REXUS/BEXUS

Experiment

Proposal Form

Team/Short experiment name	**EXIST**
Full experiment title	**Ex**amination of **I**nfrasound in the **S**tratosphere and **T**roposphere

☐ **REXUS** ☒ **BEXUS**

☐ spinning with 4 Hz

☐ despun with Yo-Yo to about 0.08 Hz

☐ not of importance for our experiment

Science & Organisation

Team Information	
Student team leader:	**Robert Persson**, Swedish, Luleå University of Technology, Space Engineering - Spacecraft and Instrumentation, Master Program, Fifth year, 06-01-1993
Contact information of team leader:	Address: [redacted] Telephone: [redacted] E-mail: [redacted]
Members of your team (In order of team role)**:**	**Lucas Svensson,** Swedish, Luleå University of Technology, Space Engineering - Spacecraft and Instrumentation, Master Program, Fourth year, 05-04-1994 **Role: Electrical Set-up Responsible** **Sarah Zayouna**, Swedish, Luleå University of Technology, Space Engineering - Spacecraft and Instrumentation, Master Program, Fourth year, 24-07-1992 **Role: Electrical**

David Skånberg, Swedish, Luleå University of Technology,
Space Engineering - Spacecraft and Instrumentation,
Master Program, Fourth year, 07-04-1993
Role: Electrical

Vincent Still, British, Luleå University of Technology,
Spacecraft Design,
Master Program, First year, 28-09-1993
Role: Mechanical Set-up Responsible

Jonas Blidnert, Swedish, Luleå University of Technology,
Spacecraft Design,
Master Program, First year, 03-11-1993
Role: Mechanical

Jakob Östberg, Swedish, Luleå University of Technology,
Space Engineering - Spacecraft and Instrumentation,
Master Program, Fourth year, 22-09-1993
Role: Software Development Responsible

Max Nilsson, Swedish, Luleå University of Technology,
Space Engineering - Aerospace Engineering,
Master Program, Fourth year, 12-09-1994
Role: Software, and Outreach Responsible

Sandra Nilsson, Swedish, Luleå University of Technology,
Space Engineering - Space and Atmospheric Physics,
Master Program, Fourth Year, 02-07-1993
Role: Scientific Research Responsible

Hannah Petersson, Swedish, Luleå University of Technology,
Space Engineering - Spacecraft and Instrumentation,
Master Program, Fourth Year, 07-08-1992
Role: Scientific

Yared Woldu, Swedish, Luleå University of Technology,
Space Engineering - Aerospace Engineering,
Master Program, Fourth Year, 07-05-1994
Role: Economics Responsible

What is the scientific and/or technical objective of your experiment?	Sound waves propagating at frequencies lower than that of human hearing, i.e. less than 20 Hz, are defined as infrasound. The majority of infrasound measurements have been performed at ground level, but those measurements are unlikely to capture the entirety of the infrasound spectrum; the infrasound is obstructed by natural or manmade structures. Then, due to the infrasound's ability to propagate across long distances without suffering from high attenuation, the atmosphere offers a better path for the waves than across ground level. Low frequency sound can travel far, and can therefore be used to predict severe weather conditions, meteors, and earthquakes (Bedard, Georges, 2000). For this reason, the team sees the importance of this area of research for future understanding of infrasound in the atmosphere, and what it can predict. A deeper understanding of low frequency sounds at stratospheric altitudes may also help in examining the weather conditions and geological activity on other planets, especially on Mars as the pressure in the Earth's stratosphere is at the same order of magnitude as the atmospheric pressure close to the surface of Mars. Similar analyses, e.g. the High Altitude Student Payload (HASP) experiments of 2014 and 2015, at different latitudes, has yielded results of high scientific value. The EXIST team hopes that by using the knowledge from previous experiments and comparing the results, a wider fraction of the infrasonic spectrum can be analyzed and understood. This is also an opportunity to listen for infrasound in this unique environment, since Esrange lies above the Arctic Circle. In addition to this, the area contains a highly developed network of ground stations measuring infrasound (Gibbons et. al 2015), which will be used to compare with the stratospheric results. The previous flights have been done over Arizona and New Mexico, leaving the question of airborne measurements in the rest of the world open.

	Due to the sparse amount of previous measurements, the team wishes to create an opportunity for future experiments to facilitate further investigation of infrasound, based on EXIST's results. To accomplish this, infrasound will be measured in the stratosphere and compared both with measurements from ground stations in the same area, and with the data from the HASP experiment. This will give an indication if there is a significant difference between measurements done on the ground, in the air, and at different latitudes. The expected outcome is that the transducers used for measuring infrasound on the balloon will be able to capture a more complete spectrum of infrasound than the ground stations. This sound is expected to be a low amplitude infrasonic hum that needs to be amplified and filtered to produce data that is useful, and which differs from that measured at the ground stations. ***Y Gibbons S Asming V Eliasson L Fedorov A Fyen J Kero J Kozlovskaya E Kvaerna T Liszka L Näsholm S Raita T Roth M Tiira T Vinogradov*** *The European Arctic: A Laboratory for Seismoacoustic Studies [Journal]. - 2015.* ***T Bedard Jr A Georges*** *Atmospheric Infrasound [Journal]. – 2000*
Are you planning to fly an existing REXUS/BEXUS experiment?	No.
Why do you need a rocket / a balloon?	To capture as much of the infrasound spectrum as possible, the measurements need to be taken above ground level. The altitude which the balloon floats, i.e. greater than 20 kilometers, is ideal for mitigating interference normally measured at ground level, for instance wind noise, as well as natural and artificial obstacles. The timespan for the experiments is greatly increased compared to that of a sounding rocket.
What flight characteristics do you require?	A flight plateau of at least 20 kilometers is optimal for measuring infrasound, since the measurements will be taken above the tropopause, far away from the anthropogenic, infrasonic interference from ground level. However, the sensors will perform

	continuous measurements and therefore the complete flight will be of interest. In order to get as much data as possible, the longer the duration of the flight is, the better. Apart from the altitude requirements, the experiment does not require any other specific flight characteristics, such as daylight or a minimum float time.
Where did you get the idea from?	Prof. Javier Martin-Torres, Chair of the Atmospheric Science research group at Luleå University of Technology, who found the subject intriguing through his interest in geophysical and atmospheric studies (Bedard, Georges, 2000), originally proposed the experiment idea in May of 2016 as a BEXUS experimental concept. Since the research involving high altitude infrasound is sparse, the team will attempt to contribute to the studies by comparing the results with one of the few prior experiments in this field. In the years 2014 and 2015, a student-driven High Altitude Student Payload program realized experiments conducted by Dr. Daniel Bowman, who sought to measure stratospheric infrasound for use in detecting geophysical events (Bowman et. al., 2015). These experiments inspired the EXIST team to conduct infrasound measurements at near polar latitudes on a different continent. ***T Bedard Jr A Georges*** *Atmospheric Infrasound [Journal]. – 2000* ***R Bowman D Johnson C Anderson J Phillips D Ronan T Lees J Gupta*** *Carolina Infrasound Scientific Report (HASP) [Journal]. - 2015*

Describe your experiment	The experiment will consist of two sensor boxes containing everything needed to record infrasound, except power supply. In order to define the vertical source of the infrasound, it is preferable to place these sensor boxes as far as possible from each other, at a minimum of 10 meters. If it is only possible to use less than 10 meters of the flight train, then the two sensor boxes will be put a meter apart, for redundancy.

	The sensor boxes will be attached to the flight train and connected to the gondola power supply and down/up-link via cables. The sensor boxes will measure differential pressure, speed and direction of the wind, internal and external temperature, and vibrations that might be caused by the gondola or other noise sources. Wind is the single largest generator of interference for infrasound stations on the ground, making it interesting to measure. To record infrasound, a team in Japan who wants to collaborate with this project to test their sensor array, will provide the microphone arrays. There will also be an infrasound sensor provided by the same team to measure the lower range of infrasound, <0.1Hz, that the arrays will not pick up. The sensor boxes will also contain a microcontroller and a Global Positioning System receiver. The high-resolution data that the sensors record will be saved on a memory in the sensor box. The memory type has yet to be decided. The gondola will receive the low-resolution data from the sensor boxes and relay that data through the BEXUS downlink. It will also relay uplinked telecommands to the sensor boxes.
What data do you want to measure?	The experiment revolves around measuring infrasonic waves. Thus the most important data to record is the infrasound audio in the troposphere and lower stratosphere. The experiment will also measure the amount of vibrations the balloon exerts onto the payload, the wind speed, and the temperature. The purpose of these secondary data measurements is to provide context information and to determine what parts of the recorded infrasound might be balloon induced interference.
How do you want to take measurements?	Microphone arrays consisting of 16 small infrasound microphones per array will be used to measure infrasound. These arrays will measure the higher range of infrasound, between 0.1 Hz to 20 Hz. A highly sensitive infrasound sensor will measure the frequency below that. The main concern is to get the microphone arrays and the infrasound sensor away from the gondola to increase the accuracy

	of the measurements, as it has been previously concluded by the High Altitude Student Payload experiments that induced interference can occur from low frequency vibrations in the balloon and payload (Bowman et. al., 2015). Interference can also be caused by the operation of other experiments. There will also be a differential pressure sensitive sensor that measures the lower range of infrasound, from zero hertz up to 22 Hz. To document the environmental conditions, the experiment will also have temperature sensors, hot-wire anemometers, and accelerometers accompanying the microphones. Hot-wire anemometers were used by HASP 2015 and worked in the stratosphere. Each instrument will be provided with a Global Positioning System data set to get exact time and position stamps. ***R Bowman D Johnson C Anderson J Phillips D Ronan T Lees J Gupta*** *Carolina Infrasound Scientific Report (HASP) [Journal]. - 2015*.
Describe the process flow of your experiment.	- Before lift-off: All systems and sensors will be activated. Sensor data will be stored on the on-board memory units and low-resolution data will be downlinked to the ground station through the BEXUS down-link to secure the experiment's functionality and to measure data during the entire ascent - During the ascent: Check that all subsystems and sensors are still working and sending telemetry. This will be checked continuously during the whole flight - The experiment will go in to safe-mode during liftoff, cutoff and landing to protect the memory device from data corruption. This means that memory writing will stop when safe-mode is activated
What do you plan to do with your data after the flight?	After the flight, the gathered data will be analyzed in various stages. Post-flight hardware analysis will determine the state of the memory devices. If they are intact after landing, the recorded sound data will be examined with the ground stations, and furthermore the low-resolution data will be compared with its high-resolution

counterpart for further analysis. If some fatal incident occurs that causes the memory to be found damaged, only the transmitted data will be analyzed.

The team will have access to software used in the International Monitoring System, as well as software developed at the Swedish Institute of Space Physics to use for analyzing data, according to Doctor Johan Kero. The data produced from the flight will be compared to data from ground stations (open source access) around the flight path that use this software, and using the same software in the analysis will allow a high level of cross-comparison of the data (Gibbons et. al., 2015).

Data about the functionality of the microphone array will be sent to the collaborating team in Japan for their own analysis. The last stage of the analysis will be to compare the results with previous experiments, with a hypothesis. All data will be analyzed in collaboration with Dr. Daniel Bowman, who was the Student Leader of the High Altitude Student Payload flights and Professor Yamamoto, who wishes take part in the result analysis as a way to test their developed microphones.

As a result of the experiment, the team would like to publish the preliminary results and potential hypothesis derived from the experimental data in a scientific paper. The goal is to reach out to the scientific community with the hypothesis. This to encourage further research within this area, to contribute with possibly useful experimental data, and to push the knowledge even further for future experiments.

Y Gibbons S Asming V Eliasson L Fedorov A Fyen J Kero J Kozlovskaya E Kvaerna T Liszka L Näsholm S Raita T Roth M Tiira T Vinogradov *The European Arctic: A Laboratory for Seismoacoustic Studies [Journal]. - 2015.*

<table>
<tr>
<td>Organisation of your project</td>
<td>The team is divided into several sets of expertise, with one sub team leader for each expertise who will be responsible for organizing their sub team.
The teams are as follows, including their main areas of responsibility:
• Scientific Team: Research, background, and data analysis
• Mechanical Team: Payload design, construction, testing, and integration
• Electrical Team: Circuit board development, circuit board assembly, sensor testing, and integration
• Software Team: Software development, testing, and integration
In addition to these teams, there will be three additional positions:
• Project Manager: Organizing, planning, and leading the team. Primary point of contact
• Economics: Responsible for acquiring funding and budgeting the project
• Public Relations: The project's public outreach and secondary point of contact</td>
</tr>
</table>

Are you scientifically and technically supported by institutes and/or senior scientists?	*Professor Lars-Göran Westerberg*, Luleå University of Technology, Department of Engineering, Sciences, and Mathematics **Primary endorsing professor** *Professor Thomas Kuhn*, Luleå University of Technology, Department of Computer Science, Electrical, and Space Engineering. Associate Professor for the Atmospheric Science Group *Doctor Johan Kero,* Staff Scientist, Swedish Institute of Space Physics *Olle Persson, Luleå University of Technology, Department of Computer Science, Electrical, and Space Engineering.* *Ex-REXUS/BEXUS Project manager* Foreign Endorsement *Doctor Daniel Bowman*, a recent graduate of the University of North Carolina-Chapel Hill's Geophysics program. *Doctor Masa-yuki Yamamoto*, Professor, Kochi University of Technology. Visiting professor, National Institute of Polar Research
Do you have access to a workshop or a laboratory that meets the fabrication and testing needs of your experiment?	A dedicated project development room is available for use during the entire project timeline of one year, allowing the team to perform complete system under test (SUT) set-ups. The project room features both electrical test equipment and a complete mechanical workshop, including a 3D-printer. Any additional testing in the form of a shaker or a vacuum chamber set-up can be done at the Swedish Institute of Space Physics and the Esrange facilities respectively. In Luleå there is a central workshop at the university dedicated to research and project groups, and can be used for the manufacturing of the sensor boxes. This workshop will be available for the team's mechanical department.

Do you have all the material and equipment that is needed for your experiment? If not, how do you plan to obtain it?	Luleå University of Technology allows free use of NX CAD/CAM/CAE, Cadsoft Eagle, and Cadence OrCAD for mechanical and electrical printed circuit board design, respectively. Through a joint collaboration with Kochi University of Technology via Professor Yamamoto, the team has been granted use of a balloon-flight ready set-up for measuring infrasound developed by SAYA Inc. (SAYA INC, 2016). These bread board model instruments of model ADXIIINF02 can be seen in figure 7 of Appendix 1 and have, according to Professor Yamamoto, been vacuum tested to 7 hPa in a 100% CO2 atmosphere at ISAS/JAXA. The array has also passed a -120°C temperature test and ridden on-board a previous sounding rocket experiment. The highly developed collaboration between SAYA Inc. and Kochi University of Technology allows a high level of freedom for product modification if the team finds this to be necessary (Kochi University of Technology, 2016). ***SAYA INC. 2016.*** *saya-net.com. [Online] SAYA INC, 2016. [Accessed on 16 10 2016.] http://www.saya-net.com/products/INF02.html.* ***Kochi University of Technology. 2016.*** *Faculty Members. kochi-tech.ac.jp. [Online] 2016. [Accessed on 16 10 2016.] http://www.kochi-tech.ac.jp/kut_E/about/prof/yamamoto-masa-yuki.html.*
How do you plan to finance your expenses?	Luleå University of Technology will be the main financial sponsor for most of the expenses. If additional financial aid is needed, the Swedish National Space Board will be contacted as a secondary source. Beyond that, if needed, local companies will be contacted as well as applications for suitable grants.
Who else will support you (sponsors, others)?	Several different grants, e.g. Per Bengtsson's Stiftelse (Gustafsson, 2014), can be applied for that are strictly for scientific research. Those grants are handed out both by Luleå University of Technology and different organizations/companies. The requirement for receiving a grant is that it is a student project. These grants would support the project financially. The Atmospheric Science Group at Luleå University of Technology will contribute with their knowledge and expertise that they hold

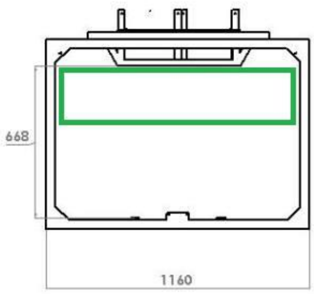
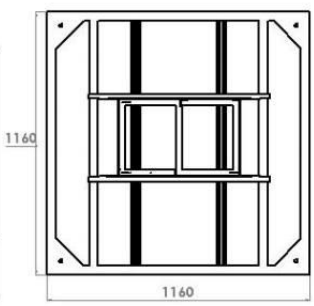
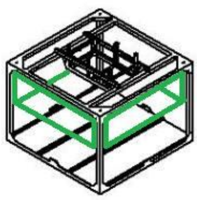
	about the atmosphere. They will assist with the selection of ideal equipment and techniques to analyze data, supporting the team throughout the whole process. Thomas Kuhn, associate professor in the Atmospheric Science Group, will be helping with funding through Luleå University of Technology. Professor Yamamoto will support the infrasound experiment by sponsoring the group with infrasonic microphone arrays developed at Kochi University of Technology in Japan. ***Gustafsson, Thomas. 2014.*** *ltu.se. Control Engineering. [Online] 05 03 2014. [Cited: 16 10 2016.] http://www.ltu.se/research/subjects/control/Nyheter-Aktuellt/Utlysning-av-stipendier-ur-Per-Bengtssons-stiftelse-1.110126?l=en.*

Outreach Programme	
Describe your outreach programme for before, during and after the REXUS/BEXUS flight campaign.	At the start of the project, a website will be created to inform about our experiment and the REXUS/BEXUS projects in general. Accounts will also be created on social media sites that will be interlinked with each other so that posting on one site will reach all the others. Frequent updates on the progress of the project will be posted on these accounts The update frequency will depend on the milestones reached by the team, with update intervals ranging from a month to a few days. In addition to these social media accounts, a YouTube channel will be created with the aim of making educational videos about the science surrounding the experiment, as well as presenting the mechanical and electrical aspects and methods in an educational manor. This will make it easier for those who do not know much about the subject to understand more about the experiment. The team will be interviewed by the Institution for System- and Space Technology at Luleå University of Technology for an article to be posted on their website. We will also present our project to students at our university and potentially to students at a local space focused high school. The team will also present the project to students at the university, and other high schools will be considered. Since the project will be collaborating with a project in Japan and doing analysis with a professor from USA, there might be some outreach possibilities there, which will make a more international outreach feasible. The aim is to produce data that can be presented and published in scientific conferences and papers, for example the International Astronautical Congress and the European Planetary Science Congress (EPSC) in Europe or a SpaceUp unconference in Sweden.

Experimental Set-up & Technical Information

Mechanics	
Describe your experimental set-up.	Each sensor box will contain: • A microphone array on the outside of the box to minimize the interference and measure the higher range of infrasound • Infrasound sensor, Paroscientific 6000-16B or 6000-23A, to measure the lower range of infrasound • Analogue to Digital Converter • Electrical filters, to improve signal clarity • Global Positioning System receiver • Memory • Wind sensors, to measure the relative wind speed for the balloon and wind direction. • Accelerometer, to measure vibrations • Microcontroller • Thermometer, to measure inside temperature. • Possibly resistors for heating the components in the box. Each box will be insulated to conserve heat and will be mounted on the gondolas flight train where it will be fastened to the cable. Each box will receive power from the gondola power supply and transfer/receive data via the downlink through cables.
Estimate the dimensions and the mass of your experiment (kg and m).	**Dimensions:** **Gondola Relay Box [0,25m x 0,25m x 0,25m]:** This shows all the components that will be attached directly in the gondola; • Electronic component box: **0,15m x 0,15m x 0,1m** **External Sensor Box [0,25m x 0,25m x 0,25m] [x~3]:** This shows all the components that will be attached in the self-contained, external module; • Mounting system: **0,05m x 0,05m x 0,10m** • Sensor Electronic Box: **0,15m x 0,15m x 0,1m**

	Mass: **Gondola Relay Box [~1,1kg]:** • Mounting system and holding frame: **0,7kg** • Sensor Electronic Box: **0,4kg** **External Sensor Box [~0,9kg per box]:** • Mounting System and holding frame: **0,5kg** • Sensor Electronic Box: **0,4kg**

Indicate the preferred position of your experiment:	The ideal position for the experimental modules would be to mount the sensor boxes on the flight train and the relay box anywhere on the upper section of the main gondola. The experimental setup, as mentioned before, works wirelessly, which has the added advantage of being able to situate the relay box anywhere on the main gondola. See Figure 5 in Appendix 1. The main reason for the external mounted sensor module is to allow for the most accurate measurements from the differential pressure transducer, thermometer, and accelerometer. Although having the sensors mounted externally would maximize the measurement accuracy, mounting the sensors onboard the main gondola would still achieve results within the defined scope. See Figure 6 in Appendix 1. In order to mount the module externally, the experiment would require some form of mounting system to attach the module to the main cable. Although in theory this could be mounted along any length of the cable, the further away from the main gondola, the better. This is due to the previously mentioned advantages of more accurate measurements. See Figure 4 in Appendix 1. To ensure that our relay box signals have minimal interference from other experiments on the gondola, the ideal position would be anywhere on the upper section of the gondola, see green highlight in figures 1, 2, and 3.  Fig*ure* 1: Front view of a gondola  Fig*ure* 2: Top view with mounting rails  Fig*ure* 3: Isometric view

Electrics/Electronics	
Will you need the 28 V DC power supply from the REXUS service system or power from the BEXUS gondola, respectively?	Yes.
Will you need (additional) batteries? What do you need for charging?	No.
Estimate the electrical consumption of your experiment (Ah or Wh).	The estimated electrical consumption is 10.7W per sensor box. The total electrical consumption of two sensor boxes during six hours of flight is estimated to be 129Wh.
Do you use any equipment with high inrush currents? If so estimate the current (A).	No.
Do you need auxiliary power? Do you need a separate umbilical?	No.
Use of uplink and downlink:	All the data from the sensors will be saved locally in each sensor box with high resolution. A lower resolution of the data will be downlinked during the flight. Uplink will be used for telecommands and to power down the system after landing. The downlink data rate can be between 0.005 and 0.02 Mbit/s. It can be scaled up or down if necessary.
Provide an event timeline, including the experiment actions during flight, such as timer or telecommand events.	All systems will be tested and initiated before lift-off when the experiment is mounted in the gondola and flight train. The experiment will be active during most of the flight except launch, cut-off and landing when the experiment will be in safe-mode. The experiment will be turned off after landing by telecommand. Low-resolution sensor data will continuously be sent to the ground station through the BEXUS downlink

Environmental Questions & Safety Issues	
Does the experiment use wireless devices?	No.
Does the experiment create any disturbing magnetic or electrical fields?	No.
Do you expect to use high voltages in any part of your experiment?	No.
Is the experiment sensitive to light?	No.
Is the experiment sensitive to vibrations?	Yes, vibrations could cause noise in the measurement of the infrasound. The effect of vibrations will be minimized by placing the sensor boxes outside of the gondola to avoid disturbances that may be caused by other experiments and the balloon itself. Vibrations from other sources will be detected by accelerometers to ensure that the impact of the vibrations will be mitigated in the final result.
Does the experiment generate vibrations?	No.
Will you use any flammable, explosive, radioactive, corrosive, magnetic or organic products?	No.
Will you use a laser?	No.
Is your experiment airtight? Are parts of your experiment airtight?	The experimental setup is not airtight; but some of the electronic components are. The sensor boxes will be mounted externally on the gondola flight train, and cannot be airtight as that would prevent vital functionality. Certain key components will be both airtight and watertight. The

	main component that will be protected is the memory storage as this stores all of the experiment-critical data.
Are there any hot parts (> 60°C)?	No.
Are there any moving parts? Are the moving parts reachable?	None of the modules or components of the experiments are moving, unless the flight train is unavailable for use for this experiment. If this is the case, the experiment will either be mounted on boom-arms, or on a hanging cable which may have moving parts.
Do you need any pressure systems from EuroLaunch before launch?	No.
Is there any aspect in your experiment which you believe may be viewed as a safety risk by others (regardless of whether you will mitigate this risk in your design)?	No.

Additional comments	*List of references*

- **Y Gibbons S Asming V Eliasson L Fedorov A Fyen J Kero J Kozlovskaya E Kvaerna T Liszka L Näsholm S Raita T Roth M Tiira T Vinogradov** The European Arctic: A Laboratory for Seismoacoustic Studies [Journal]. - 2015.
- **R Bowman D Johnson C Anderson J Phillips D Ronan T Lees J Gupta** Carolina Infrasound Scientific Report (HASP) [Journal]. - 2015.
- **T Bedard Jr A Georges** Atmospheric Infrasound [Journal]. - 2000.
- ***SAYA INC. 2016.*** *saya-net.com. [Online] SAYA INC, 2016. [Accessed on 16 10 2016.] http://www.saya-net.com/products/INF02.html.*
- ***Kochi University of Technology. 2016.*** *Faculty Members. kochi-tech.ac.jp. [Online] 2016. [Accessed on 16 10 2016.] http://www.kochi-tech.ac.jp/kut_E/about/prof/yamamoto-masa-yuki.html.*
- ***Gustafsson, Thomas. 2014.*** *ltu.se. Control Engineering. [Online] 05 03 2014. [Cited: 16 10 2016.] http://www.ltu.se/research/subjects/control/Nyheter-Aktuellt/Utlysning-av-stipendier-ur-Per-Bengtssons-stiftelse-1.110126?l=en.*

Appendix 1

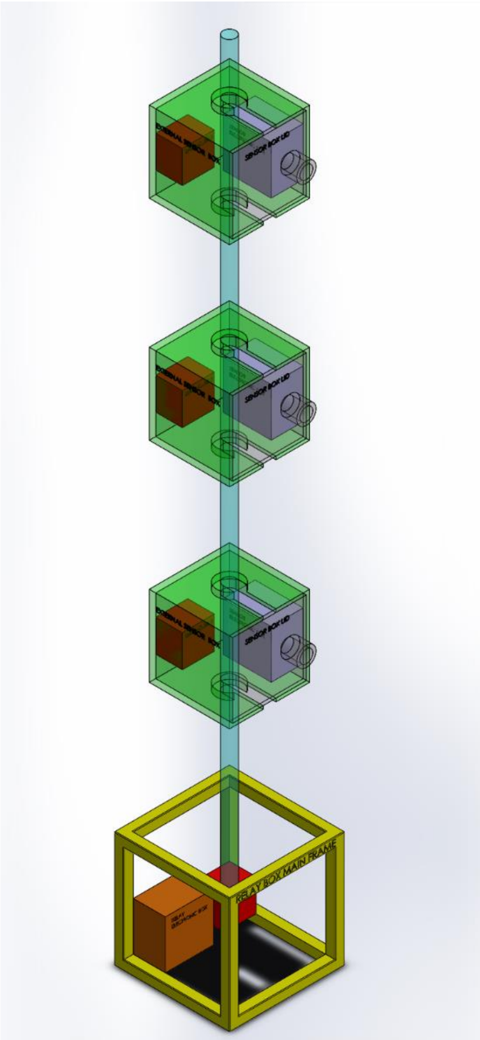


Figure 4: The set-up on the gondola and flight train. The green boxes are the sensor boxes, while the devices inside the yellow frame are the relay box devices within the gondola space. This model is not to scale.

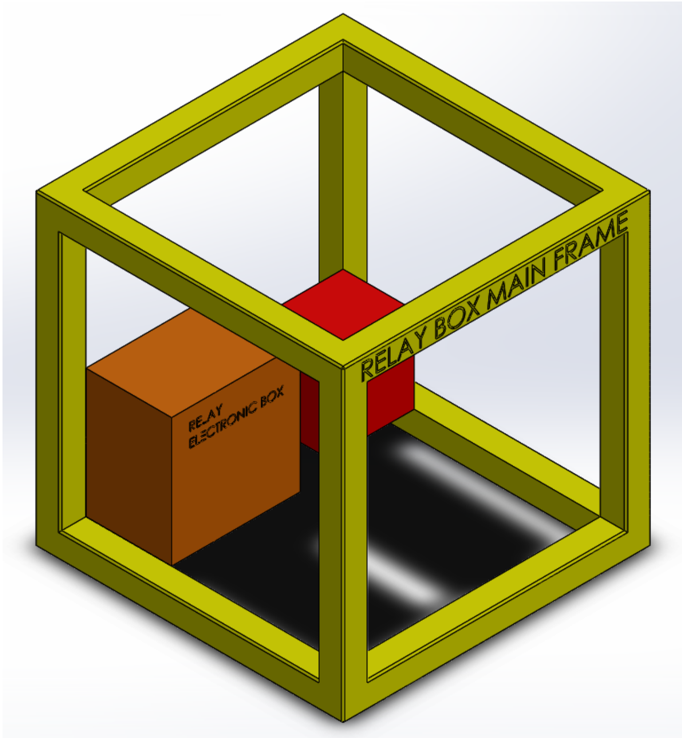


Figure 5: A close up of the gondola set-up for the relay box

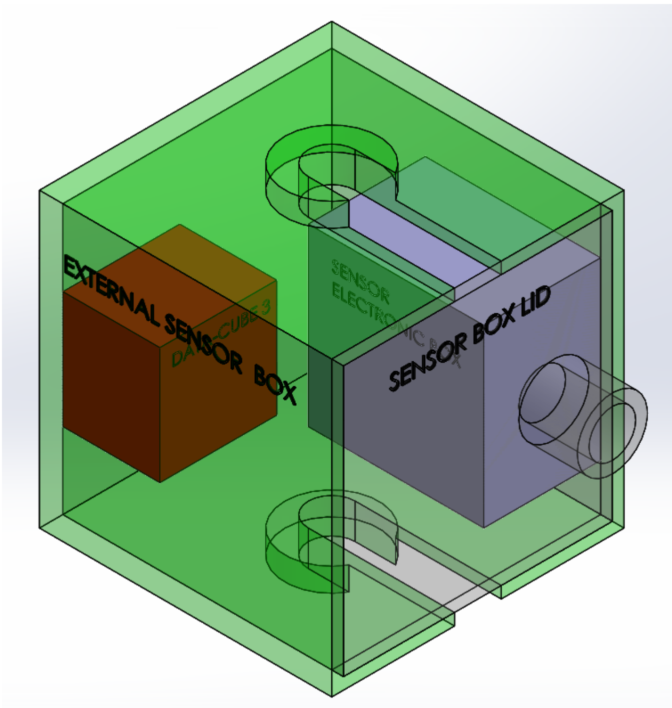


Figure 6: A close up of the external sensor box

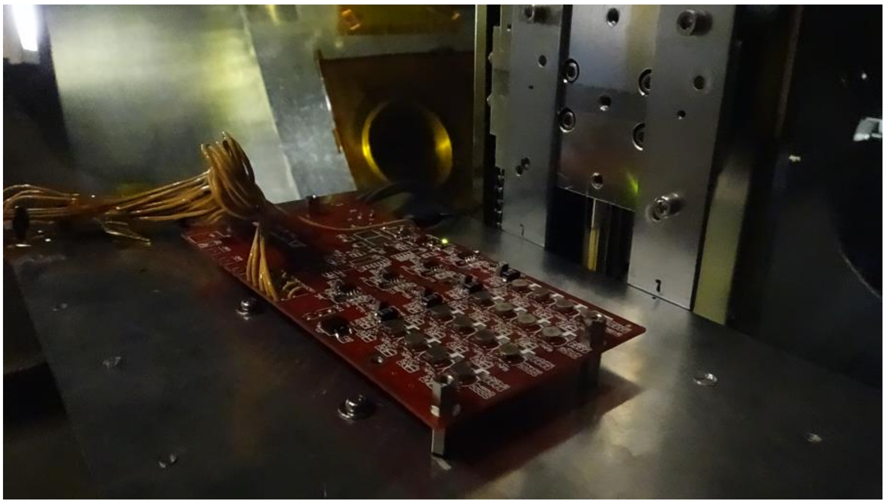


Figure 7: A photograph of the chassis-less Japanese infrasonic microphone array ‘ADXII-INF02’ from M.-Y. Yamamoto.

A special thanks to Rene Laufer