main scientific objective, and a main technical objective: the primary scientific objective is to establish the SNR improvement (if any) from ground-based observations to stratospheric observations in the infrared. In order to achieve this scientific objective, the primary technical objective is to construct a gimbal system that is capable of stabilising the optics setup to arcsecond accuracy.

Pending success of these primary objectives, secondary scientific and technical objectives include:

I (Scientific) Observations of globular and open star clusters for the purpose of population studies

II (Scientific) Observations and evaluation of galaxies and nebulae for fine structure detail and infrared characteristics

III (Scientific) Comparison of IRISC observations with observations done by other instruments in the same wavelength band

IV (Technical) Construction of a thermal system suitable for maintaining and optimising operation of a near-infrared camera within the BEXUS environment

1.4 Experiment Concept

The experiment will be comprised of a telescope with baffle, a CMOS sensor, and a gimbal stabilisation system, which will work together to obtain long-exposure images of astronomical targets. The control system is responsible for selecting and tracking the astronomical targets using the position and orientation of the BEXUS gondola. It also stabilises the telescope during exposure using an active feedback control. Sensors include a gyroscope, accelerometer, GPS, and a compass/magnetometer, to ensure all vital information for finding and tracking targets is available to the control system. A small sanity camera will also be used for visual verification of the state of the system, in the event that images provided by the BEXUS telemetry are not as expected. The thermal control system will ensure that an optimal operational temperature is maintained for the duration of the experiment.

1.5 Team Details

1.5.1 Contact Point

Project Manager

		Diego Talavera
	Address	Snårvägen 17
		981 42
		Kiruna
		Sweden
	IRISC Email	contact@irisc.space
	Personal Email	dietal-8@student.ltu.se

Endorsing Professor

		Thomas Kuhn
	Title	Associate professor
	Address	Rymdcampus 1
		981 92
		Kiruna
		Sweden
	Telephone	
	Email	thomas.kuhn@ltu.se

1.5.2 Team Members

The IRISC Team consists of twelve people of a number of different educational and personal backgrounds. All team members are studying at the LuleåUniversity of Technology, Kiruna Space Campus.

Diego Octavio Talavera Maya - Management

Current Education: MSc in Space Sciences and Technology (SpaceMaster).

Previous Education: BSc in Aerospace Engineering at the Autonomous University of Baja California (UABC).

Responsibilities: Project Management.

Anja Möslinger - Control system

Current Education: MSc in Space Sciences and Technology (SpaceMaster).

Previous Education: BSc in Mechatronics at the Johannes Kepler University (JKU)

Responsibilities: Control system, Stabilisation system, Camera system

Eligius Franciscus Maria Weterings - Electrical

Current Education: MSc in Space Sciences and Technology (SpaceMaster).

Previous Education: BSc in electrical engineering at the University of Rotterdam (HR) with a specialization in computer sciences and mathematics at the University Utrecht (UU).

Responsibilities: Embedded systems, electrical engineering.

Kimberly Tuija Steele - Science and Optics

Current Education: MSc in Space Sciences and Technology (SpaceMaster).

Previous Education: BSc(Astronomy)(Hons)

Responsibilities: experiment scientific background and overall objectives; defining experimental parameters; contacting and collaborating with industry partners that manufacture off-the-shelf optics components; data analysis; interpreting and documenting images; documenting and publishing findings.

Veronika Haberle - Science

Current Education: MSc in Space Sciences and Technology (SpaceMaster).

Previous Education:

Responsibilities: Outreach & data analysis.

Adam Smialek - Control system

Current Education: MSc in Space Sciences and Technology (SpaceMaster).

Previous Education: BSC in Aerospace Engineering at Warsaw University of Technology (WUT) with a specialisation in Automatics and Flight Systems

Responsibilities: Onboard control system & Outreach.

Ajith Kumar BASKAR - Mechanical

Current Education: Master Programme in Spacecraft Design

Previous Education: Bachelor of technology in Aerospace Engineering

Responsibilities: Mechanical engineering.

Harald Magnusson - Software

Current Education: Master Programme in Space Engineering, Luleå University of Technology

Previous Education:

Responsibilities: Software (onboard & ground station).

Niklas Ulfvarson - Software

Current Education: Master Programme in Space Engineering, Luleå University of Technology

Previous Education:

Responsibilities: Software (onboard & ground station).

Sabina Björk - Electrical

Current Education: Master Programme in Space Engineering, Luleå University of Technology

Previous Education: -

Responsibilities: Energy technology, electrical engineering.

William Eriksson - Software

Current Education: Master Programme in Space Engineering, Luleå University of Technology

Previous Education:

Responsibilities: Software (onboard & ground station).

2 Experiment Requirements and Constraints

A list of requirements and constraints are listed below. The requirements are separated in functional, performance, design and operational requirements.

2.1 Functional Requirements

F.1 The telescope shall successfully track the celestial bodies of interest.

F.2 The camera shall take images in the near infrared (NIR) spectrum.

2.2 Performance Requirements

P.1 The gimbal stabilization system shall point the telescope towards the celestial body with an accuracy of at least 1 arc seconds.

P.2 The optics shall be cable of making pictures of 0.5-1.5 x 0.3-1 degrees.

P.3 The NIR camera shall make images in the range of 720-850 to 1200 nm.

P.4 The NIR camera shall have a resolution of at least 16 MP.

P.5 The NIR camera shall be able to make images with exposure times between 0.5 and 150 seconds.

P.6 The experiment shall measure the location and orientation of the gondola.

2.3 Design Requirements

D.01 The experiment shall be able to operate in the temperature profile of the BEXUS environment.

D.02 The experiment shall be able to operate in the pressure profile of the BEXUS environment.

D.03 The experiment shall be able to operate in the vibration profile of the BEXUS environment.

D.04 The absolute position of the telescope relative to the gondola shall be known with a accuracy of 0.1 degrees.

D.05 The supporting structure shall not twist by more than 0.1 degrees.

D.06 The experiment shall never be pointed directly at the sun $\pm$ 27 degrees.

D.07 The experiment shall be able to fly during the entire day.

D.08 The temperature of the NIR camera shall be held at $0 \pm 5\,^{\circ}$C.

D.09 The images obtained shall be send to a ground station by the E-link system with a maximum data rate of 1000 kilo bits per second.

D.10 The experiment shall be mounted at the side of the gondola.

D.11 The experiment shall not consume more power than 250 Wh.

D.12 The volume of the experiment shall not exceed 65 x 40 x 40 cm.

D.13 The mass of the experiment shall not exceed 20 kg.

D.14 The experiment shall be able to run for at least 2.5 hours.

D.15 The experiment shall be able to function autonomously.

D.16 The data stored in the experiment shall be able to survive the landing.

2.4 Operational Requirements

O.1 The experiment shall be able to be controlled by the ground station when requested.

O.2 The experiment shall rotate to a 'safe' location while descending.

2.5 Constraints

C.1 The shared E-link data transfer rates are limited by coverage and quality of reception.

C.2 There shall be no direct internet connection on the ground station.

C.3 The mass and volume should fit inside the gondola together with the other experiments.

C.4 The budget for the experiment is limited by the generous companies and organizations that sponsor IRISC.

3 Project Planning

3.1 Work Breakdown Structure

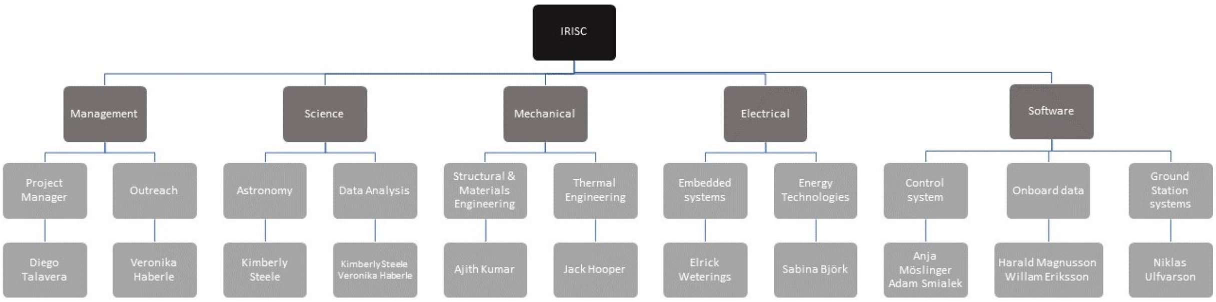

Figure 3.1.1: Yes, it looks ugly, I'll change it later, also the WBS below (Diego)