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Supplementing Engineering Technology Curriculum through Space Grants

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Supplementing Engineering Technology Curriculum Through Space Grants (WIP)

1. Abstract

In an Engineering Technology (ET) program with 5 different concentrations, it is not possible to cover the detailed theory and applications of all high-level classes that are taught in a dedicated single discipline engineering technology program. Through support from space grant consortia, that are annually funded by NASA to develop and implement student fellowships and scholarships programs, many research projects are tailored to equip students with necessary knowledge and skills that are not normally covered in regular classes. In this paper, a grant from the Louisiana Aerospace Catalyst Experiences for Students (LaACES) program is used to supplement the experience of a team of senior engineering technology students with 3 different concentrations (mechanical, computer, and mechatronics). The team will go through 2 semesters of training, hands-on activities, design, building, and testing to finally produce a 500-gram battery-powered payload (MegaSat) that will be launched to an altitude of 100,000 ft to measure weather parameters during the ascending and descending trips. The MegaSat will also measure the amount of solar energy that can be collected during the trip and the possibility of utilizing it to power the MegaSat partially or fully in future trips. The experience includes building circuits from scratch through prototyping, soldering surface mount electronic components, testing and troubleshooting, calibration and analyzing error in measurement and propagation of uncertainty. In addition, students will utilize data acquisition and analog to digital conversion techniques with Arduino microcontrollers and custom shields to read and save data collected during the trip to an SD card. Among many other skills, students will learn and practice teamwork skills, project management, planning, cost analysis, risk management, failure analysis, project documentation, as well as professional reporting and presentation. Along with these learning outcomes, students will analyze the collected data and compare results to theoretical values, when available, and present their findings before a panel of professionals. The acquired experience will be presented with examples and partial results of the project.

Keywords: NASA space grants, curriculum supplement, engineering technology

2. Background

2.1. Engineering Technology Program

In a small and relatively new Engineering Technology (ET) program with 5 different concentrations, such as the one in Southeastern Louisiana University, the curriculums are designed to meet the school requirement, Board of Regent (BoR) requirement, the Accreditation Board for Engineering and Technology (ABET) through its Engineering Technology Accreditation Commission (ETAC) requirement, as well as the requirements of the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC). However, being a program out of 3 programs housed under 1 department, with 5 ET concentrations, it is hard to cover all the high-level ET courses that can be covered in a dedicated ET department. The structure of the ET program, its concentrations, and its relation with other programs and departments, are illustrated in Figure 1. The five concentrations that are offered are Computer, Construction, Electrical Energy, Mechanical, and Mechatronics. The average annual enrollment in the 13-years old program is about 300 and the average annual number of graduates is about 30. The enrollment and graduation numbers are listed in Table 1.

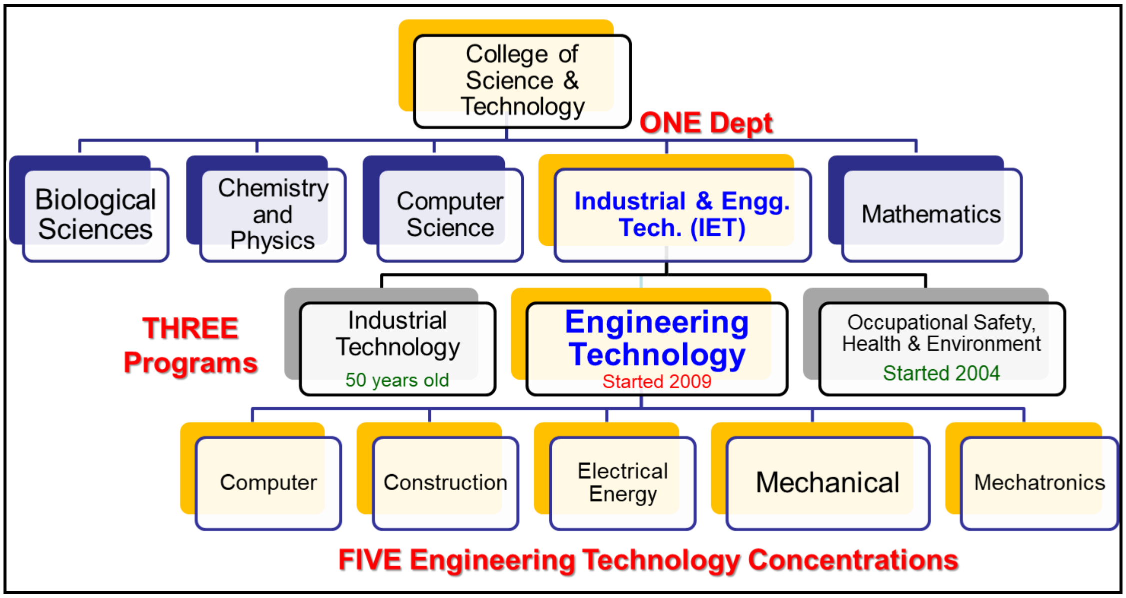

Figure 1 Engineering Technology Program at Southeastern Louisiana University

To meet all the aforementioned requirements, some curriculum limitations took place. These limitations resulted in having only 33 credit hours dedicated for each concentration, 31 common ET credit hours shared among the 5 concentrations, in additions to 10 hours of Math, 15 hours of Natural science, 17 hours of General Education, 12 hours of English, and 6 hours of Technical Electives, totaling 124 hours for the ET degree. Figure 2 and Figure 3 show sample ET curriculum sheet and chart for the mechanical ET concentration. Because of these limitations, advanced courses, (such Measurements and Data Acquisition, Kinematics of Machines, Vibration) are not taught as separate classes but have some of their components scattered and embedded into other classes to fulfill the minimum requirements. Also, no separate labs are offered but rather many labs are partially embedded with the relevant lectures due to the hour's limitations.

Table 1 Enrollment and Graduation data for the ET program

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Enrolled	139	228	266	296	337	330	317	317	293	296	224	290	275	278
Graduated	0	1	11	11	32	26	27	34	38	26	18	34	28	24

A close look at the mechanical ET concentration reveals that a total of 46 hours is contributing directly or indirectly to the concentration as a core class or a general ET class. This includes the 2 3-hour senior design classes, a 3-hour project management class, and a 1-hour seminar class. The two technical elective classes may contribute to the concentration but most probably will be from other concentrations, or even different program (such as Industrial Technology, Math, or Computer Science), based on the availability of the classes.

CATALOG YEAR: **2021-2022**

Engineering Technology - MECHANICAL Concentration

Bachelor of Science

NAME: W#:

	Grade	Semester	Minimum Grade of D Required:	Grade	Semester	Minimum Grade of C required:	
ENGLISH (12 hrs)			ENGL 101 Freshman Composition (3 hrs)			OSHE 111 Introduction to OSHE (3 hrs)	ENGINEERING TECHNOLOGY (31 hrs)
			ENGL 102 Critical Reading and Writing (3 hrs)			IT 407 Six Sigma Industrial Quality (3 hrs)	
			ENGL 230, 231 *or* 232 (3 hrs)			ET 100 Introduction to Engineering Technology (3 hrs)	
			ENGL 322 Intro to Prof and Technical Writing (3 hrs)			ET 111 Engineering Graphics (3 hrs)	
NATURAL SCIENCE (15 hrs)			Biology - GBIO 151 (3 hrs)			ET 202 Computer Applications (3 hrs)	
			Biology - BIOL 152 (1 hr)			ET 213 Electrical Circuits (3 hrs)	
			Chemistry - CHEM 121 Lecture (3 hrs)			ET 241 Introduction to Engineering Materials (3 hrs)	
			Physics - PHYS 191 Lecture (3 hrs)			ET 490 Seminar (1 hr)	
			Physics - PLAB 193 Lab (1 hr)			ET 492 Project Management (3 hrs)	
			Physics - PHYS 192 Lecture (3 hrs)			ET 493 Senior Design I (3 hrs)	
			Physics - PLAB 194 Lab (1 hr)			ET 494 Senior Design II (3 hrs)	
GENERAL EDUCATION (17 hrs)			ART, DNCE, MUS, *or* THEA (3 hrs)			ET 205 Mathematical Methods for Engineering (3 hrs)	MECHANICAL CONCENTRATION (33 hrs)
			HIST 101, 102, 201, or 202 (3 hrs)			ET 212 Introduction to Programming (3 hrs)	
			COMM 211 Introduction to Public Speaking (3 hrs)			ET 271 Engineering Statics (3 hrs)	
			ECON 201 or ECON 202 (3 hrs)			ET 283 Manfacturing Processes (3 hrs)	
			ANTH, ECON, POLI SCI, PSYC, *or* SOC (3 hrs)			ET 371 Engineering Dynamics (3 hrs)	
			SE 101 or Free Elective (2 hrs) not required of transfer or re-admitted students with 30 hours or more.			ET 375 Applied Thermodynamics (3 hrs)	
	Grade	Semester	Minimum Grade of C Required:			ET 376 Applied Fluid Mechanics (3 hrs)	
MATH (1			MATH 175 Precalculus with Trigonometry (5 hrs)			ET 381 Strength of Materials (3 hrs)	
			MATH 200 Calculus I (5 hrs)			ET 385 Mechanical Design (3 hrs)	
						ET 425 Control and Automation (3 hrs)	
						ET 478 HVAC (3 hrs)	
						[1]Technical Elective (3 hrs)	Tech Elec (6 hrs)
						[1]Technical Elective (3 hrs)	

[1]Technical Electives can be chosen from:
ET 322 Programmable Logic Controllers
ET 362 Solar Thermal Systems
ET 400 Internship
ET 422 Mechatronics Systems
ET 480 Advanced Strength of Materials
ET 484 Advanced Manufacturing Techniques
ET 488 Robotics and Automation
IT 351 Machine Tool Technology
IT 444 Computer Integrated Manufacturing (CIM)

LAST UPDATED: 08/25/2021 TOTAL SEMESTER HOURS: 124

Figure 2 Mechanical Engineering Technology curriculum sheet

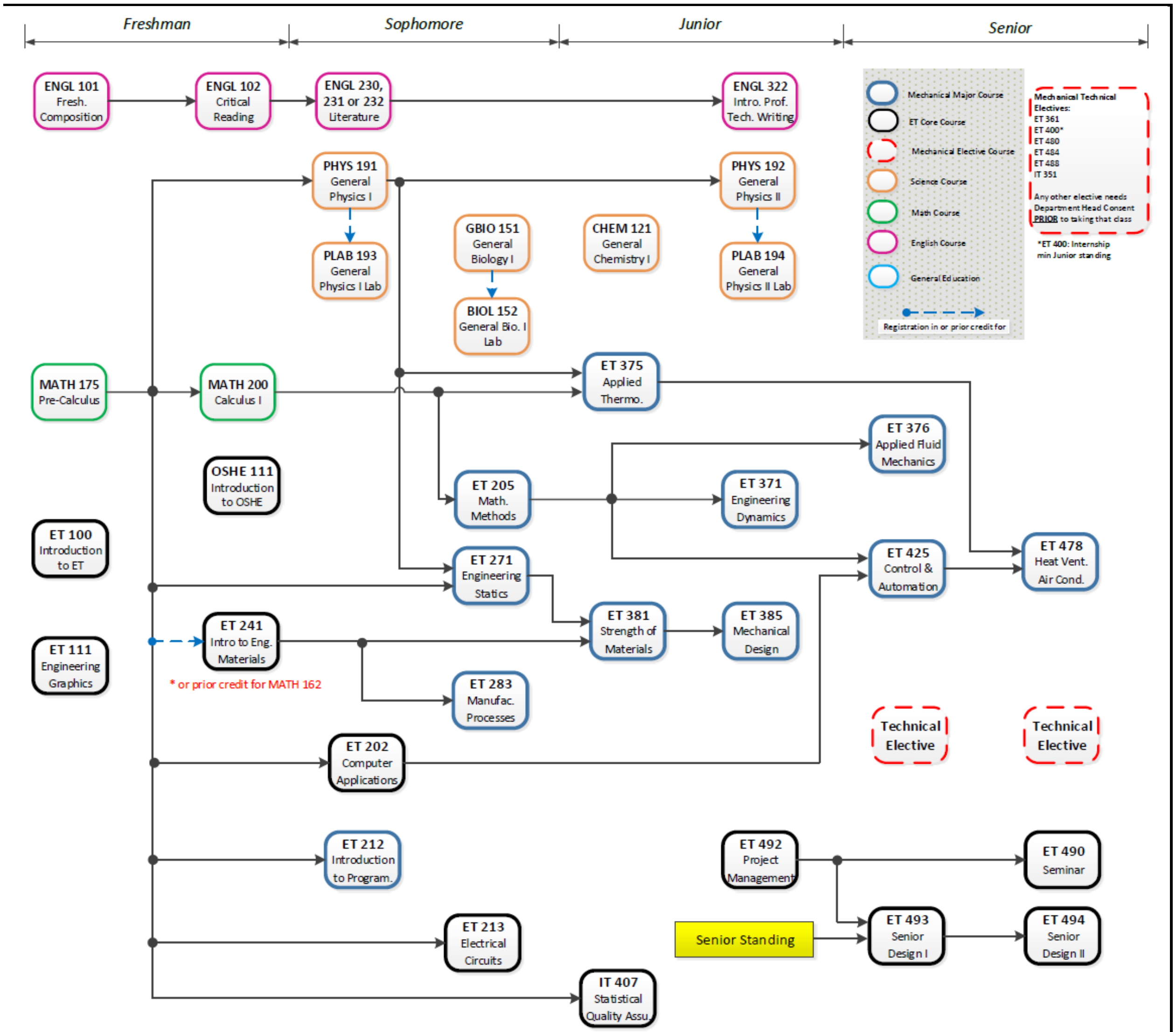

Figure 3 Mechanical Engineering Technology curriculum chart

Throughout the life of the ET program, the two senior design classes, as well as research, educational, and hands-on projects embedded in other high-level classes, were used to supplement the knowledge and skills of the ET students to equip them with the important skills and prepare them for their career. At the end of these projects, students conclude their experience and present their work at local conferences, professional meetings, and school showcases. This comes in the form of oral presentations, posters, as well as professional conference proceedings [1 - 11]. Furthermore, some groups prepare a detailed student manual for the project they completed so that it can be used later on to guide other groups in getting the same knowledge through hands-on experience. This initiative is applied and sponsored mainly through the senior design project funds as well as through grants from agencies such as Louisiana NASA space grant (LaSPACE) and Louisiana BoR. These grants provide several Project-Based Learning (PBL) experience for the engineering technology students. The PBL is proven to be an integral part of curricula in engineering technology program, [12].

2.2. Louisiana Space Grant Consortium

The Louisiana Space Grant Consortium (LaSPACE) is a statewide consortium of academic institutions and other organizations that was established in 1991 under the National Space Grant College and Fellowship Program, which is a national network managed by the National Aeronautics and Space Administration (NASA). The mission of LaSPACE is to enhance Aerospace technology, Solar System exploration, and Space Science research, education, and public awareness throughout the state of Louisiana thereby promoting technical workforce development, state economic growth, and a scientifically literate citizenry. The LaSPACE programs include Research, Graduate Fellowships, Workforce Development, and Pre-College Educational and Public Outreach, to strengthen the Science, Technology, Engineering, and Math (STEM) education for a diverse aerospace workforce, and to develop the research and economic infrastructure to boost Louisiana's contribution to the aerospace "frontier" [13]. The Louisiana Aerospace Catalyst Experiences for Students (LaACES) Program is one of the programs that runs for a full academic year and through which LaSPACE funds teams from different schools in Louisiana to design and build small payloads and fly them to a high altitude (about 100,000 ft) through helium balloons. During the first semester of the program, student teams from participating schools go through a series of lectures and hands-on activities, through LaSPACE-LaACES webpage, to help build their skills in basic electronics, sensor interfacing, real-time programming, mechanical development, and project management. During the second semester, students apply these skills to design, develop, fabricate, and fly a small (less than 500 gram) balloon payload. Payloads from all student teams are then flown at the end of the academic year under the management of LaSPACE at the NASA Columbia Scientific Balloon Facility in Palestine, TX, or other adequate areas, [14].

3. LaACES Project Outline

In this paper, the focus will be in a grant from the Louisiana Aerospace Catalyst Experiences for Students (LaACES), and how it is used to supplement the experience of a team of senior engineering technology students with 3 different concentrations (mechanical, computer, and mechatronics). The experience and skills acquired by the students through this project will be highlighted in the following section. Through LaACES program, the team goes through 2 semesters of training, hands-on activities, design, building, and testing, to finally produce a 500-gram battery-powered payload (MegaSat) that will be launched, through a balloon, to an altitude of 100,000 ft to measure weather parameters during the ascending and descending trip. The MegaSat of the engineering technology team of Southeastern Louisiana University is planned to measure the amount of solar energy that can be collected during the trip and the possibility of utilizing it to power the MegaSat partially or fully in future trips. The launch trip is planned for the last week of May and will be organized by the LaSPACE administration to accommodate the 11 participating teams from seven different schools in Louisiana. During the trip, each team will present their Final Readiness Review (FRR) document, get their payloads inspected against the size and mass specs, then integrate them in two flight strings. The two flight strings then will be connected to two helium-filled balloons, released to ascend in the space up to 100,000 ft then descend down after balloons are cut from the strings. The ascending and descending trips, altogether, usually take two and have hours, from release to landing. The chase trip is scheduled during the descending trip and will follow the tracking information from the precise GPS modules integrated with each flight string, to pick up the payloads, retrieve the SD cards from the MegaSat boards, get the collected data and analyze them. Each participating team plans some scientific experiment such as measuring the ozone, ultraviolet, solar irradiance, … etc, during the trip. At the end of the launch trip organized by LaSPACE, each team will give a science presentation demonstrating their achievement and the results of their data analysis. The engineering technology team will also present their work including the design, testing, calibration, and pre-launch preparation to a panel of engineering technology faculty and industrial partners as a partial fulfillment of their senior design II project.

The LaSPACE management team prepared a series of recorded lectures along with hands-on activities for both semesters of the project and compiled them as the Student Ballooning Course (SBC), [15]. All the hardware, electronics, tools, training kits, and equipment used in the project were either provided or funded by the LaACES grant. Through the SBC and its accompanying hands-on activities, the project allows student to get the experience of design, develop, and launch a high-altitude cube satellite to collect and analyze data collected from space. The experience includes building circuits from scratch through prototyping, soldering through hole and surface mount electronic components, testing and troubleshooting, calibration, analysis of error in measurement, and propagation of uncertainty. In addition, students learn how to utilize data acquisition and analog to digital conversion techniques while programming Arduino microcontrollers and custom GPS shields to read and save data collected during the trip to an SD card. The team is planned to attach a set of solar panel films to the payload to evaluate the possibility of collecting enough solar energy during the launch trip and whether it can be utilized to partially of fully power the payload in future trips. Among many other skills, students learn and practice teamwork skills, project documentation, professional reporting and presentation, project management, planning, cost analysis, risk management, and failure analysis. Along with these learning outcomes, students will analyze the collected data and compare results to theoretical values, when available, and present their findings before a panel of professionals. To professionally document the progress, each team member utilizes a shared Google Drive to create a Project Journal in a Google document. The individual Journal acts as the master document for the project, follows the format of a research report, and is updated multiple time during the week to report any progress. The author checks the project journals and gives feedback on a weekly basis to help student to prepare the required professional reports and correct any issues encountered in the work done. There are two required individual reports (SkeeterSat Calibration, and Sensor Interface & Calibration), and three required group professional reports namely, Preliminary Design Review (PDR), Critical Design Review (CDR), and Flight Readiness Review (FRR) that will be submitted to the LaSPACE administration for review throughout the period of the project. In addition, a group academic report is required at the end of each semester for the two Senior Design classes.

3.1. Phase I Milestones

The Student Ballooning Course is split in two phases. Phase I is dedicated to the Fall semester, and during which the following major tasks were accomplished:

- Circuit Prototyping
- Soldering Skills Training
- Building, testing, calibrating the SkeeterSAT, and performing uncertainty analysis
- Programming Arduino microcontroller
- Data Acquisition, Digital I/O, and Analog to Digital Conversion
- Building GPS logger with Arduino
- Performing sensor calibration

All students went through a hands-on soldering training and soldered major components through a solder tutorial kit. To apply these skills, the major sub-projects, the SkeeterSAT, was completed right after.

3.1.1. SkeeterSAT

The SkeeterSAT, Figure 4, is a simple data collection system that uses auditory tones from a speaker to present recorded temperature data. So, it is used as a form of a temperature sensing device. Every student studied the circuit diagram and the theory behind it, and was given all the individual components along with the empty PCB, and completed the soldering of the components. Subsequently, they performed a calibration process using the audio software, Audacity, to produce the Fast Fourier Transform (FFT) for the resulting tone, a hotplate, a precise digital thermometer and a beaker. The students could relate the expected theoretical output of the circuit to the actual output and performed an uncertainty analysis after the calibration.

In the SkeeterSAT, temperature is detected using the RL0503-55.36k-122-MS thermistor, which acts as a variable resistor whose value changes with respect to the temperature it is subjected to. The varying resistance of the thermistor is then processed by the TLC556 Timer, and output as the pitch of the speaker's audio as follows: when the temperature detected increases, the resistance will decrease, and the pitch of the audio will increase; when the temperature detected decreases, the resistance will increase, and the pitch of the audio will decrease. With this knowledge, it should be possible to use this system as an accurate temperature sensor by analyzing various spectra of the speaker's audio and developing a relationship describing how the frequencies of the spectrum change with respect to changes in temperature.

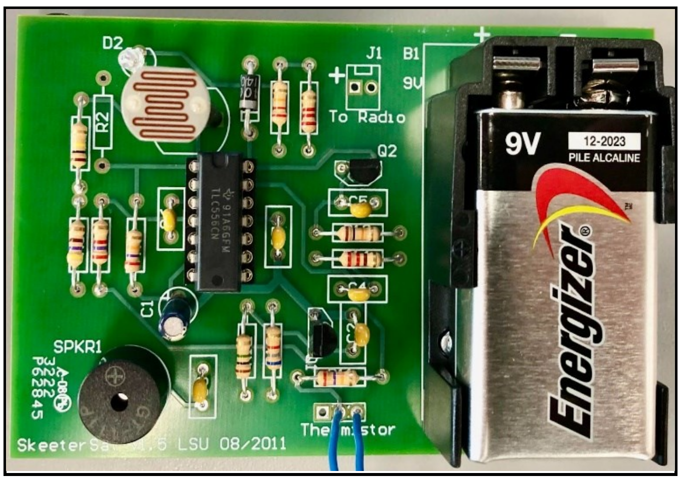

Figure 4 Completed SkeeterSAT project (soldered from scratch)

A sample of the FFT spectrum, produced by the Audacity software, during the calibration process is shown in Figure 5. Students used the concept of uncertainty propagation to find the uncertainty in the resulting temperature based on the uncertainty in the frequency reading. The relation between frequency and temperature was described by a best fit formula in the form of:

$$T = a_1 f^{n_1} + a_2 f^{n_2} + a_3 f^{n_3} + a_4 \tag{1}$$

And the following formula was utilized to calculate the relative uncertainty:

$$\frac{\sigma_T}{T} = \sqrt{\left(a_1 n_1 f^2 \frac{\sigma_f}{f}\right)^2 + \left(a_2 n_2 f \ \frac{\sigma_f}{f}\right)^2 + \left(a_3 n_3 \frac{\sigma_f}{f}\right)^2} \tag{2}$$

The final calibration process and propagation of uncertainty analysis resulted in the following chart, Figure 6.

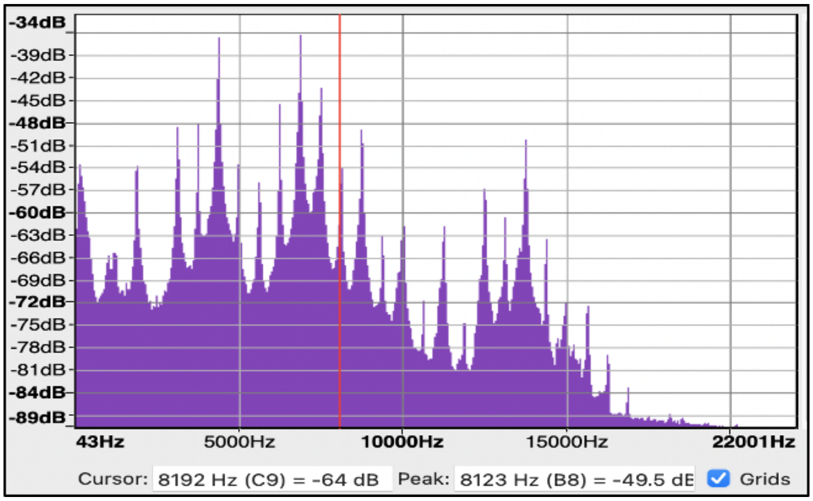

Figure 5 Sample Frequency spectrum of SkeeterSAT beep recording

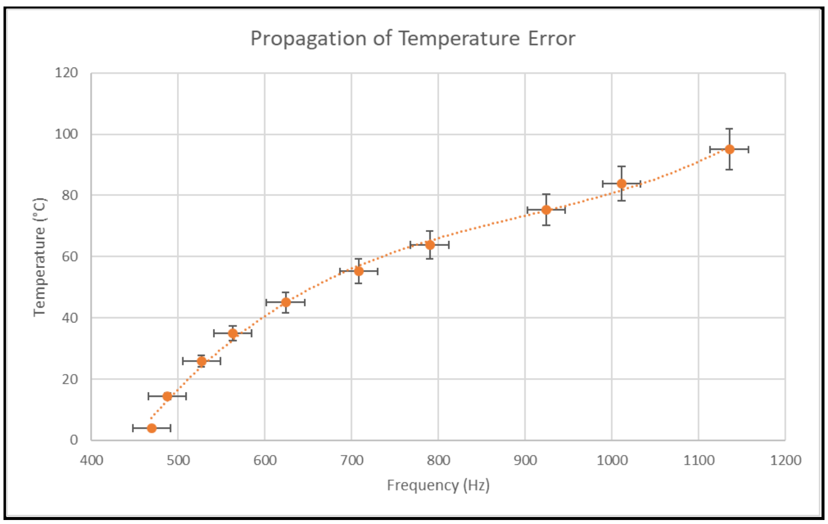

Figure 6 SkeeterSAT Final calibration chart

Students could conclude that this circuit produced an approximation for temperature defined by a function of the system's fundamental frequency, allowing for predictions of temperature values in the range of 4.0 °C to 94.0 °C with an accuracy of ±7-8 %, Table 2.

Table 2 Beeb frequencies and the resulting temperatures with the associated uncertainties

Freq. (Hz)	Temp. ± σ_T (°C)	Temp. ± σ_T %
1135	95.9 ± 6.5	95.9 ± 7
1011	81.7 ± 5.6	81.7 ± 7
924	75.1 ± 5.1	75.1 ± 7
790	65.3 ± 4.5	65.3 ± 7
708	57.1 ± 4	57.1 ± 7
624	45 ± 3.3	45 ± 7
563	32.8 ± 2.4	32.8 ± 7
527	24.1 ± 1.8	24.1 ± 8
488	13.1 ± 1	13.1 ± 8
469	7.4 ± 0.6	7.4 ± 8

3.1.2. GPS Logger Shield

The second major sub-project that student completed as part of their training and preparation for the main project was the GPS Logger Shield, Figure 7. Student assembled an Adafruit Ultimate GPS Logger Shield with Arduino Mega controller, coded them to gather GPS data and store them in an SD card.

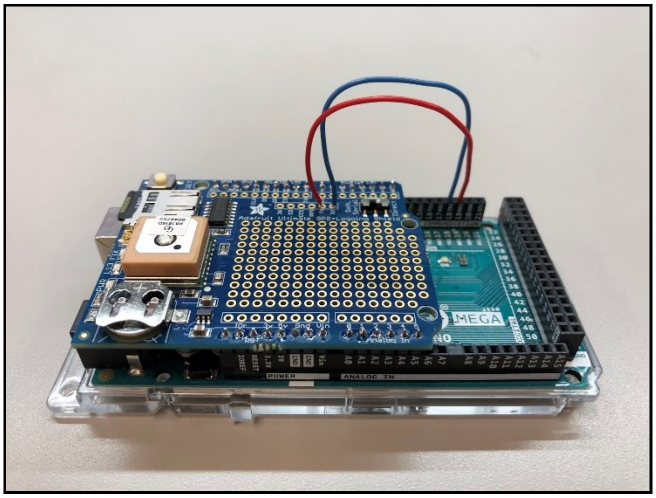

Figure 7 Adafruit GPS Shield Assembly

Student learned the different formats of data sent by the GPS module. Students used NMEA Sentence format and collected data for time, latitude, longitude, and speed. A sample collected data that was stored in the SD card and retrieved after the experiment is shown in

	A	B	C	D	E	F	G	H	I	J	M
1	Tag	UTC Time	Status	Latitude	N/S	Longitude	E/W	Speed (kn)	Course (deg)	Date (ddmmyy)	Mode/Checksum
2	$GPRMC	145021	A	3030.205	N	9028.186	W	0.75	142.5	211122	A*73
3	$GPRMC	145022	A	3030.205	N	9028.186	W	0.61	139.34	211122	A*7E
4	$GPRMC	145023	A	3030.205	N	9028.185	W	0.57	138.13	211122	A*79
5	$GPRMC	145024	A	3030.205	N	9028.185	W	0.6	141.23	211122	A*74
6	$GPRMC	145025	A	3030.204	N	9028.185	W	0.65	149.01	211122	A*77
7	$GPRMC	145026	A	3030.204	N	9028.185	W	0.66	155.58	211122	A*75
8	$GPRMC	145027	A	3030.205	N	9028.185	W	0.57	145.53	211122	A*71
9	$GPRMC	145028	A	3030.205	N	9028.185	W	0.45	141.5	211122	A*7C
10	$GPRMC	145029	A	3030.206	N	9028.185	W	0.31	141.38	211122	A*77
11	$GPRMC	145030	A	3030.206	N	9028.185	W	0.31	147.43	211122	A*76
12	$GPRMC	145031	A	3030.206	N	9028.185	W	0.27	142.27	211122	A*77
13	$GPRMC	145032	A	3030.206	N	9028.185	W	0.26	129.2	211122	A*7D
14	$GPRMC	145033	A	3030.206	N	9028.185	W	0.32	128.44	211122	A*79
15	$GPRMC	145034	A	3030.205	N	9028.185	W	0.3	92.01	211122	A*4C
16	$GPRMC	145035	A	3030.205	N	9028.185	W	0.25	87.57	211122	A*4F
17	$GPRMC	145036	A	3030.205	N	9028.185	W	0.25	70.89	211122	A*4F
18	$GPRMC	145037	A	3030.205	N	9028.185	W	0.22	71.28	211122	A*42
19	$GPRMC	145038	A	3030.206	N	9028.185	W	0.2	82.9	211122	A*41
20	$GPRMC	145039	A	3030.206	N	9028.185	W	0.29	82.33	211122	A*4F
21	$GPRMC	145040	A	3030.206	N	9028.185	W	0.27	100.81	211122	A*7C

Figure 8 Sample data collected from the Adafruit GPS Shield

3.2. Phase II Milestones

Phase II, which is the Payload Development and Deployment Phase, is dedicated to the Spring semester, and during which the following major tasks are planned to be completed:

- Project Management Plan
- Preliminary Payload Design
- System Development
- System Integration
- System Verification
- Environmental Testing (Vacuum & Temperature)

Some of these tasks are still ongoing and the launch trip is planned at the 3rd week of May. Below is a highlight of these tasks along with the knowledge and skills associated with them.

3.2.1. Project Management Plan

Students discussed with the author the distribution of the workload and signed a team contract according to the following chart, Figure 9.

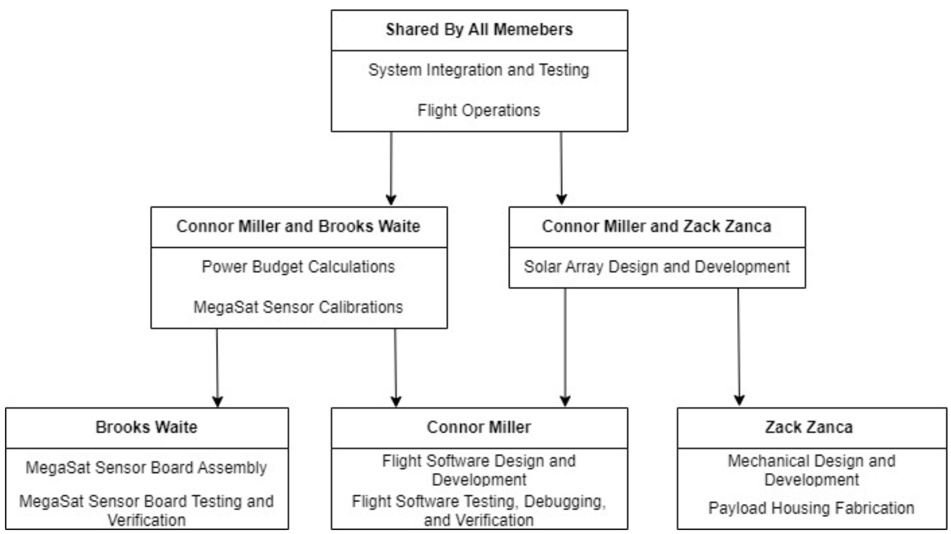

Figure 9 Team Workload/Responsibility Distribution

The team followed the timeline that was drafted at the beginning of the project, and updated the timeline frequently to indicate the completion of tasks.

3.2.2. Payload Mechanical Design

The team worked to meet the design requirements and restrictions including the mass and dimension limits, temperature and vacuum resistance, and used a ¾ inch polystyrene insulation board to build the box (rectangular prism) containing the main system board (MegaSat). The final design for the payload was a rectangular prism with a base of 22 cm by 22cm and a height of 15 cm. It is required to have holes for the humidity sensor, external temperature sensor, and solar panel connectors. The solar panel film will be glued to the four sides of the box. A CAD model was developed and multiple designs for the internal layout of the box was tried until the final layout appearing in Figure 10 was adopted. The box is required to maintain the MegaSat and attached sensors steady during the trip. It is also required to keep the battery steady and separated from the board to avoid any generated heat.

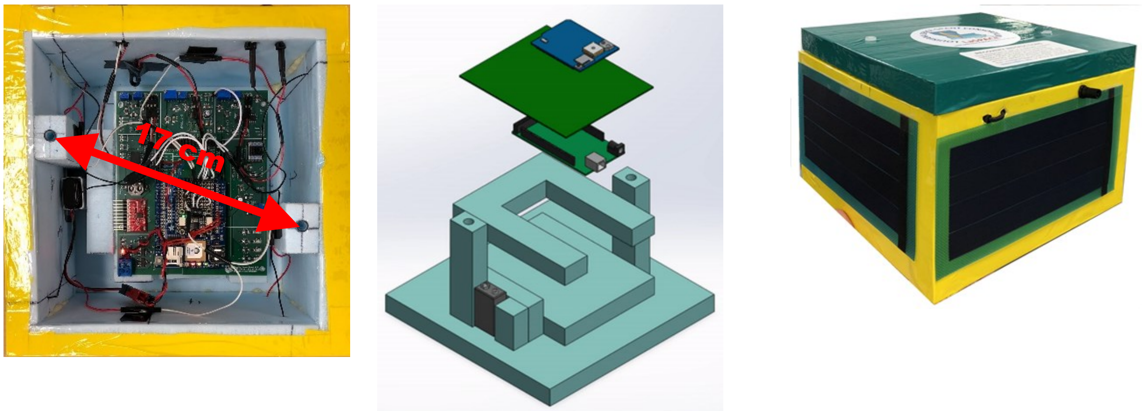

Figure 10 Payload Structure. Left: Top View, middle: Exploded View, right: 3D View

3.2.3. Electrical Design

The team used Arduino Mega 2560 as the system controller. The MegaSat sensor board, a custom PCB designed by LaSPACE, provides the sensors for the weather conditions including two temperature sensors, a pressure sensor, and a humidity sensor. An array of external solar cells is used to measure solar radiation levels the payload experiences during flight. The Adafruit GPS Logger Shield is used to communicate with GPS satellites to record altitude, velocity, and location of the payload. The GPS shield also has a module for a micro-SD card to record data, as well as a real-time clock. The system's components are supplied power by a DC battery source that can be 9-12V. Ordinary PN junction diodes (1N457 Diode) were used for temperature sensing while a near-linear voltage output of the HIH-4000 humidity sensor is used to measure the change in relative humidity. The SSCDANN015PAAB5 TruStabality sensor from Honeywell is used to measure pressure. This sensor has two analog voltage outputs, ranging from 0.25V to 4.75V (5-95% of 5V), corresponding to a detectable range of 0-15 psi of absolute pressure. The second output, however, is connected to an operational amplifier to provide a highly sensitive amplified output to detect extremely low pressures while in vacuum conditions. The GPS module is contained on the GPS logger shield. This module can provide various types of GPS data in the form of NMEA sentences according to the 0183 protocol. Finally, an array of four photovoltaic solar cells is glued to the outer surface of the payload container and the open circuit current of the solar array is measured by the Adafruit AN219. This is will be utilized to estimate the potential solar energy during the actual flight.

3.2.4. MegaSAT System Concept

This was attained through designing all functional groups and components leading to the high-level complete system diagram appearing in Figure 11. The diagram shows five major components that can be divided into two functional groups. The first group, denoted by the red shading, is composed of the power consuming components. These components include the Arduino Mega 2560, the MegaSat Shield, the current sensor, and the GPS Logger Shield. The other group is the non-power consuming components, denoted by green shading. These consist of the batteries that supply power to the system and the solar panels that will supply a voltage to be measured by the Arduino.

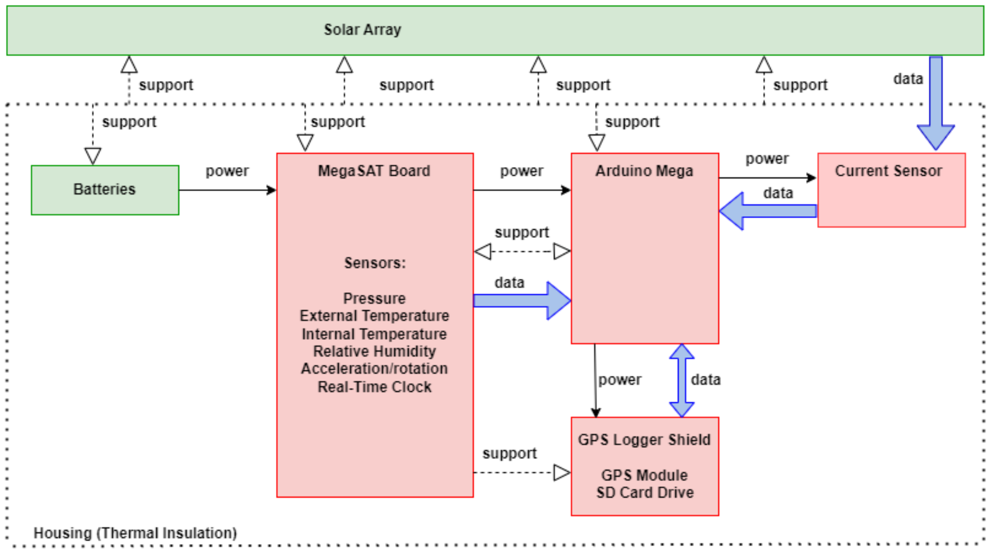

Figure 11 High-level Complete System Diagram

3.2.5. MegaSAT Sensor Board Assembly and Calibration

All components were soldered to the MegaSat board and it was assembled with the GPS shield, and the Arduino Mega to match the system design described above.

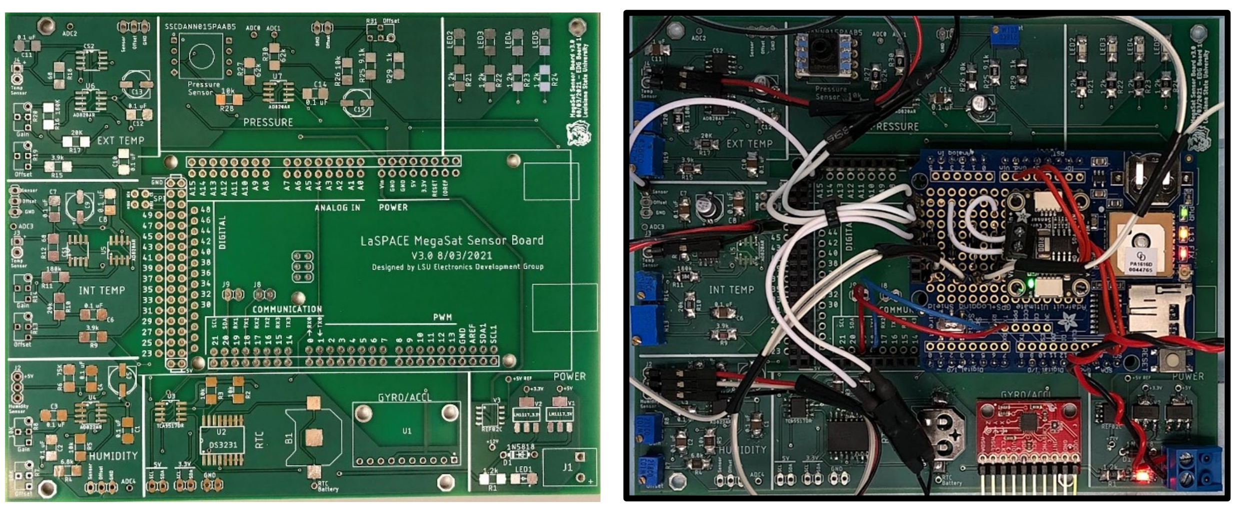

Figure 12 MegaSat board. Left: As Received, right: Assembled with the GPS Shield and & DC Current Sensor

Temperature sensors (internal and external) were calibrated using multiple points. The external temperature charts are shown in Figure 13. A hotplate, a precise digital thermometer and a beaker were used to perform the calibration. Other sensors were calibrated in a similar way.

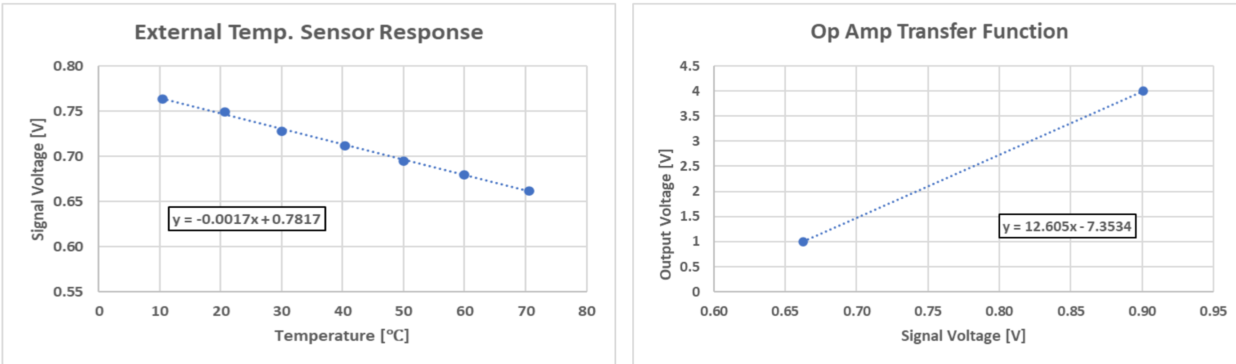

Figure 13 External Temperature Sensor Calibration

3.2.6. Flight Software

The team developed the flight software with multiple control and output components. The flowcharts of the software are shown in Figure 14 and Figure 15.

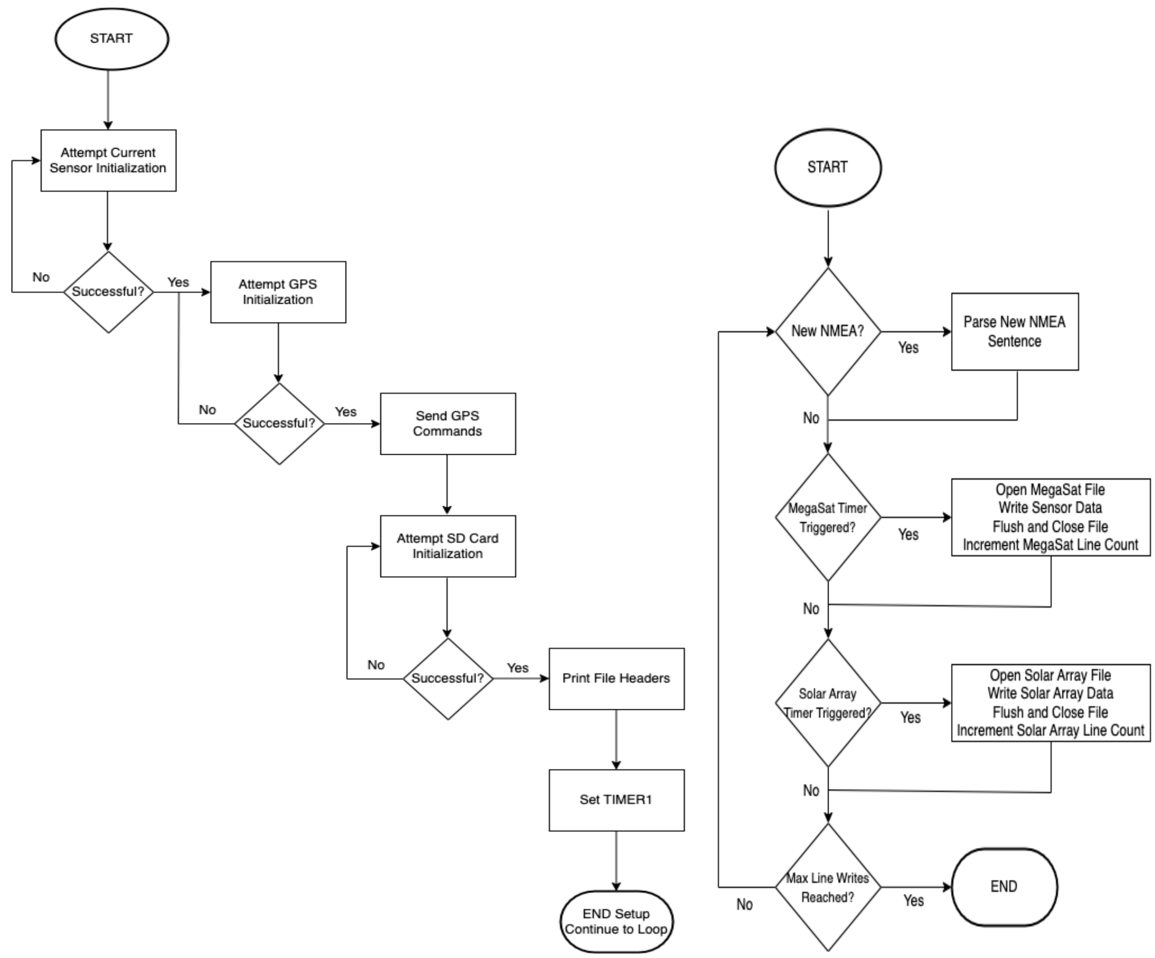

Figure 14 Flight Software flowcharts. Left: Setup function, right: Loop function

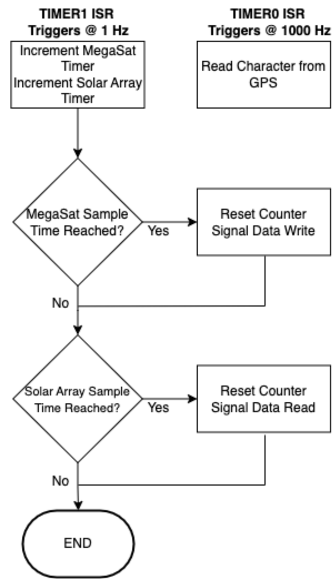

Figure 15 Flight Software flowcharts. Interrupt Service Routines

3.3.7. Payload Tests

Once the software was completed and debugged for errors, the system was tested for one to two hours and the output data files from the SD card were inspected. Code was modified to fix issues encountered in file naming, and the system was then taken for a trip to Louisiana State University (LSU) and tested in the vacuum chamber. Test was successfully completed and could withstand all the low temperatures (up to -40 F) and vacuum that expected to be encountered in the space.

Figure 16 Team members in front of the Thermal/Vacuum Chamber Test at LSU
Left to right: Brooks, Connor, Zack

System is planned to be tested with a shake table as well as subjected to a drop test to ensure it can withstand the turbulences and shocks during the flight.

4. Project Outcomes

So far, the two phases of the projects allowed the students to acquire several knowledge and skills. These include but not limited to teamwork, time and project management, communication, oral presentation, circuit design and troubleshooting, soldering, data acquisition, sensor calibration, uncertainty analysis, data logging, system integration, interfacing, coding,

In addition, the team presented three times and participated with 2 posters at different venues. They are planned to do two more presentations, one to present their FRR, and the second is to present their data after the launch trip in May.

At the time of submission of this paper, one team member was hired by Boing and received an offer from NASA because of his efforts in this project.

5. Conclusion

Through this space grant, students from engineering technology could utilize a PBL to acquire skills and knowledge that they do not usually get in their curriculum. This supplements the knowledge acquired during the course of study at the Engineering Technology program. The acquired experience is presented with some examples and partial results in this paper.

6. Acknowledgement

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