ARLISS2022 **report**

Submission date: November 17, 2022

• **Team information**

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CanSat class	Open class

• **Members**

role	**Name (grade)**
PM	**Wang Fangcheng**
Accounting/Control Team Leader	**Hiromi Hirano**
structural team leader	**Amane Amakawa**
Circuit team leader	**Michinari Kake**
sub PM	**Naoya Hasegawa**
sub PM	**Akihiro Kushima**

• **CanSat production purpose/reason for participation in the competition**

Achieve a record of 0m in flyback that has never been achieved before.
For. There are still few examples of flybacks by drones, and it is difficult to achieve 0m.
The ability to move and hover is very advantageous.

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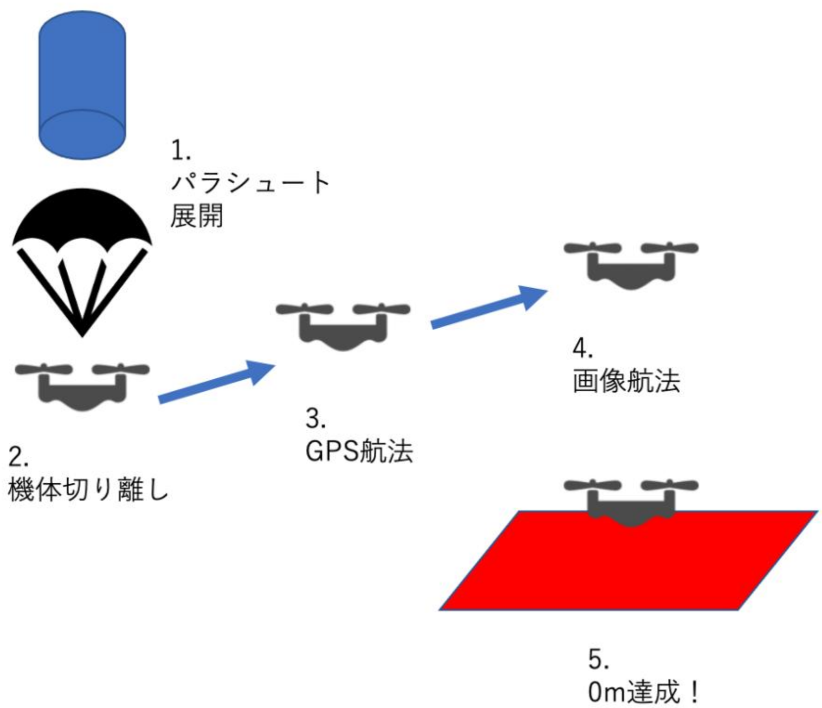
Chapter 1 **Mission Statement**

Achieved 0m for the first time in flyback history using a multicopter.

Multiple teams have achieved 0m with CanSat runbacks, but 0m with flybacks has yet to be achieved . Last year, a team from the University of Tokyo proposed a new approach to achieving 0m, using a multicopter flyback, and demonstrated that it is an effective method. However, the technology to smoothly transition from aircraft deployment to autonomous flight and to accurately land on a target using image navigation, which is essential for achieving 0m, is still under development. **In particular, power shortages during long and long-distance flights are a serious issue. The goal of this mission is to solve these technical issues and achieve a flyback distance of less than 5 meters. An even higher goal is to use visual navigation to become the first person in history to reach zero meters.**



Chapter 2 **Success Criteria**

minimum success	1. The parachute deploys/functions 2. The aircraft can be released from the case 3. The aircraft and the case can be separated 4. The aircraft arms can be deployed 5. Self-position can be estimated using GPS etc. 6. Logs can be obtained 1. Parachute resistance can be changed at an appropriate altitude 2. Able to reach within 5m of the goal point using GPS navigation etc. 3. Appropriate
full success	termination determination and termination processing can be performed 4. The aircraft can be terminated without damage

advanced success	1. The position of the target point relative to the aircraft can be estimated from the captured image. 2. It is possible to land at the goal point using image navigation.

Chapter 3 **Setting requirements**

3.1 **System requirements (requirements for ensuring safety and regulation)**

Request number	System requirements (ARLISS launch safety standards)
S1	**The total mass of the aircraft, case, and accessories to be dropped by** S1 is 1050g or less
S2	The size of the S2 **aircraft is 146 mm or less in diameter and 240 mm or less in height.**
S3	S3 **aircraft can be easily released from the cylindrical carrier**
S4	The quasi-static load (over 10G) during S4 **launch may impair its functionality to meet safety standards. Tests have confirmed that this is not the case.**
S5	Tests have confirmed that the vibration load (30Hz to 2000Hz, 15G or more) **during** S5 launch does not impair the functionality required to meet safety standards.
S6	**Tests have confirmed that the functions required to meet safety standards are not impaired by the** shock load (40G or more) during S6 **rocket separation (when parachute is deployed).**
S7	S7Has **a deceleration mechanism to prevent it from falling at dangerous speeds near the ground, and its performance has been confirmed through tests. is made of**
S8	As a countermeasure against S8 **loss, it is possible to check the dropped position of the aircraft/case using GPS, etc. and its effectiveness has been confirmed through testing.**
S9	**Communication between** S9 aircraft ground stations is possible
S10	**It has been confirmed that it is possible to comply with the regulations for turning off the power of radio equipment at the time of** S10 launch (devices **that are FCC certified and have a power output of 100 mW or less do not need to be turned off. Also, when using a smartphone, it is FCC certified and requires a software or hardware switch . things that can be turned off)**
S11	**We have confirmed that we are willing and able to adjust the** S11 radio channel. **There is**
S12	S12 **CanSat, whose design has been confirmed to meet S1-10, performs everything from loading the rocket to starting the mission.** We have been able to conduct end-to-end tests simulating the process from start to recovery after launch, and there will **be no major design changes related to** safety in the future.
S13	S13Able **to maintain stable posture in the air**
S14	**Handle lithium polymer batteries with extreme caution, including before and after the** S14 mission.
S15	S15 **monitors altitude and remaining battery power during flight, and if it is determined that it is difficult to continue the mission, lowers the throttle and makes a soft landing.**
S16	**If an emergency occurs during** S16 flight, a forced landing instruction will be sent from the ground station via radio to ensure safety. **make a soft landing**

S17	You can store and prepare the CanSat for dropping within 5 minutes.

3. 2 mission request

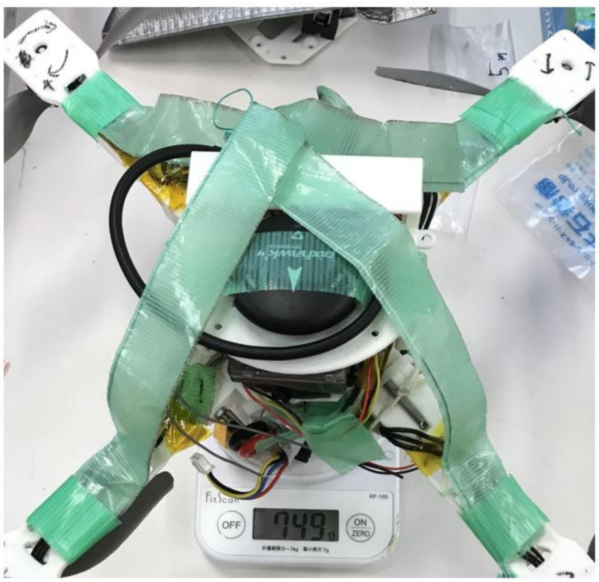
number	Mission requirements
M1	Using the motor, the aircraft can be controlled by continuously obtaining enough thrust for flight for about 5 minutes.
M2	The main parachute for stabilizing the aircraft can be deployed immediately after the aircraft is released.
M3	The case can be deployed without getting tangled with the parachute.
M4	The arms of the aircraft can be deployed when a sufficient distance is secured between the case and the aircraft.
M5	After deploying the arms and stabilizing the posture, the aircraft can be separated from the case.
M6	It has been confirmed that autonomous control without human intervention will be implemented during the mission.
M7	GPS navigation allows the aircraft to autonomously guide itself to a position where the camera can photograph the goal point.
M8	Can take images of the surface
M9	The relative position of the goal point and the aircraft can be estimated from images taken by .
M10	Using image navigation, the aircraft can be guided close to the goal point and make a soft landing.
M11	Appropriate termination judgment and termination processing can be performed.
M12	After the mission, it is possible to submit the specified control history report to the management and judges and explain the logs and acquired data.

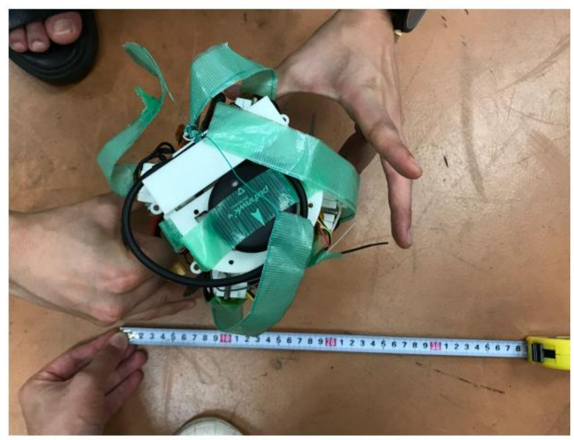
Chapter 4 **System specifications**

4.1 **Aircraft appearance**

Diameter [mm]	When stored: 210 When expanded: 570
Height [mm]	When stored: 280 When expanded: 180
Mass [g]	Aircraft: 749 Cases: 151 Total: 900

The arms were designed to open and close as shown in the following photo. I closed the arms, put them in the case, and when I got out of the case, the arms unfolded.





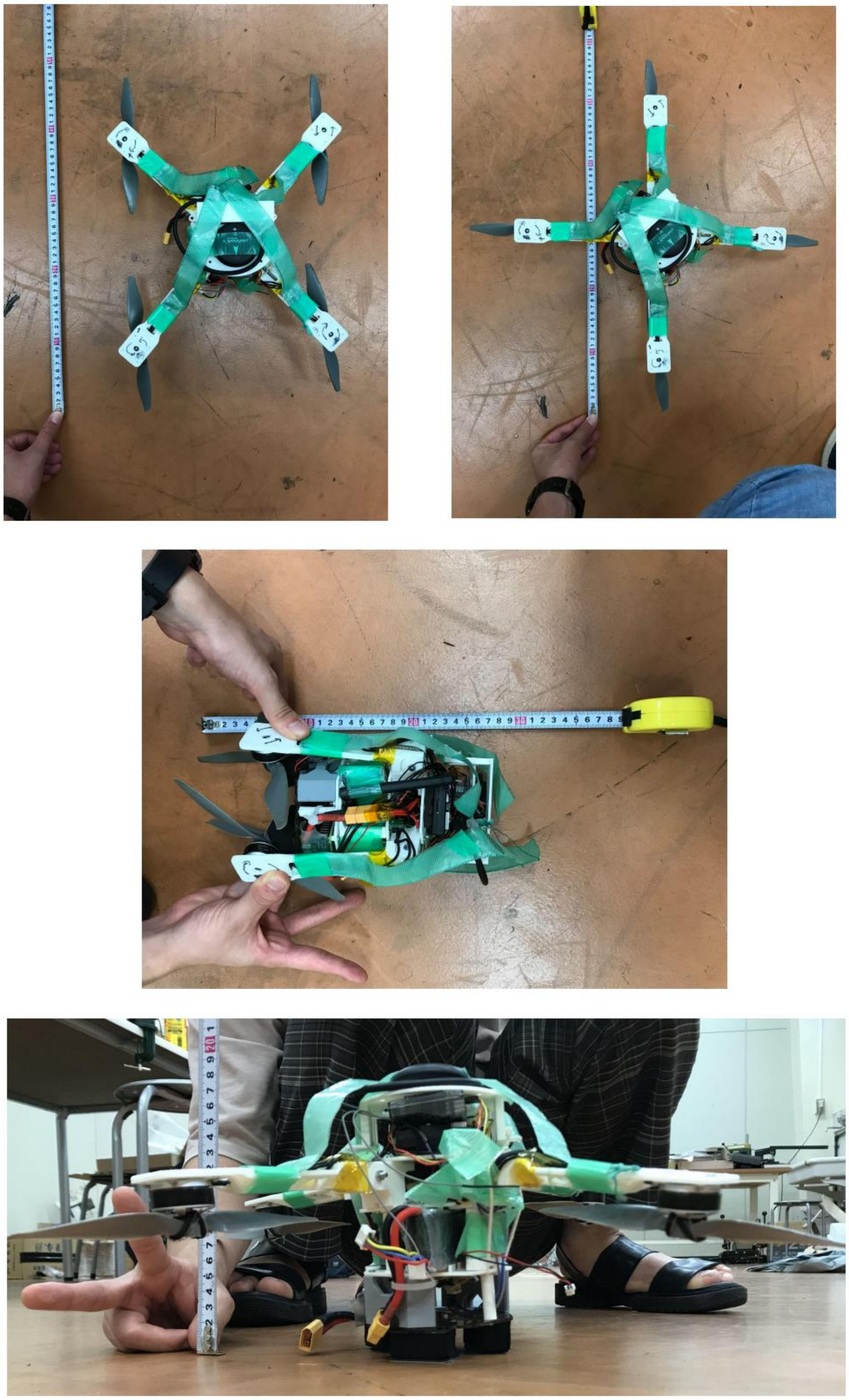


Figure 3.1.1. **Appearance of the aircraft**

4.1 **Inside view and mechanism of the aircraft**

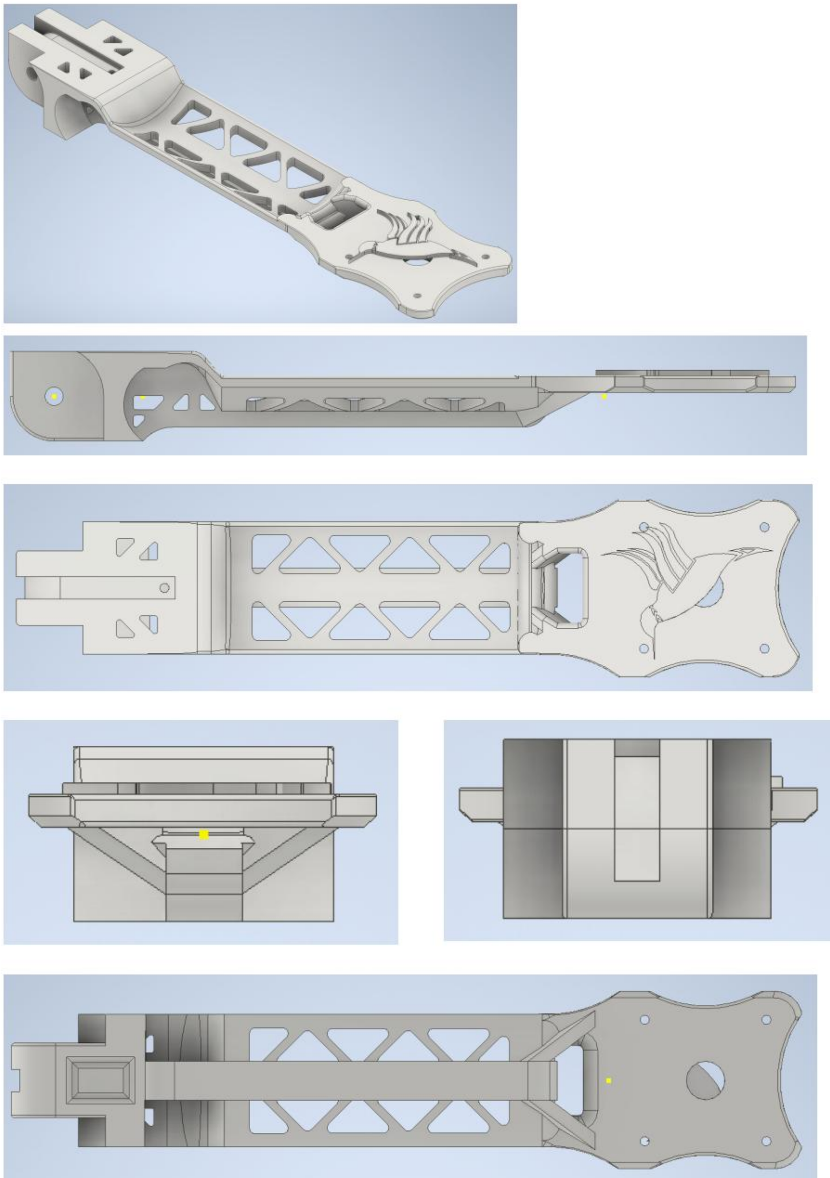


Figure 3.2.1. **Arm part of the aircraft**

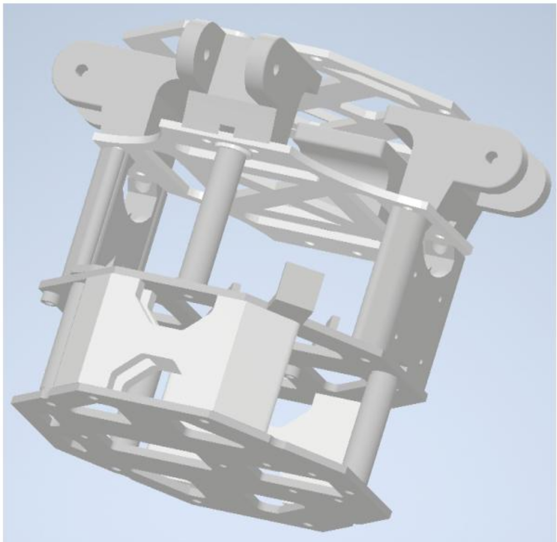
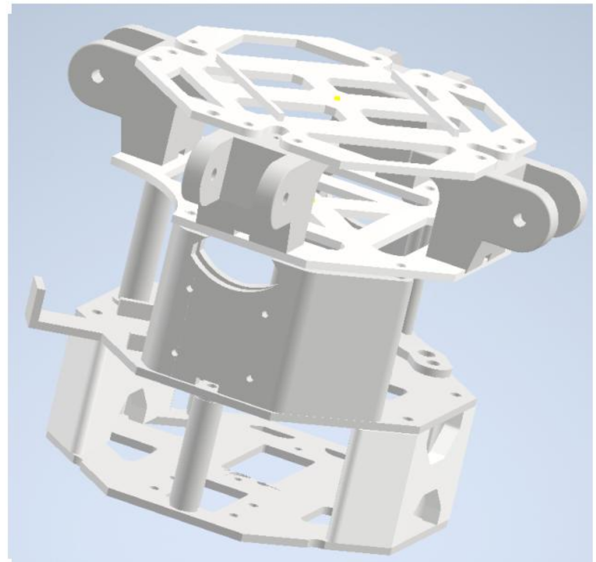
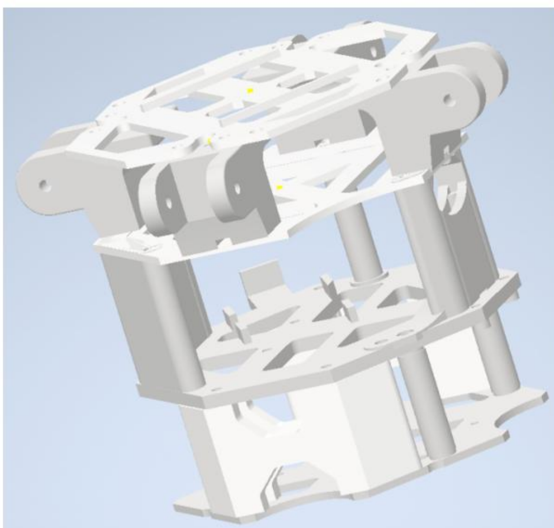
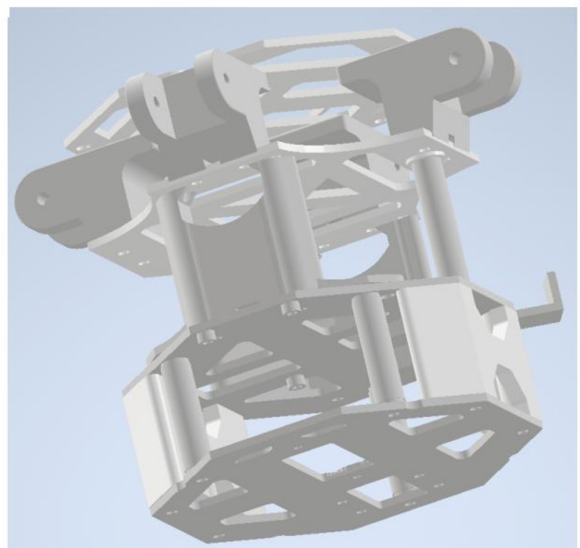
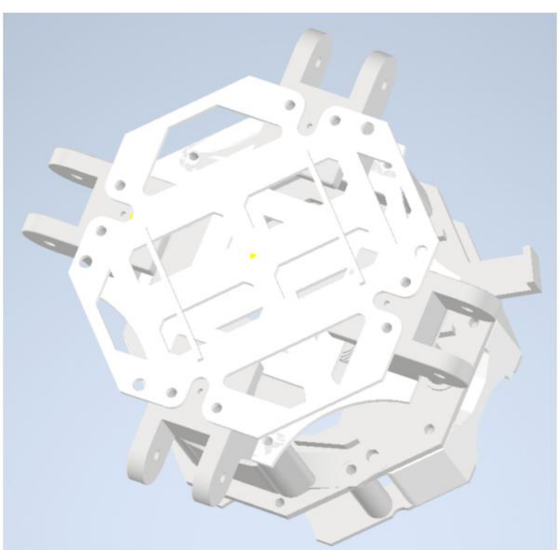
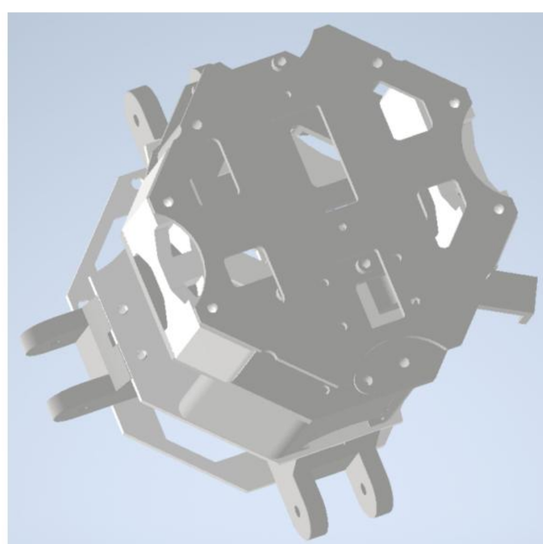







Figure 3.2.2. **Fuselage section of the aircraft**

The structure of the aircraft consists of four boards, nine supports, four arms, and their bases. Each part has been made lighter by removing the meat. In particular, the arms are designed to have a nearly Y-shaped cross-section, taking into account the ability to fold, reduce weight, and withstand stress. In addition, the pillars were designed to have spacers and hollow cylinders arranged alternately to reduce weight and increase durability. The distance sensor, which is placed facing downwards on the bottom, was designed to be placed inside the fuselage, so a hole for the distance sensor was drilled in the bottom board. The sides of the bottom board were gouged out to prevent the propeller from interfering with the propeller when stored.

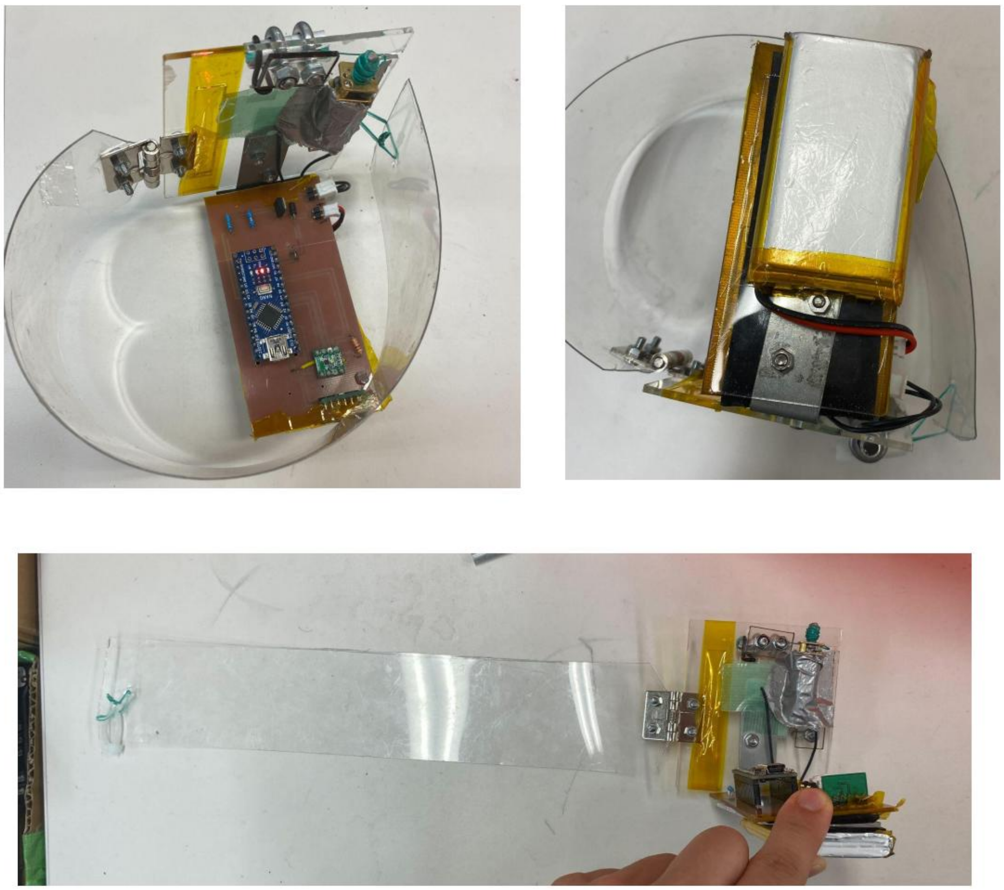


Figure 3.2.3. **Case structure**

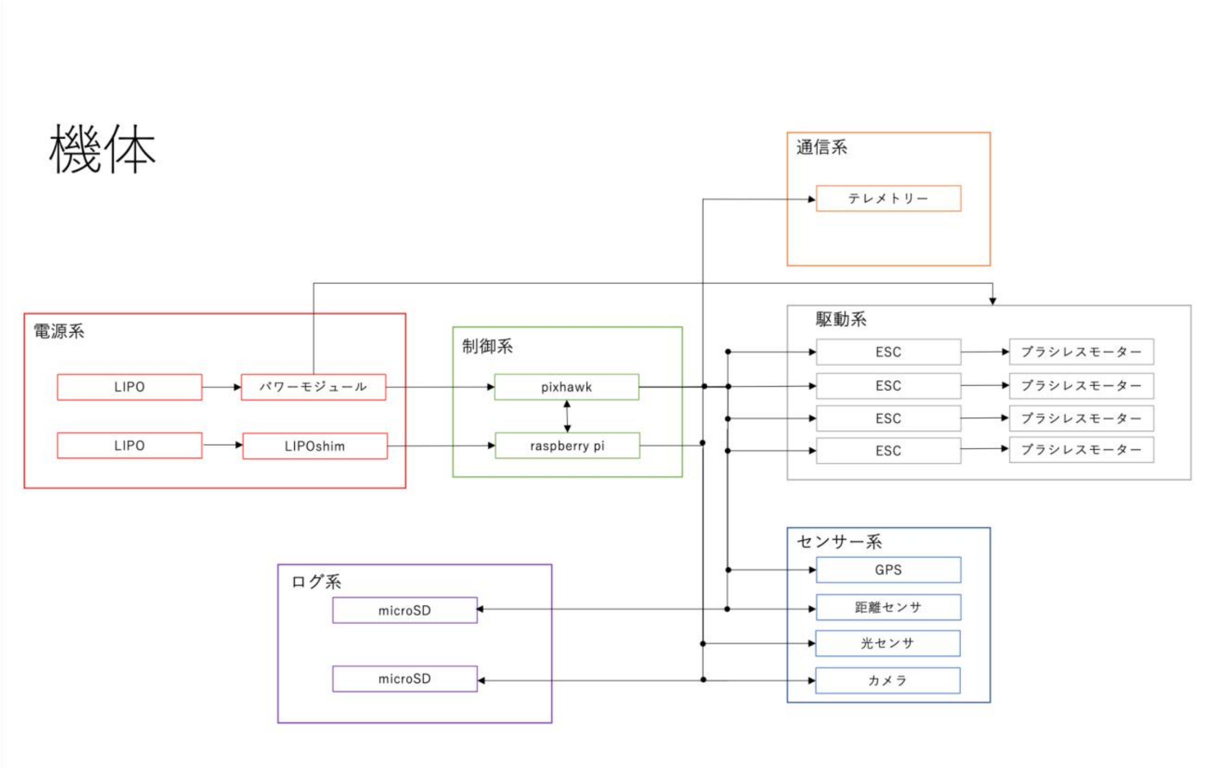
The structure of the case basically consists of two planes. One is the plane to which the circuit for the case and the parachute are connected, and the other is the plane to which the arm that holds the drone and the part from which the drone is suspended are connected. **The case is made by connecting these two planes with an L-shaped metal fitting . When releasing the arm holding the drone, it uses the physical force generated by the parachute's deployment. This is a mechanism to reduce the number of intervening parts as much as possible and achieve more reliable operation. Additionally, after releasing the arm, the drone is suspended from the parachute via the case for several seconds to stabilize the drone. When releasing this, the mechanism is such that the drone is separated by activating a motor based on detection by sensors. The reason why the same mechanism is basically adopted for these two different operations is to avoid diversification of defects. Problems with one mechanism can also occur with the other, so try again.**

It is easy to obtain synergistic effects in experiments, reduce costs, and realize a more reliable mechanism.

Helpful.

The surface of the base is covered with nonflammable Kapton tape to prevent ignition at contact points.

ÿCircuit characteristics



The flight controller, Pixhawk, is responsible for navigation and control of the aircraft. You can also set the aircraft's destination to Pixhawk.

Raspberry **pi is responsible** for guiding the instructions . **Pixhawk includes an ESC that controls the motor, a GPS sensor, and a distance sensor.**

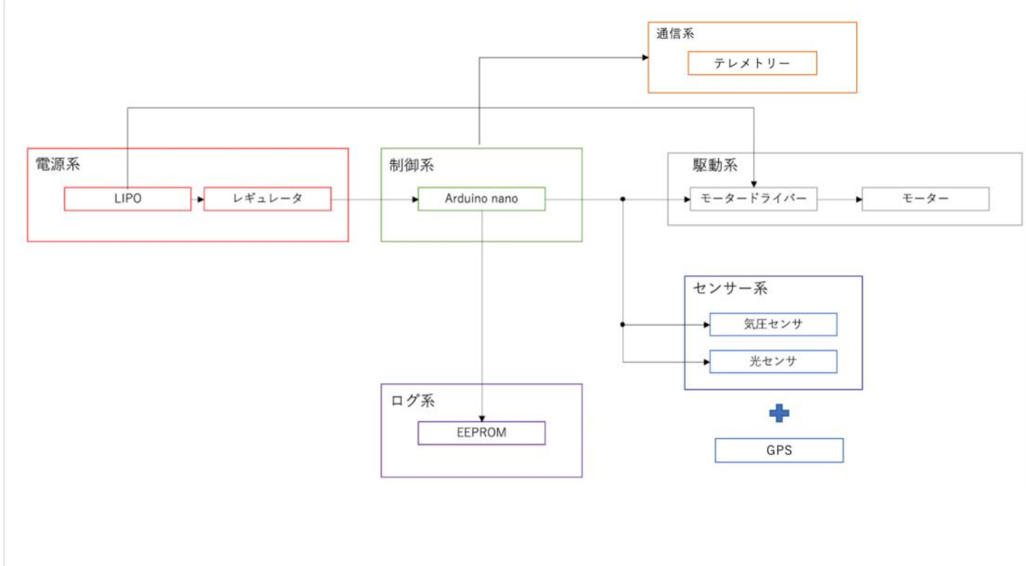
The sensor is connected. In addition, there is an optical sensor that recognizes when the arm is deployed, and a

The camera that takes the picture **is connected to the Raspberry pi. The parts list is as follows.**

pixhawk4	https://cdn.sparkfun.com/assets/d/d/9/9/3/Pixhawk4-DataSheet.pdf
raspberry pi zero 2W	https://datasheets.raspberrypi.com/rpizero2/raspberry-pi-zero-2-w-product-brief.pdf
telemetry	https://easel5.com/service/products-information/products/wireless-module/es920lr2/
Esc	http://www.gforce-hobby.jp/products/G0211.html
brushless motor	https://www.little-bellanca.com/SHOP/21364.html
GPS	http://www.holybro.com/product/pixhawk-4-gps-module/

distance sensor	https://www.sgbotic.com/products/datasheets/sensors/DE-LiDAR%20TFmini%20Datasheet-V1.7-EN.pdf
light sensor	https://akizukidenshi.com/download/ds/macron/MI5_series_jp.pdf
camera	https://docs.rs-online.com/3b9b/0900766b814db308.pdf
3s LIPO 1800mAh	https://www.amazon.co.jp/2 pack Lipo battery 3S-1800mAh-SkylarkM4-FPV250 Mini Shredder 200INDY250-Nighthawk-250RC Heli Plane UAV Drone FPV/dp/B07H7GSQMQ?th=1

Case



Regarding the case, we decided to use Arduino instead of **the Raspberry Pi used in the aircraft to reduce power consumption. and said. Regarding the recognition that the aircraft has been ejected, we use two pressure sensors and a light sensor, making it redundant. It has longevity. Additionally, the deployment actuator is motor driven. The parts list is as follows It is.**

1s LIPO	https://www.li-polymer-battery.com/wp-content/uploads/2021/03/LP606090-3.7V-4000mAh-without-protection-circuit-and-wires-Datasheet.pdf
arduino nano	https://www.arduino.cc/en/uploads/Main/ArduinoNanoManual23.pdf
atmospheric pressure sensor	https://akizukidenshi.com/download/ds/bosch/BST-BME280_DS001-10.pdf

motor	https://www.sengoku.co.jp/mod/sgk_cart/detail.php?code=EEHD-0SDW
light sensor	https://akizukidenshi.com/download/ds/macron/MI5_series_jp.pdf
telemetry	https://easel5.com/service/products-information/products /wireless-module/es920lr2/
GPS	https://akizukidenshi.com/catalog/g/gK-09991/

ÿAbout the power

source used: Lipo batteries are used for both the case and the main body. The LiPo battery is installed inside the aircraft and is designed to minimize impact when dropped. Additionally, a shock

absorbing sponge is attached to the aircraft. For transportation and storage, use Lipoguard (URL shown below) and carry salt just in case. Also, be sure to check the remaining amount to prevent over-discharge. https://www.amazon.co.jp/Strongest Flameproof-LiPo-Guard-LiPo Battery-Safety Bag /dp/B00D77M7WW/ ref=sr_1_5_mod_primary_new?keywords=Lipoguard &qid=1659085881&sbo=RZvfv%2F%2FHxDF%2BO5021pAnSA%3D%3D&

ÿMission Sequence

The link for the mission sequence is as follows.

https://drive.google.com/file/d/1KmxLbAi5wnleChj0Q8fSPLNg4LziRTfG/view?usp=sharing

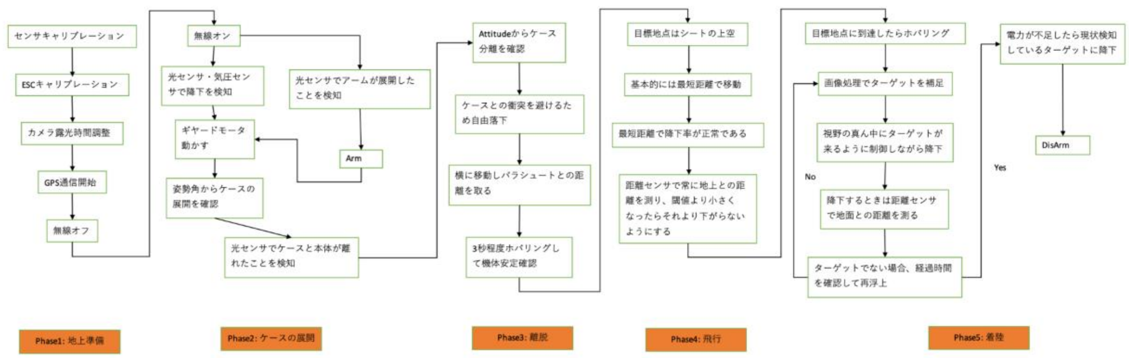


Figure 5.1.1. **Mission sequence**

ÿAlgorithm

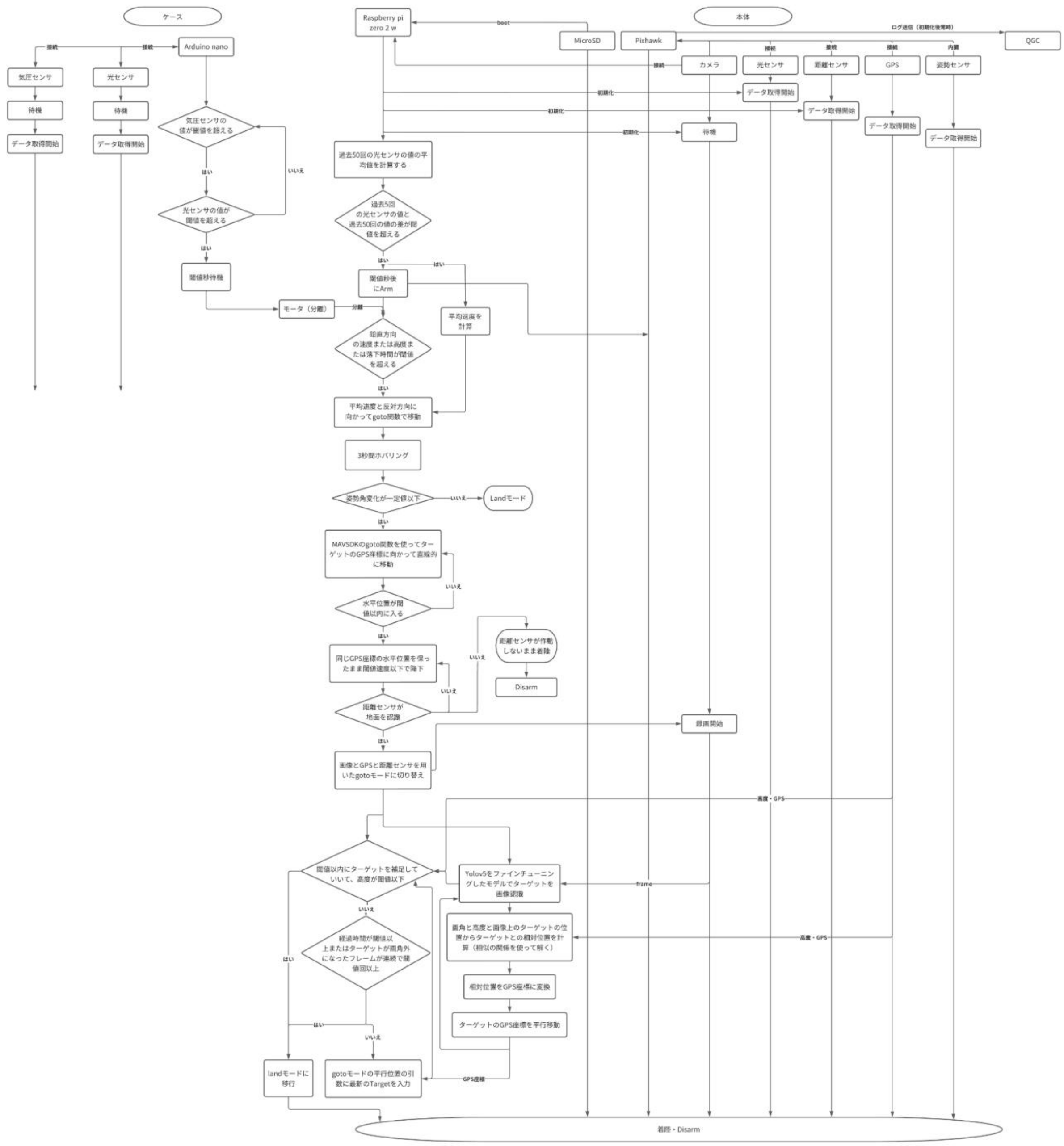


Figure 5.1.2. **Algorithm**

The flowchart above can be viewed in more detail using the link below. https://drive.google.com/file/d/1GWV_lsY-_SaTt4MdFmg-kbmtaUujkxFU/view?usp=sharing

Algorithm special notes

• As last year's team demonstrated, MAVSDK's goto mode is more **stable than other modes. GPS guidance is the core mode of the algorithm, so use a highly reliable mode. • The following points are provided as a fail-safe design. • Program to make an emergency landing if the attitude is not stabilized after separation. • The timing to stop a free fall is determined using three data : altitude, falling speed, and free fall time** to ensure deceleration and avoid dangerous falls.

- **If the target cannot be captured continuously, image navigation will be interrupted and the aircraft will land using only GPS control.**
- **If it takes too long, stop the search midway and land safely. • If the aircraft lands without the distance sensor operating, provide an interrupt process so that the propeller rotation can be forcibly stopped from the outside.**
- **In addition to the ulog file automatically created by PX4, we will also implement a homemade log in real time in case file saving fails. (Data such as attitude and mode are exported to a json file** in real time, and **can be visualized later using matplotlib, etc.) • There is no way to convey the arm status of the main body to the case, but the arm and the subsequent emergency landing are reliable. The performance is increased by the number of tests. A method of exchanging data between the case and the main body via wireless communication was also considered, but this idea was rejected because the reliability of the wireless communication itself could not be easily guaranteed and the risk of complicating the system would be greater. .**

• **Measures to prevent being caught in the parachute after separation are as follows.**

- **By calculating the average speed of the speed just before separation and calculating the local wind direction, the direction in which the parachute will flow is predicted, and the parachute is evacuated in the opposite direction. • The resistance of the parachute is smaller than that of the parachute, so the resistance is smaller due to free fall and keep a distance from the case.**

• **To use goto mode, convert the target coordinates from image recognition to GPS coordinates. This allows you to continue using a highly reliable mode until the end. The feasibility of this has been confirmed through experiments. The disadvantage of this method is that it is affected by GPS errors ,** so I would like to experiment with navigation using speed and relative position without using GPS to check the accuracy. **(For example, a method has been considered that divides the image into four parts, top, bottom, left, and right, and controls the amount of vertical and horizontal movement depending on where the center of the target** is within the four parts.) • **Machine learning model used to recognize the target is suitable for inference This model is a fine-tuned version of the Yolov5 model using the target image. This allows the position of the target on the image to be flexibly recognized under various conditions.** To speed up the **inference speed, convert the model learned with Pytorch to a tflite model. This allows the target position to be corrected more frequently.**

Chapter 5 **Test item settings**

number	Verification item name	Corresponding self-examination items Request number(s)	Scheduled implementation date
V1	**Mass test**	S1	6/29
V2	**Aircraft storage and release test**	S2, S3, S17	6/29
V3	**Quasi-static load test**	S4	7/8
V4	**Vibration test**	S5	7/5
V5	**separation (parachute opening) impact test**	S6	7/5
V6	**parachute drop test**	S7, M2	6/19
V7	**Landing impact test**	S7	6/15
V8	**GPS data downlink test**	S8, S9	7/6
V9	**Wireless channel change test**	S10, S11	7/16
V10	End-to-end exam	S12,S13, S14,S15, S16, M1, M6, M7, M8, M9, M10, M11	7/9
V11	**Control history report creation test**	M12	7/9
V12	**fuselage case separation/deployment test**	M3, M4, M5	7/6

Chapter 6 **Examination Contents**

v1. **Mass test**

- **Purpose**

Make sure that the combined mass of CanSat and parachute meets the specified mass of 1050g or less. confirm.

- **Test content**

Measure the CanSat and parachute using a mass meter, and check the mass listed in the regulations. (1050g) or less.

- **Results**

The total weight of the CanSat (758g) and parachute (261g) is 1019g, which is within the regulation It was confirmed that the weight was 1050g or less. Figure 7.1.1 shows the mass measurement results.

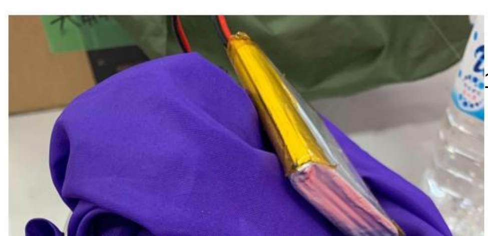


Figure 7.1.1 Parachute and CanSat mass

• **Discussion**

It was found that the total weight of CanSat, including the mass of the parachute, met the regulations. As development progresses in the future, it is necessary to keep in mind that the number of necessary parts may increase, and to continue reducing the weight of structural parts and parachutes while maintaining the necessary strength.

v2. **Aircraft stowage/release test • Purpose All mechanisms**

including the fuselage, parachute, and case can be stored in the carrier, reducing its own weight. Confirm that it can be released by hand. •

Test details:

Store the aircraft in the carrier. Also, remove the board placed under the carrier and apply external force. Visually determine whether the aircraft will be ejected in such a situation and record the video. • Results

The video

of the storage of the aircraft is shown in the link below. https://youtu.be/9yC2coBD9Xc **As shown in Table 7.2.1, it was confirmed in all four experiments that the CanSat was released under its own weight after being stored.**

Table 7.2.1 **Results of carrier release experiment**

	Experiment video	Release judgment
	https://www.youtube.com/watch?v=7 UcdPmFz-KU	I was able to release it under my own weight.
	https://www.youtube.com/watch?v=p qxWqwkseO8	I was able to release it under my own weight.
	https://www.youtube.com/watch?v=b NR8K4np-CY	I was able to release it under my own weight.
	https://www.youtube.com/watch?v=R 4Mm1Npijrc	I was able to release it under my own weight.

Case storage tests were also conducted when only one side of the case was open. the You can watch the video in the link below. https://www.youtube.com/watch?v=cpaBoifj7QU

•

Consideration It can be seen that all the parts are released from the carrier. Also, the parachute

It can be seen that the aircraft falls a little later than the cased aircraft. Considering that there is a distance between the cased aircraft and the parachute, the parachute opens under the influence of aerodynamic force, and the case deploys in conjunction with this, separating the case and the aircraft in a stable state. The result was a release with no problems for future sequences.

v3. **Quasi-static load test •**

Purpose:

To confirm that the functionality required to meet safety standards is not impaired by quasi-static loads during

launch. • Test

details: Store the aircraft in a bag. Connect a rope to the bag and swing it horizontally. In other words, we will verify whether the aircraft can withstand when a 10G load is applied to the case containing the CanSat in uniform circular motion. **Below is a photo of the measured radius.**

Figure 7.3.1. **Radius measurement**

• **Results**

A video of the experiment is shown in the link below.

https://www.youtube.com/watch?v=HeCdNsZy1b8

When performing uniform circular motion with a period of f=0.84[s]

and a radius of r=1.8[m],

ÿ = 2ÿ/ = 7. 48[/] = ÿ = 7. 48×1. 8 =

= 2 13 . 464[/] / = 100. 2 71[/

Therefore, a static load larger than 10 2 = 98[/ **could be applied. After the test, the pixhawk and various sensors worked without problems, and no damage was found to the aircraft itself. •**

Considerations It was confirmed that the aircraft can withstand quasi-static loads.

v4.Vibration **test**

purpose

When launching by rocket, confirm that the aircraft can withstand the vibration load applied during launch. • Test

details A test is conducted that applies random vibrations equivalent to sine wave vibrations of 30Hz to 2000Hz and 15G or more to verify whether the aircraft can withstand it. • Results

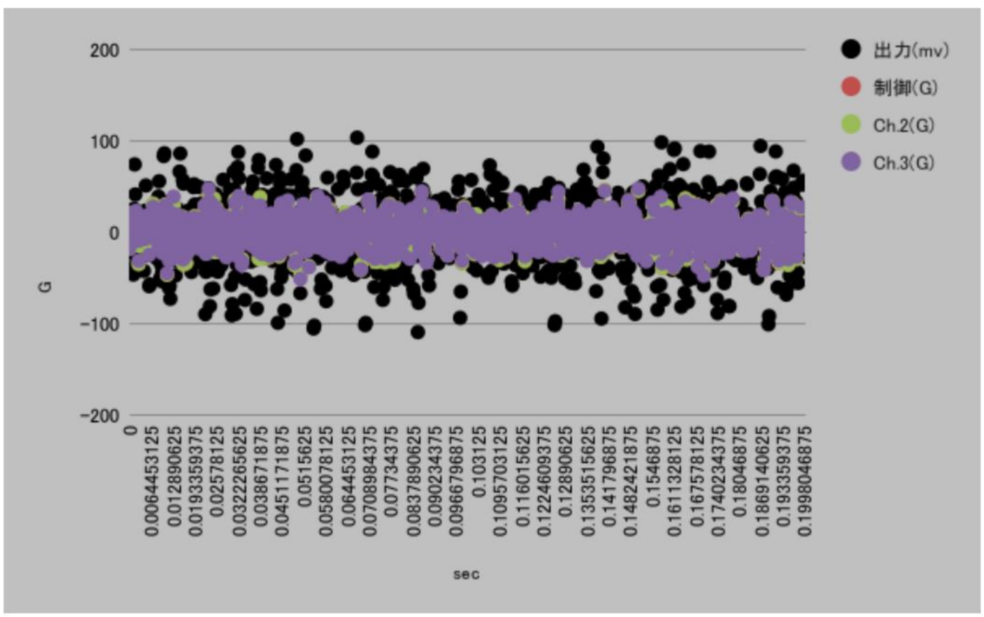


Figure 7.4.1. **Random vibration test graph**

A random vibration test was conducted. Detailed results can be found at the link below https://docs.google.com/spreadsheets/d/1_qXtPwNr6XXI7nx6xqxZRH0IvA8xKsnZ/edit?usp=sharing&ouid=105218032502245381253&rtpof=true&sd=true https://docs.google.com/spreadsheets/d/1xwIIQ0aZ BBk3yWSe_QGqPwUth1qHf 5uL/edit?usp=sharing&ouid=105218032502245381253&rtpof=true&sd=true https://docs.google.com/spreadsheets/d/1ApvWuXt3DJhMzKLoPhcKyIeGYiZS-tz X/edit?usp=sharing&ouid=105218032502245381253&rtpof=true&sd=true **As you can see from Figure 7.4.1, the random amplitude is over 15G.**

There was no damage to the aircraft (mass test photo above). There may be **a malfunction in the GPS, motor, etc.**

• **Consideration**

It is thought that malfunctions of GPS etc. can be prevented by attaching a cover.

v5. **Separation (parachute deployment) impact test** • Confirm that the

target

aircraft and case can withstand the separation impact from the rocket (approximately 40G) and the parachute deployment impact (approximately 50G).

• **Test details**

From mgh = ½ **mv^2,** assume that **the speed decreases to** 0 [m/s] in 0.2 [s], and **then let it fall freely from** h = 5.10 [m] (equivalent to a 50G impact). **Make sure it can withstand. • Results The video of this test**

is as

follows: https://www.youtube.com/watch?v=9n8EBviCSKE **The video confirms that sufficient impact load is applied. Also, from the photos below, you can confirm that the case is undamaged and is functioning normally.**

Figure 7.6.1. **Case after test**

v6. **Parachute drop test • Purpose: To prove that**

it is

possible to deploy and decelerate a parachute. • Test details The robot

was dropped

from the Shin-Katsushika Bridge in Matsudo City, where it is possible to fall from a high place, and the process was captured using a high-angle camera. The load was set to 900g to

match the

actual weight of CanSat. • Results The video

is linked below. https://youtu.be/Ogr4uxLjtuY

• **Consideration** The height of the lowest surface of the bridge girder of Shin-Katsushika Bridge from the ground is 8m, and the time it takes to reach **the ground** from a height of 4m, which is half of that height, is 0.75 seconds from the video, so the speed in this section is 5.3m It is **about /s . The drag coefficient of the parachute estimated as the terminal velocity is 0.314, and conversely, if a parachute with this** drag coefficient is fully opened, it will be freely dropped from a he

When calculated, the velocity at 4 m is 5.13 m/s, and the velocity at 8 m is 5.29 m/s, which nearly **matches** the measured values, so it can be said that these values can be treated as the terminal velocity. **If the parachute is changed in the future,** a test will be conducted each time.

v7. **Landing impact test target**

Indicates that the device can withstand the impact of being dropped by a parachute and has not lost its ability to carry out its mission. • Test content Since the terminal speed is known to be 5.3m/s in V6, the thrust is suddenly lost and from a height of 2.5m o

Analyze the results of a fallen flight test. • Results

The flight test log and fall height are shown in Figure 7.8.1.

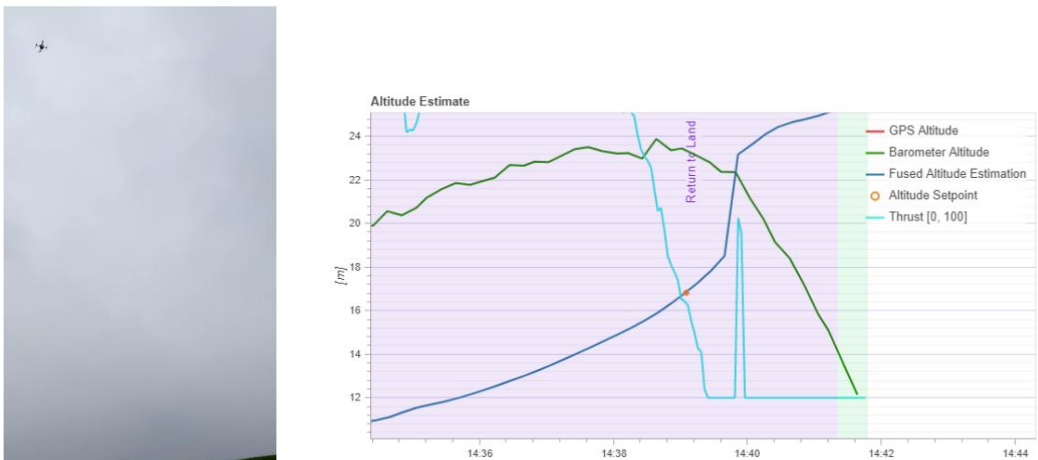


Figure 7.7.1. **Flight test log and drop height**

• **Discussion**

No damage was seen to the aircraft even after the fall. The flight test actually continues as shown in the video below. are doing. There were no problems with the battery either. https://www.youtube.com/watch?v=DuNM_hYEvsU

Similarly, as shown in Figure 7.8.2, logs are also collected and the sensor continues to operate correctly.

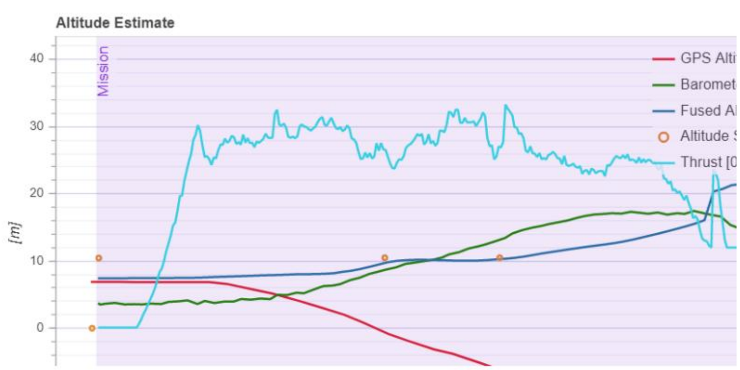


Figure 7.7.2. **Post-fall flight test log**

v8. **GPS data downlink test • Purpose Confirm that the**

aircraft

and the case that houses the aircraft can transmit the acquired GPS position information to the ground station and the communication distance.

- **Test details**

Verify the communication distance range while changing the distance between the GPS and the ground station in an open riverbed.

- **Results**

We confirmed that GPS downlink was possible at the location shown in the photo below.

- **Considerations GPS downlink is fully possible at a distance of about 1.6 km, and considering the presence of obstacles, it is thought that ARLISS, which requires a communication distance of about 4 km, will be able to provide**

sufficient support . v9. **Wireless channel change**

test •

Purpose To confirm that the channel can be changed when wireless channel adjustment is required. Also, make sure that the radio is turned off when storing the rocket.

- **Test details**

Verify that the frequency can be changed in the communication module. Also verify that the module itself can be powered down.

• **Results**

We confirmed that the telemetry frequency can be changed through Tera Term. **In addition, we confirmed that the power supply of the module** itself can be controlled using a MOS-FET circuit

• **Consideration Satisfies regulations.**

v10. End-to-End Test • **Purpose To confirm that the series of operations from CanSat drop, parachute deployment, case deployment, case separation, autonomous flight, termination judgment/processing, and data retrieval is possible.**

• **Test details**

Since it is difficult to secure sufficient height from a general bridge, etc., and it is difficult to confirm the above sequence of operations in a test flight, the aircraft is released (1), the arm on the aircraft side and the start of flight, and the GPS Induction (2), check the operation for each. 1. **Release from carrier** 2. **Detach the aircraft** 3. **Arm while shaking the aircraft -> Start flight** • **Result** 1. https://www.youtube.com/watch?v=oNlk6HtFAu0 2. https://www.youtube.com/watch?v=pGDyxmh_cgQ 3. https://youtu.be/1IxTdIMDtmQ • **Consideration**

a. **Minimum success has been sufficiently achieved.**

v11. **Control history report creation test** • **Goal Confirm that a control history report can be created. Also, confirm that a backup graph can be created.** • **Test details**

A report was created based on the logs from when the aerial arm test was conducted. The test video is below It's in the link.

https://drive.google.com/file/d/1C_uY_bx0y3_aDjJh2zx_i3aHccD-z3ji/view?usp=s haring • **Results The control history during the test flight is automatically saved as a ulog file after disarm, and** can be visualized on the website Flight Review (https://logs.px4.io/). You can check the ulog file log from **the site below or the Google Drive link below .** https://logs.px4.io/plot_app?log=54b5fd4e-c3cd-4ea8-b24b-b67dabf2f1dd https://drive.google.com/file/d/14LGwHHBzNPZIiTF1bY1d22X-fr0FzVWw/view?u sp=sharing **As a backup, we have confirmed that it is possible to create a graph like the one below by exporting the control history to a json file even in real time and extracting it.** The graph below **is a visualization of what was recorded in real time during the exact same flight test linked above . The first graph on the left is the roll angle, the first right is the yaw angle, the second left is the altitude measured by lidar (distance sensor), and the second right is the pitch angle. View lidar graph**

It can be seen **that it starts from a height of about 60cm (initially it is 0m due to the initial value of the variables),** rises to a height of about 3m, and then lands. **In addition, it is also possible to visualize the relative position of the target point and yourself, as well as the control target of the actuator . The link to the json file used at this time is as follows.** https://drive.google.com/file/d/1O9smAiqp7G-NI7-gLeaXyl_Ab-h3sL8p/view?usp =sharing

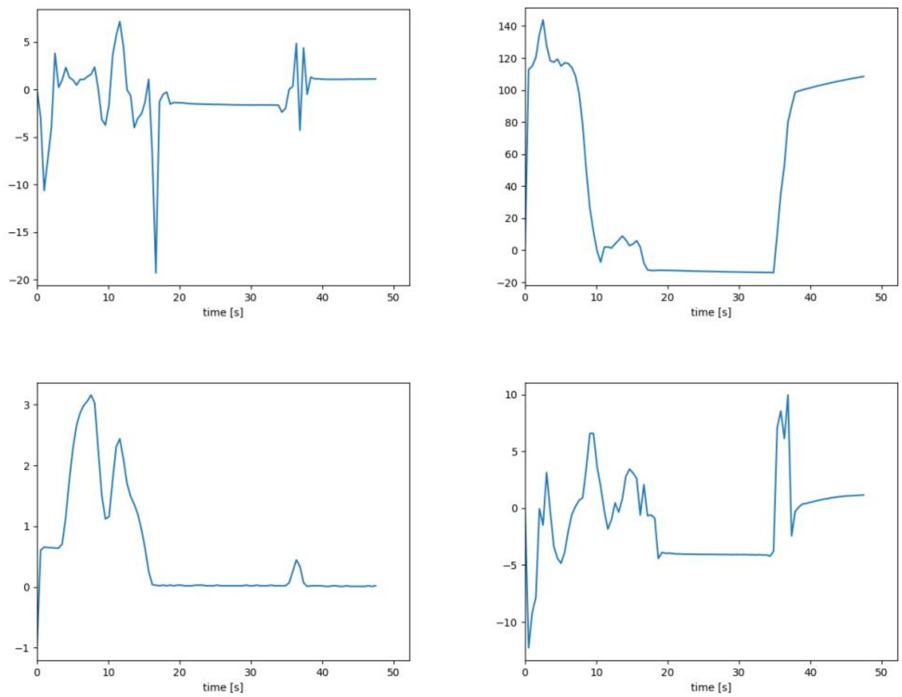


Figure 7.12.1. **Backup control history graph**

The graph below is the log of the position in the z direction when the ulog file is visualized. Note that this graph has the z direction at the bottom, and if you compare it with the graph on the left in the second row above, **you can see that the values are almost the same.**

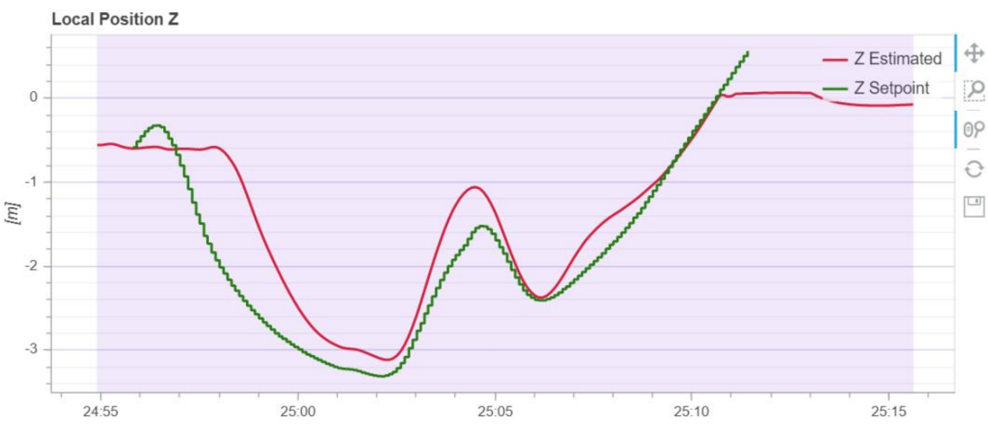


Figure 7.12.2. **Graph of z-direction position by ulog file**

v12. **Separation and Deployment Test between Aircraft Cases •**

Purpose :

After the CanSat is separated from the carrier, the parachute can be deployed reliably, the case can be deployed to a state where the aircraft can fly, and the aircraft and the case can be separated in a stable attitude. Check.

• Test details :

Open the carrier, drop the CanSat, and verify the ability to perform a series of operations including opening the parachute, deploying the case and aircraft, and separating the aircraft and the case. Specifically, ÿ After releasing the carrier, it comes out of the carrier under its own weight. ÿ After dropping the CanSat, the parachute can be deployed. ÿ After the parachute is deployed, the pin extraction structure is activated. ÿ The drone is properly deployed by the operation of the pin extraction structure. ÿThe geared motor operates, causing the pin to be pulled out and the drone to fall.

• Results

The results are shown in the video below.

Separated from parachute deployment

https://www.youtube.com/watch?v=oNlk6HtFAu0

From deployment to separation of the aircraft https://www.youtube.com/watch?v=pGDyxmh_cgQ **• Consideration:**

Necessary mechanisms have been sufficiently achieved.

Chapter 7 **Gantt chart (process control)**

The Gantt chart can be accessed from the following link. https://docs.google.com/spreadsheets/d/15CyWA0-ynnlklYTDdLQfq_JJk97_E2tuMnrCl6aL-cU/edit?usp=sharing _

Chapter 8: **Impressions of the responsible teacher**

Since I have jointly coached two teams of third-year students at the University of Tokyo and have seen them develop at the same pace, I will make comments that are common to both teams.

I conducted PDR and CDR with the participation of alumni from the laboratory's ARLISS, etc., confirmed the schedule of scheduled tests, and provided advice on how to achieve the goals. Then, on July 29th, we borrowed Nihon University's Futawa Grounds, raised the balloon to an altitude of 50 to 60 meters and dropped it, and conducted various tests. Although each test was conducted separately (subsystem test) and confirmed, the final end-to-end test has not yet been conducted. We believe that by combining each test item, we will be able to fly towards a given goal.

Additionally, safety tests are confirmed through subsystem tests. In terms of project management, the roles are clearly
We hope to see good results in the competition.

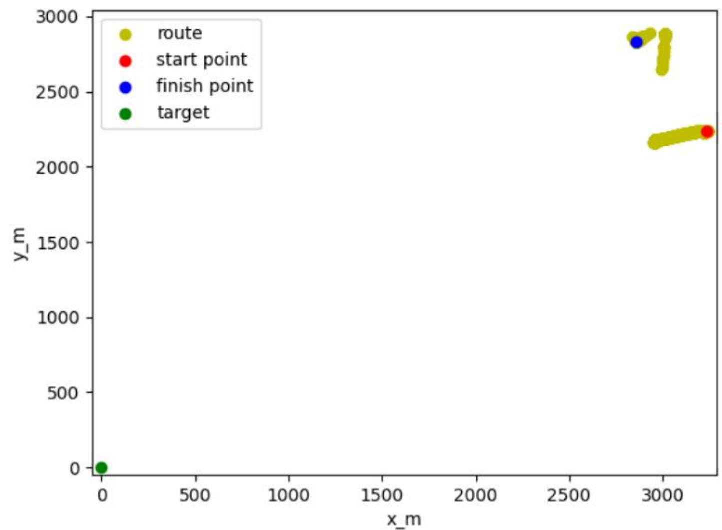
Chapter 9 **Tournament Results Report**

12.1. **Purpose**

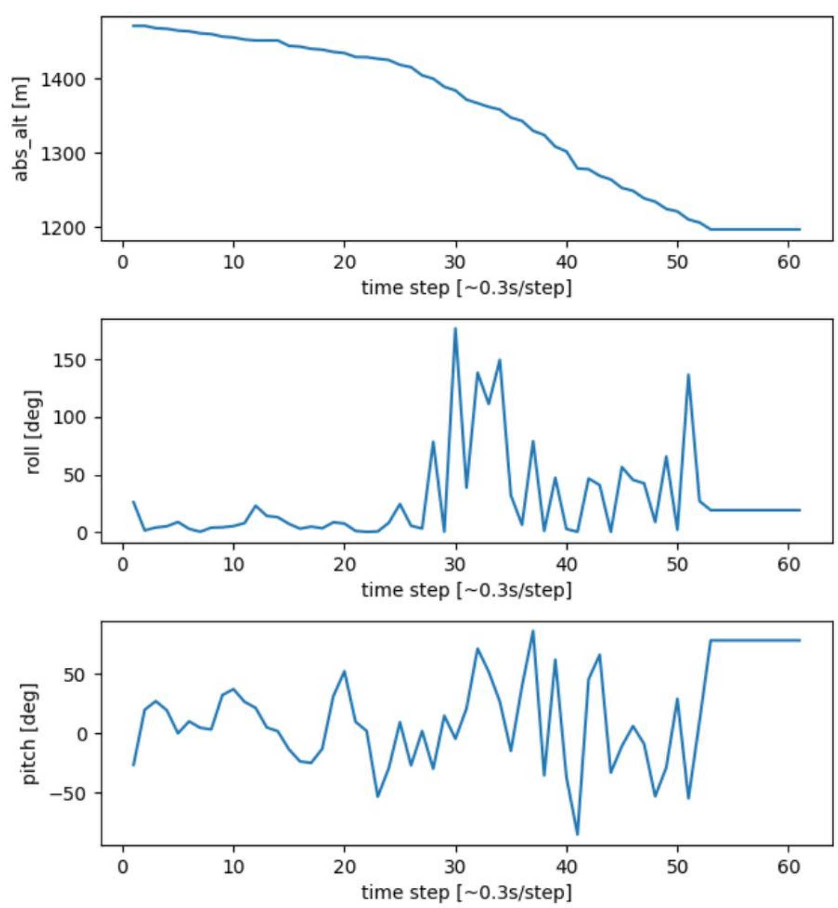
After being released from the rocket, the planned mission is to use autonomous flight to approach the target. Verify that the process runs successfully.

12.2.As **a result,**

although the deployment of **the first two-stage parachute and the separation of the parachute from the aircraft were successful, the aircraft fell free. After recovering the aircraft, we checked the logs indicating that the code had stopped just before launch. Because the cord was not working, no telemetry could be received, and it took some time to discover the aircraft.** The cause may be that the power supply to the computer that was controlling the aircraft caused a contact failure due to the shock during launch, and the power was cut off, or **that code execution was interrupted when the SSH connection between the ground station and the aircraft was severed. It is possible that it has stopped. In response to this failure, they reinforced the fixings around the microcontroller and battery** connectors, and **improved the software so that the code runs even if the SSH connection is disconnected. A similar failure did not occur on the second drop.** Although the deployment of **the second two-stage parachute and the separation of the aircraft were successful, and the aircraft's cord continued to move without stopping, the aircraft lost its attitude and crashed while recovering from free fall.** As for **telemetry , we were able to receive GPS coordinates at the ground station using lora, and succeeded in knowing the position of the aircraft at an altitude of 3000m in real time . The causes of the crash were that the aircraft swung into a pendulum state during the fall, and when it separated, it was blown away and crashed. The string connecting the parachute and the aircraft hit the propeller, preventing it from rotating. It is possible that he lost his balance, or that his arm broke when a load greater than his own weight was applied to his arm as he**



Change in position of second drop (origin is target)



Changes in altitude and roll/pitch angle during the second drop (after arm deployment)

Considering that the aircraft separated approximately 5 seconds after the arms were deployed and that there were parts where the altitude gradient changed suddenly, it is clear that the aircraft lost its attitude and crashed immediately after separation. 12.3. Please evaluate the degree of achievement of the success criteria based on the data shown in the discussion results. For items that could not be achieved, please investigate the reasons why they were not achieved, including the preparation period for development plans. Once you have determined the cause, please explain in detail what was required to resolve it.

Chapter 10 **Summary**

12.4. **Points of improvement/effort (all hardware, software, and management aspects)** Power consumption was significantly reduced by using a two-stage parachute. Efforts were made to reduce weight and maintain functionality throughout the circuit

structure. By writing daily reports, we made it a habit to check the progress of members and allocate tasks. I tried to separate working code from non-working code by managing it using Github. By modularizing the code used for control, we have made it possible to test the software in small units. By creating a checklist for the exam, we prevented failures due to forgotten items or careless mistakes. Ma Also made debugging smoother. By using simulation, we were able to debug the code without having to fly a drone. 12.5. **Challenges** How to recover after being separated in mid-air How to solve the power problem How to test without damaging the main body and create a machine that is hard to break

12.6. **Future prospects**

Improve the algorithm for returning from the air. Improve maintainability by developing navigation guidance and control technology that does not rely on commercially available autopilots. Set a deadline for development (e.g., if the technology cannot be completed by this date, give up on the technology). Make long-term plans and work backwards to assign tasks and set goals.

Please also give us some notes and advice on CanSat development for juniors looking at this material.