ARLISS2022 report

Submission date: November 20, 2022

• Team information

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	Hiroshi Arai (B3)
	Takamitsu Fukuda (B3)
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• Purpose of CanSat production and reason for participating in the competition

There are two main reasons why we participated in ARLISS this year. The first is that tests can be conducted under harsh conditions similar to those of actual satellite launches. The second reason is that we thought that achieving results at ARLISS, which is the entry point for domestic space engineers, would lead to increased recognition of the CanSat competition in the Hokkaido region.

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Chapter 1 Mission Statement

1.1 Mission statement

embodies “Less is more. ” Achieve the 0m goal with a two-wheeled aircraft that

[Background] Our ultimate goal is to achieve the 0m goal using a runback aircraft at ARLISS this year, and as a preliminary step, we are aiming to achieve the 0m goal at the Noshiro Space Event. Therefore, in order to achieve these goals, this aircraft was designed based on the concept of ``Less is more.", which has not been incorporated into CanSat in the past.

“Less is more. ” is a phrase left behind by Ludwig Mies van der Rohe, a German architect who is one of the three great masters of modern architecture. It is interpreted to mean that by removing unnecessary things (such as decorations) and perfecting a simple design, something richer and easier to use can be created.

By incorporating this concept into CanSat, we have increased the possibility of achieving the 0m goal in ARLISS. I thought so. We believe that "Less is more" in CanSat is based on the following three points.

1. To reduce the weight of the aircraft as much as possible while maintaining its strength. 2. Simplify software. 3. It must be versatile enough to be applied to a variety of missions.

First, regarding point 1, ARLISS requires long-distance travel of several kilometers, but regulations stipulate a maximum weight, so there is a limit to the battery capacity that can be used. Therefore, by reducing the weight of the aircraft, we aimed to travel longer with less energy. Specifically, while the tires on the Secon 2022 aircraft weighed approximately 180 g each due to emphasis on rigidity, the tires on this aircraft have been reduced in weight to about half that, approximately 75 g. I did this. We also cut out the meat in each part.

Regarding 2, if you add various functions to the software and make the program more complex, your computer will become more complicated. This puts a strain on the computer's processing capacity, and makes it difficult to correct errors when they occur on-site. this is This is a major obstacle to achieving the 0m goal in ARLISS, so we purposely simplified the software's functionality. Specifically, we were initially aiming for guidance through object detection using deep learning, but in consideration of the problems mentioned above, we decided to use guidance through ``color recognition,'' which has a simpler theory.

Finally, regarding 3, we believe that eliminating all waste will ultimately lead to creating a standard aircraft that can support a variety of missions and the addition of functions. When future generations tackle CanSat development for the first time, we would like to lower the hurdle by adding unique missions to this standard aircraft and continue CanSat development. This is based on our experience in the past, when we had a very difficult time recovering from loss technology.

1.2 Mission Sequence The
mission sequence is broadly divided into five phases. Mission sequence flow,

A list of the contents of the five phases is shown in Figure 1.2.1 and Table 1.2.1.

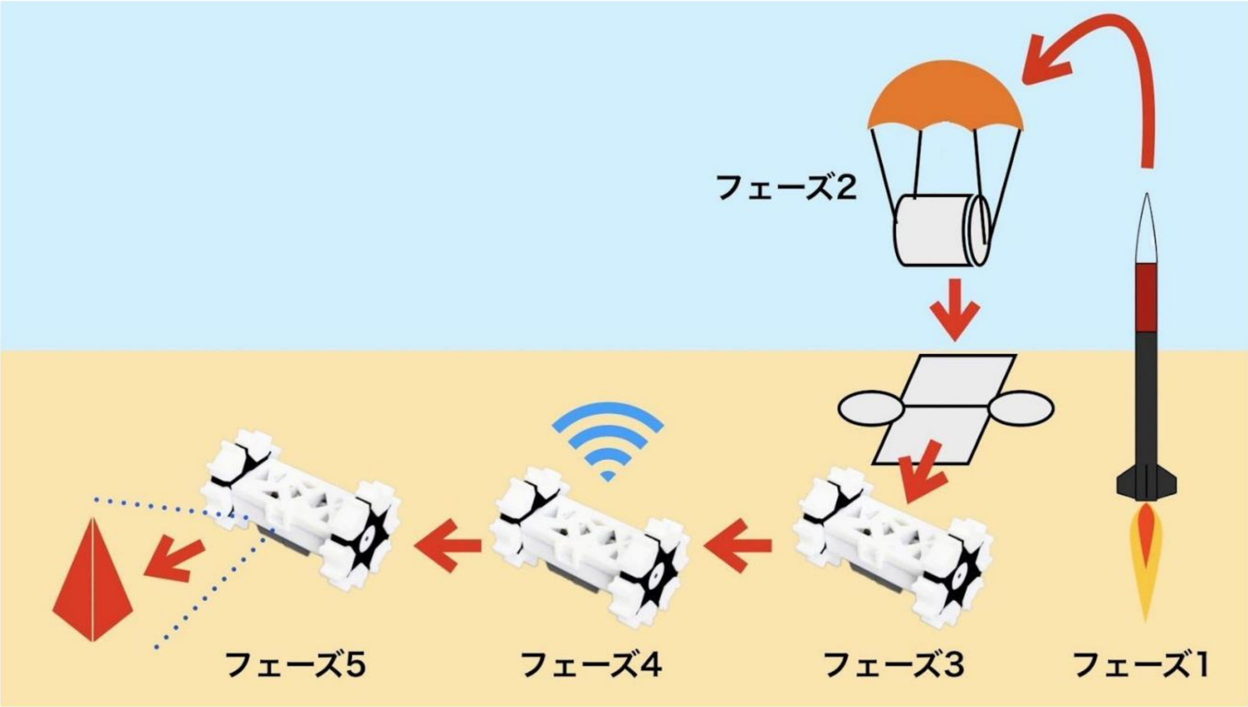

Figure 1.2.1 Mission sequence flow

Table 1.2.1 Details of each phase

Phase 1 (before dropping)	The aircraft is mounted on the storage module, and the parachute and aircraft storage module (recovery mechanism) are mounted on the carrier. Afterwards, a rocket will be used to raise the carrier to an altitude of approximately **4000 m .**
Phase 2 (dropping)	Dropping the parachute and storage module from the carrier at an altitude of approximately **4000 m .** The ejected module is decelerated by a parachute and lands at a descending speed of approximately **6 m/s .**
Phase 3 (start of running)	Once the air pressure sensor confirms the landing, the cord is burned out using a heating wire and the aircraft storage module is deployed. The aircraft separates from the release module and begins flight.
Phase 4 (Guided driving)	Drive to the target point based on GPS data.
Phase 5 (goal recognition)	When the distance to the goal point is less than **5 m ,** the guidance method is switched to color recognition using a camera and the vehicle moves toward the goal cone.

Chapter 2 Success Criteria

Table 2.1 shows the success criteria.

Table 2.1 Success Criteria

	Content	Evaluation method
Minimum Success	It detects release and landing, separates the aircraft storage module (including the parachute), and begins flight.	1. Check the barometric pressure sensor and photoresistor logs. 2. Confirm visually and from the control log that the fuselage storage module was opened by the heating wire. 3. By visual inspection. Make sure that the aircraft during the mission is not dragging the aircraft storage module. Achievement will be achieved if all 1 to 3 above are met.
Middle Success	Guide the aircraft to within a 5m radius of the goal.	Confirm that the aircraft has arrived within a 5m radius of the goal using GPS logs and actual measurements.
	It detects when the vehicle gets stuck due to steps or obstacles and returns to driving.	Visually and using GPS logs, confirm that the vehicle has returned to driving after becoming stuck.
Full Success	The camera guides the aircraft to the goal by recognizing the color of the cone (goal) and achieves the 0m goal.	Confirm that the goal has been reached visually and by the camera.
Advanced Success	The aircraft reaches the target point without any damage.	Visually check whether there is any noticeable damage (damage, deformation, etc.) or missing parts on the exterior of the aircraft after achieving full success.

Chapter 3 Setting requirements

3.1 System requirements (requirements for ensuring safety and regulation) Table 3.1.1 shows a list of system requirements.

Table 3.1.1 List of system requirements

request number	System requirements (ARLISS launch safety standards)
S1	The mass of the dropping aircraft meets the criteria.
S2	volume meets carrier standards.
S3	Tests have confirmed that the quasi-static loads during launch do not impair the functionality required to meet safety standards.
S4	Tests have confirmed that the vibration load during launch does not impair the functionality required to meet safety standards.
S5	Tests have confirmed that the impact load upon separation of the rocket did not impair the functionality required to meet safety standards.
S6	The impact load when the parachute deploys may impair its ability to meet safety standards. Tests have confirmed that this is not the case.
S7	It has a deceleration mechanism to prevent it from falling at dangerous speeds near the ground, and its performance has been confirmed through tests. I can recognize it.
S8	We have implemented countermeasures against loss, and their effectiveness has been confirmed through testing. (Examples of measures: location information transmission, beacons, fluorescent color paint, etc.)
S9	We have confirmed that we can comply with the regulations for turning off the power of radio equipment during launch. (It is not necessary to turn off devices that are FCC certified and have a power output of 100mW or less. Also, if you use a smartphone, it must be FCC certified and can be turned off with a software or hardware switch.)
S10	Verify that you are willing and able to adjust the radio channel. coming.
S11	This simulation simulates the loading of the rocket, the start of the mission, and recovery after launch. We have been able to conduct end-to-end testing, and there will be no major design changes in the future.

3.2 Mission Requirements

Table 3.2.1 shows a list of mission requirements.

Table 3.2.1 List of mission requirements

number	Mission requirements
	Tests confirmed that carrier release can be detected using the M1 barometric pressure sensor and photoresistor. I can recognize it.
	M2 Confirm that the functions required to accomplish the mission are not impaired by the impact load upon landing. This has been confirmed through testing.
	Tests have confirmed that the M3 fuselage storage module and the fuselage body can be separated.
	M4 We have confirmed the running performance in poor environmental conditions through testing.
	Tests have confirmed that M5 GPS can be used to navigate around the goal.
	M6 Tests have confirmed that the cone installed at the goal point can detect objects.
	M7 We have confirmed through testing that it is possible to guide a traveling aircraft to the goal based on M6's object detection. There is.
	If you wish to participate in the Comeback Competition, please be sure to meet the following requirements:
	It has been confirmed that the M8 performs autonomous control without human intervention during the mission.
	After the M9 mission, submit the specified control history report to the management and examiners and log/obtain it. It is now possible to explain the data obtained.

Chapter 4 System specifications

4.1 Aircraft appearance

[Aircraft body]

Table 4.1.1 describes the aircraft specifications and the range of measurement values (error ±5%) that are acceptable for review.

Table 4.1.1 Aircraft specifications (acceptable values based on error limits)

Total length	**200.0 (190.0~210.0)**
[mm] Height **[mm]**	**130.0 (123.5~136.5)**

Table 4.1.2 shows the aircraft components.

Table 4.1.2 Aircraft components

Aircraft part name	Material/Material
chassis part	ABS resin
Battery case part	ABS resin
tire	NR sponge
tire protrusion	ABS resin
stabilizer	convex tape
motor	Pololu 250:1 Metal Geared Motor (3708:20D×46L mm 6V CB)
insulation tape	polyimide tape

Figure 4.1.1-2 shows a photograph of the main body of the aircraft during actual measurements.

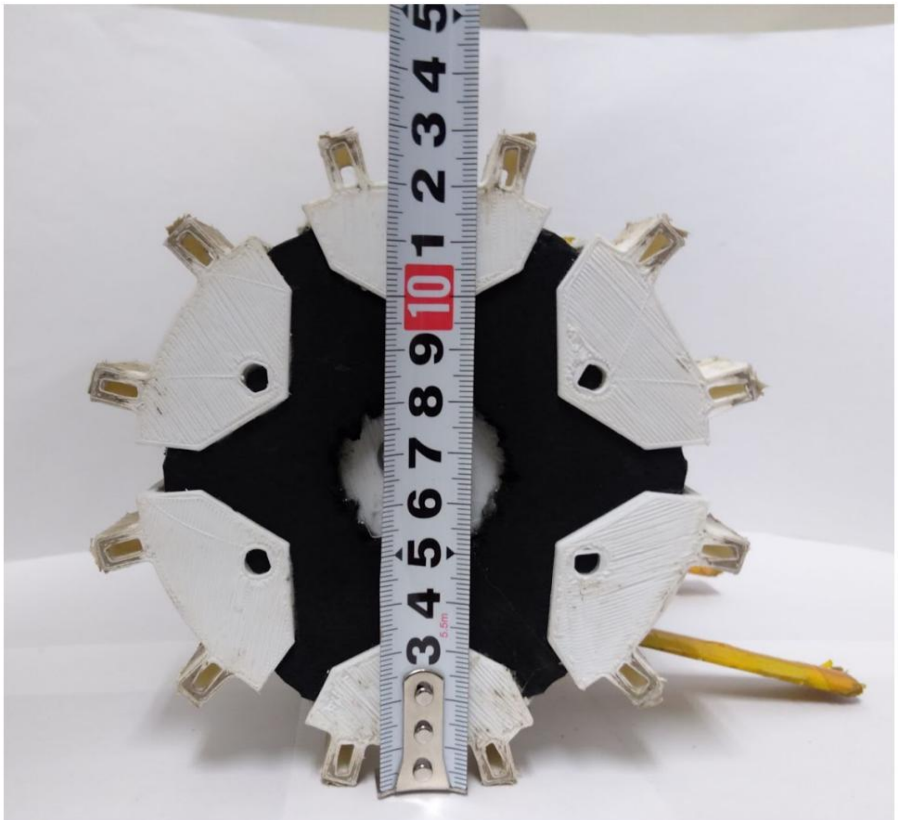

Figure 4.1.1 Aircraft height

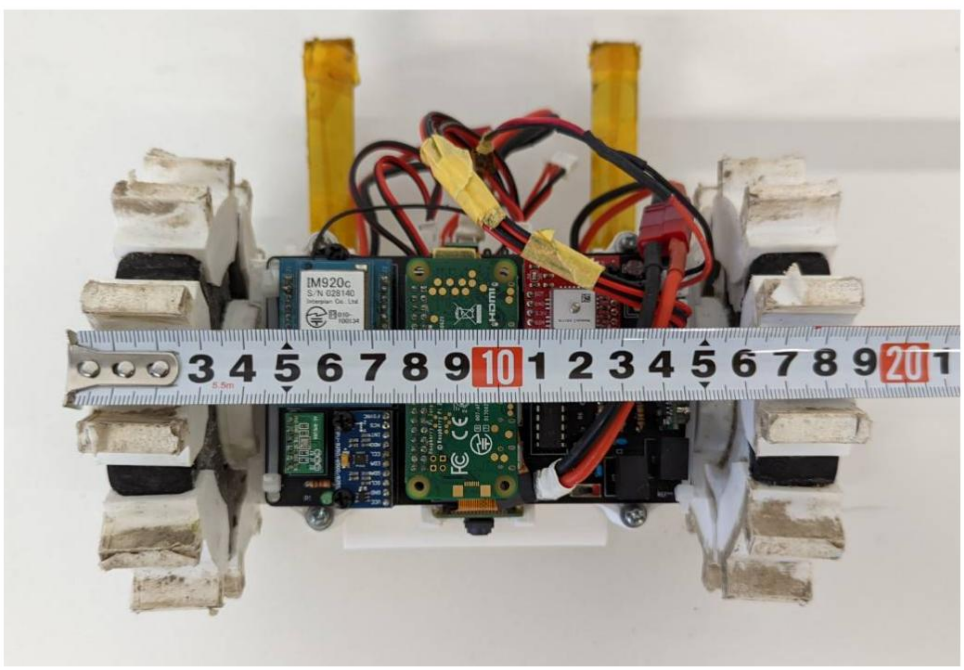

Figure 4.1.2 Overall length of the aircraft

Figure 4.1.3-4 shows an external view of the aircraft and a three-dimensional view of the CAD data.

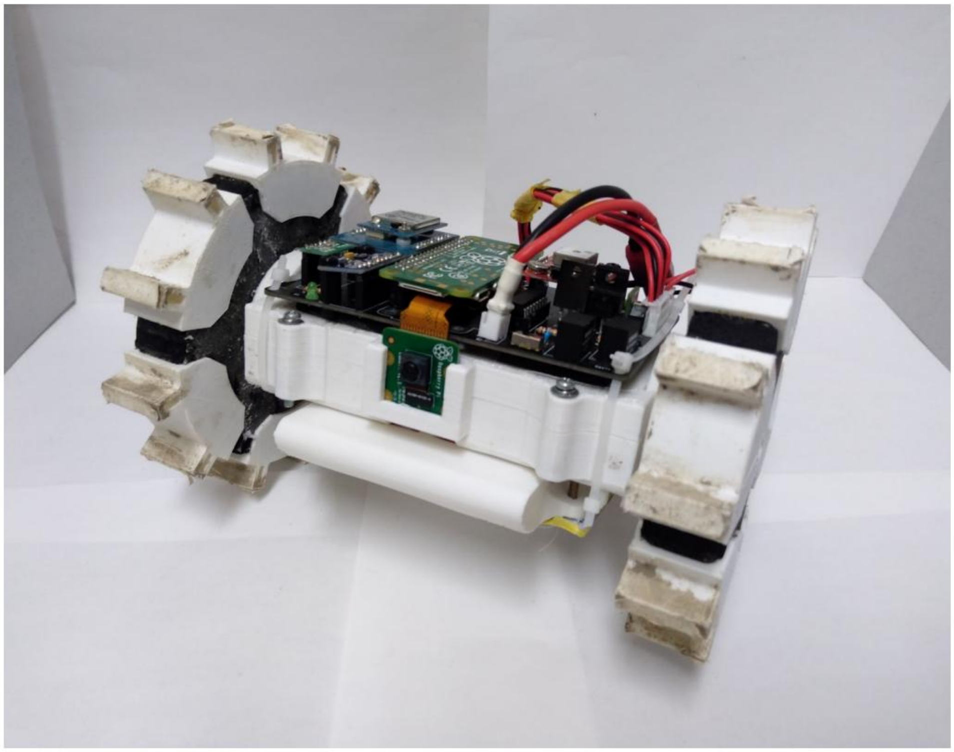

Figure 4.1.3 External view of actual machine

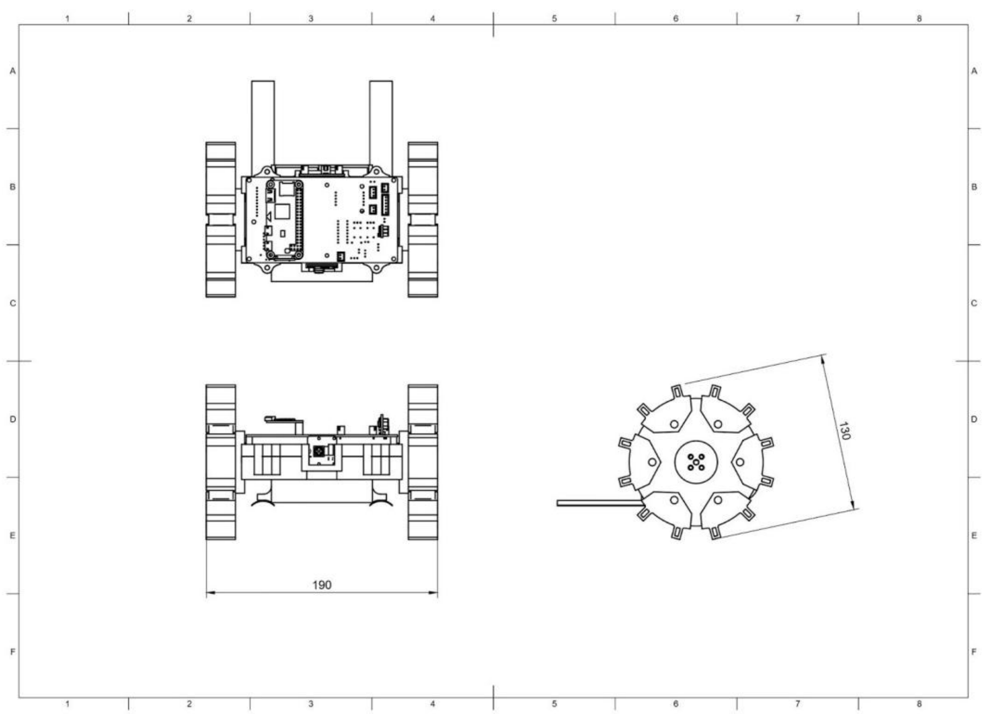

Figure 4.1.4 Three side view of the aircraft

[Recovery mechanism] The parachute and the aircraft storage module are collectively called the recovery mechanism. (Figure 4.1.5-6)

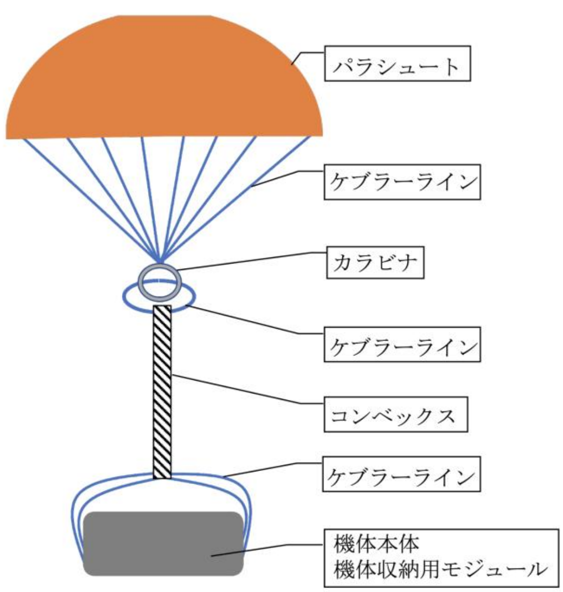

Figure 4.1.5 Schematic diagram of collection mechanism

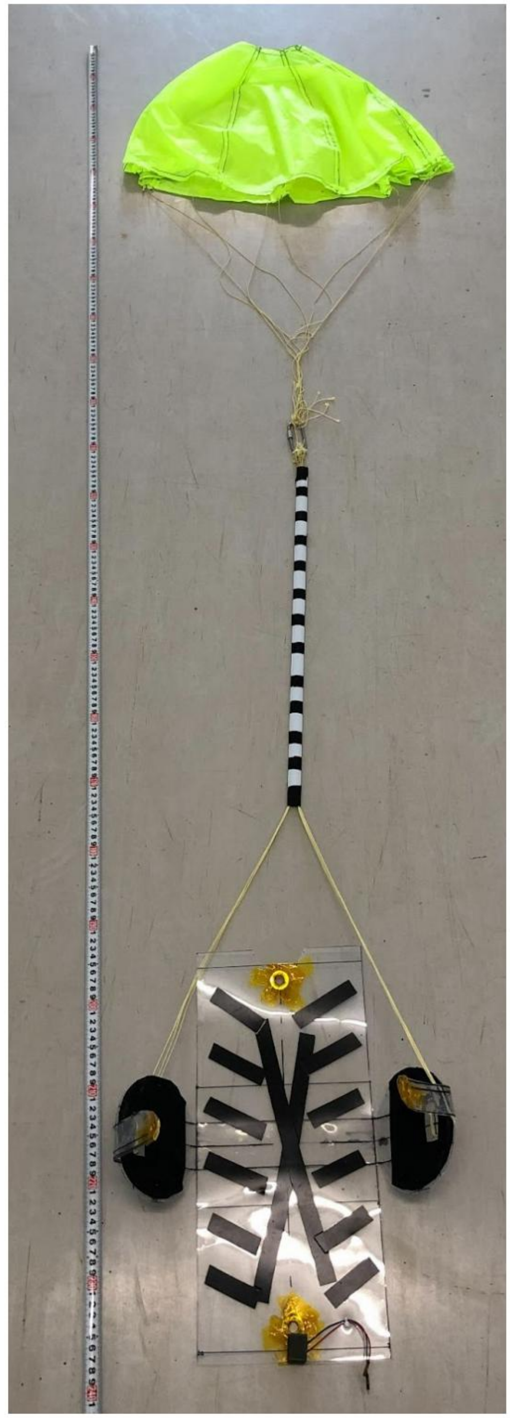

Figure 4.1.6 Exterior view of collection mechanism

<Parachute> Figure

4.1.7 shows the appearance of the parachute, and Figure 4.1.8 shows the dimensions of the gore.

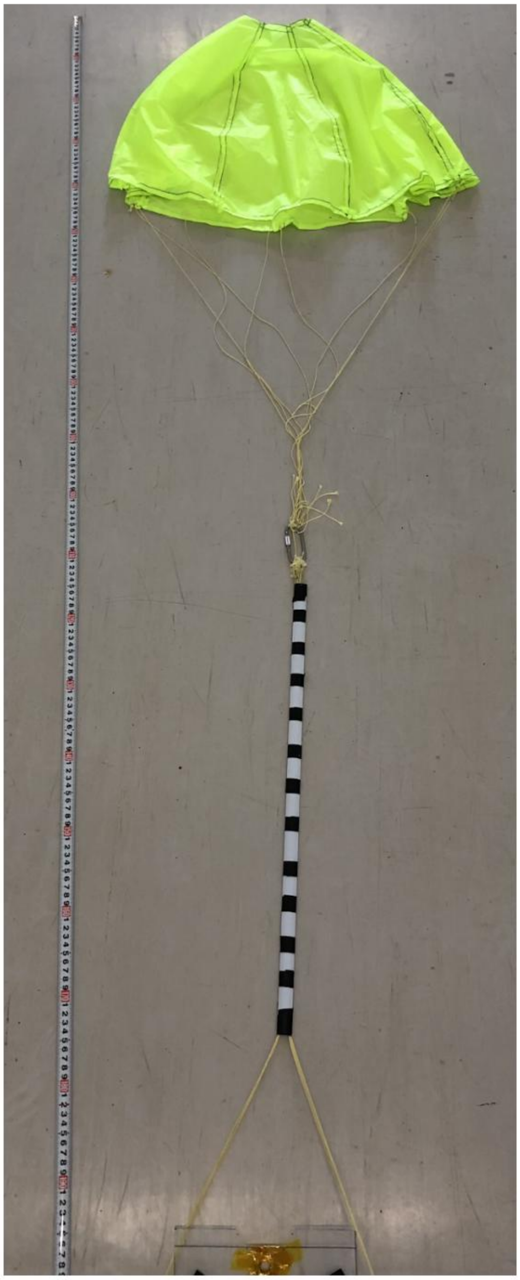

Figure 4.1.7 Appearance of parachute

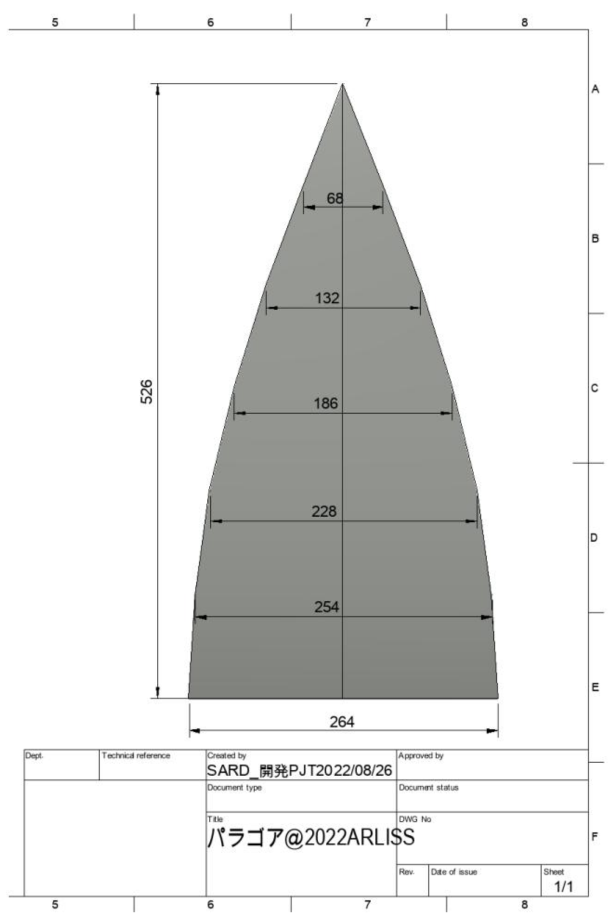

Figure 4.1.8 Gore dimension

Parachute specifications are shown in Table 4.1.2, and paracord specifications are shown in Table 4.1.3.

Table 4.1.2 Parachute specifications

shape	hemispherical
number of gore	8 [sheets]
diameter	670 [mm]
Area	1.37 [^{2}]
Spill hole diameter	0.110 [m]
canopy material	Nylon
Target terminal velocity	5 [m/s]

*The terminal velocity is set to 5 [m/s] considering that the terminal velocity is not dangerous to people or objects. did.

Table 4.1.3 Paracord specifications

Number	8 [books]
length of one	1.7 [m]
paracord material	Kevlar line, convex, carabiner

<Module for storing the aircraft body> We

used a 0.5 mm thick PP (polypropylene) sheet to prepare the module for storing the aircraft body in order to store the CanSat and protect it from impact. In anticipation of ARLISS, which is scheduled to take part in September 2022, we installed NR sponge on the side of the fuselage storage module to cushion the impact of separation from the rocket.

Figure 4.1.9 shows the external appearance of the fuselage storage module, and Table 4.1.4 shows the specifications.

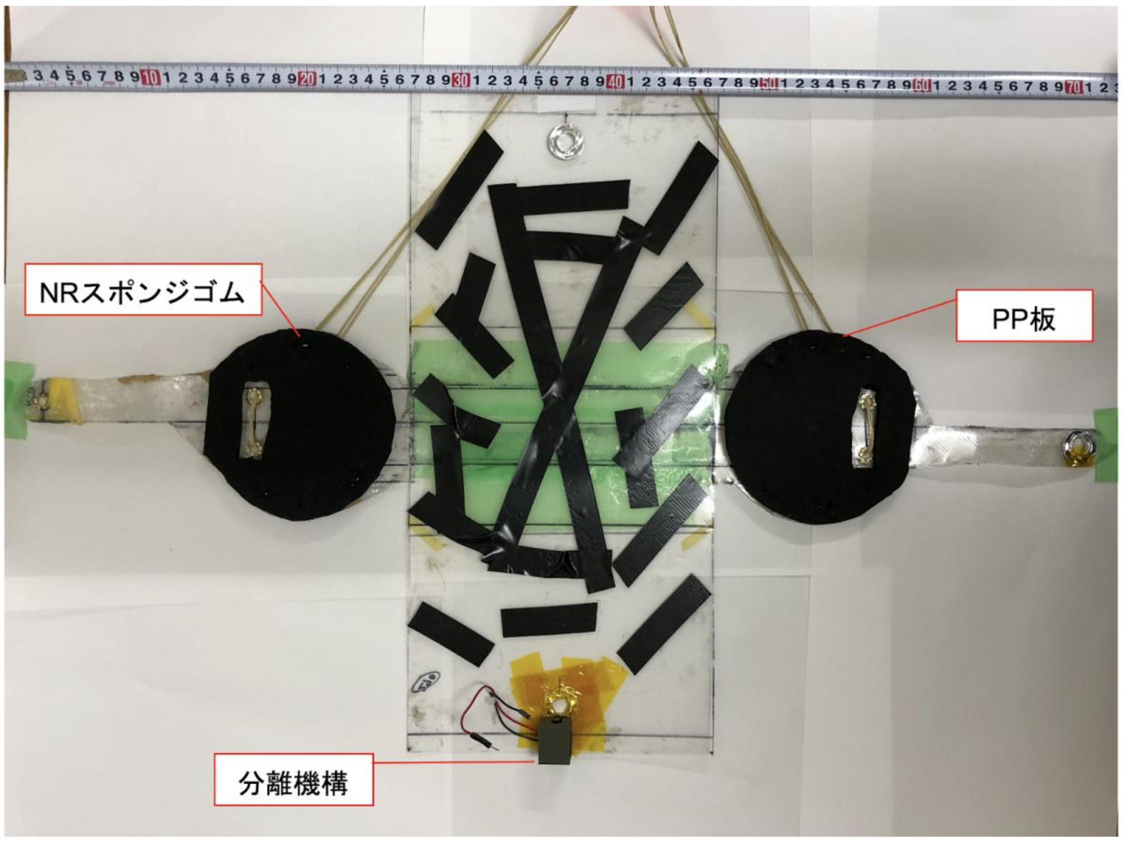

Figure 4.1.9 Exterior view of the aircraft storage module

Table 4.1.4 Specifications of the module for storing the aircraft

diameter	Approximately **142 [mm]**
length	Approximately **210 [mm]**
main material	PP board, NR sponge rubber

Separation

mechanism After landing, in order to separate the recovery mechanism and the fuselage body, the cable ties that close the fuselage storage module are cut using a coiled nichrome wire. (Figure 4.1.10)

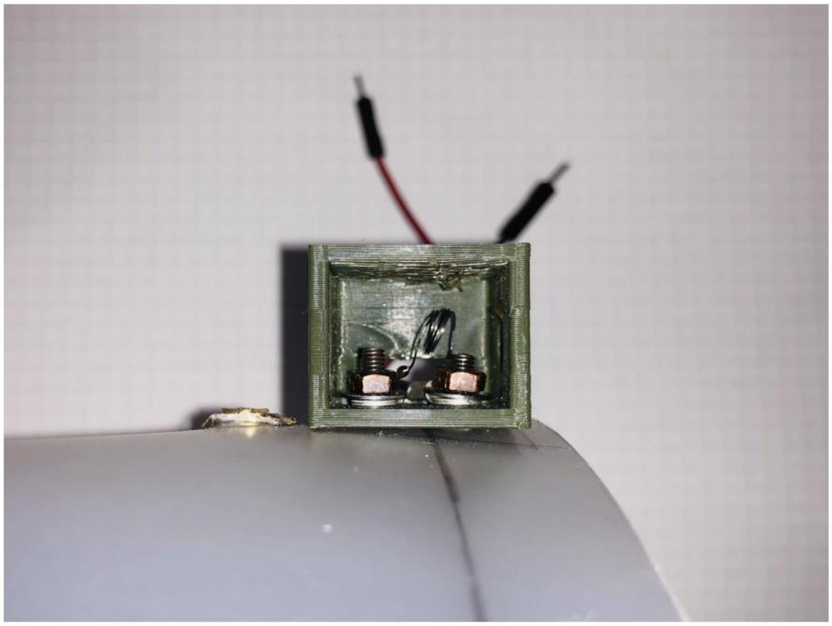

Figure 4.1.10 Appearance of separation mechanism

4.2 Aircraft interior/mechanism

The weight of the completed aircraft exceeded the originally planned weight of the aircraft previously produced for the Tanegashima Rocket Contest. Based on these results, we focused on light weight and durability, and created an aircraft with the aim of achieving a trade-off between the two points (weight and impact resistance) through simulation.

In particular, we focused on the difference in allowable stress between one-piece molding and assembly molding, so we fabricated the area around the shaft where a large stress load is expected to be applied, using one-piece molding to reduce the relative load. We improved replaceability and maintainability by manufacturing parts that are difficult to apply individually. Furthermore, by making it integrally molded, we achieved weight reduction by reducing the number of parts.

Figures 4.2.1 and 4.2.2 show cross-sectional views of the aircraft from the front and top.

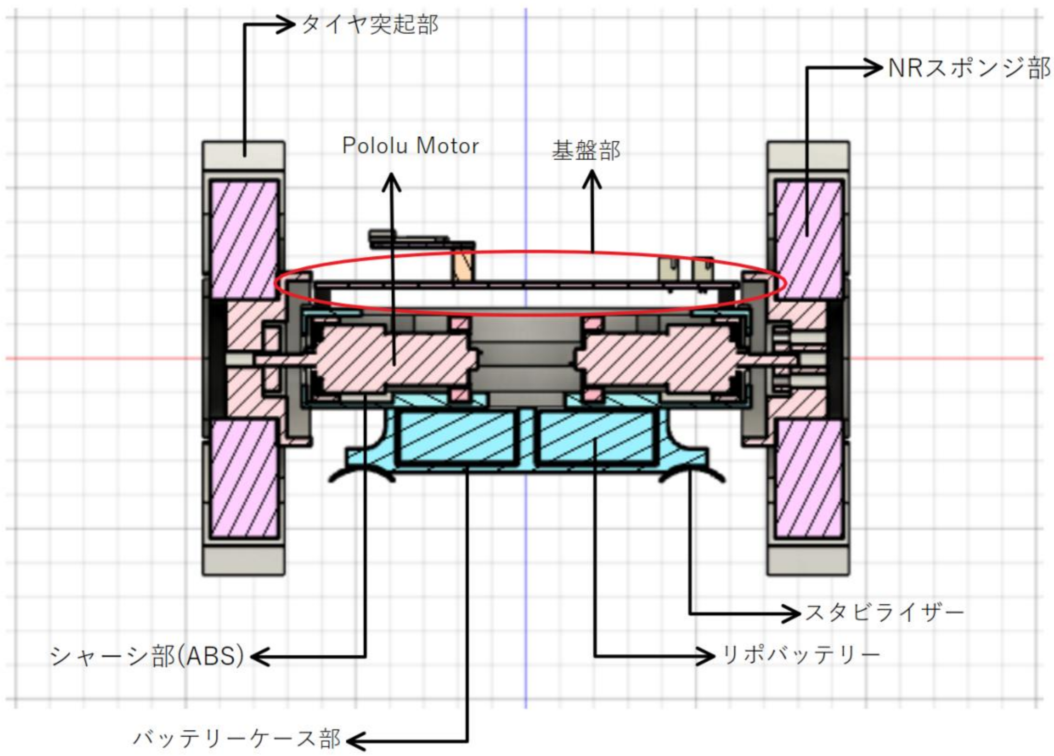

Figure 4.2.1 Cross section of the aircraft (front view)

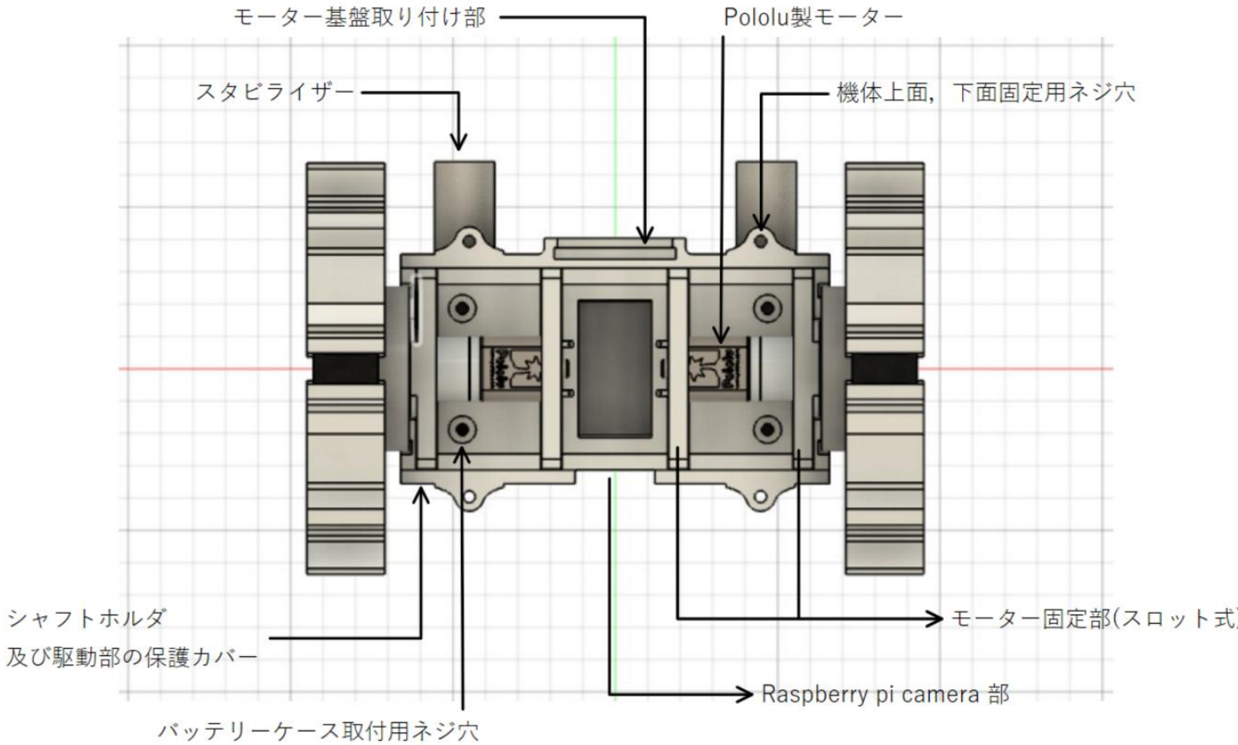

Figure 4.2.2 Cross section of the aircraft (top view)

The stabilizer was manufactured using convex tape. Also, installation
By attaching it with a slight flex during installation, it is made resistant to bending deformation.

As for the tires, we use a material with shock absorbing properties (nitrile sponge) to reduce the impact of landing on the tire side. Furthermore, as a result of considering the ground conditions and reducing the weight, grip performance has also been improved by installing six spikes (tire protrusions) on the tires. (See Figure 4.2.3)

In addition, as a countermeasure to the grass getting tangled in the tire drive part last time, the tire side I installed the cover that comes with the shaft holder. (See Figure 4.2.4)

Machine Translated by Google

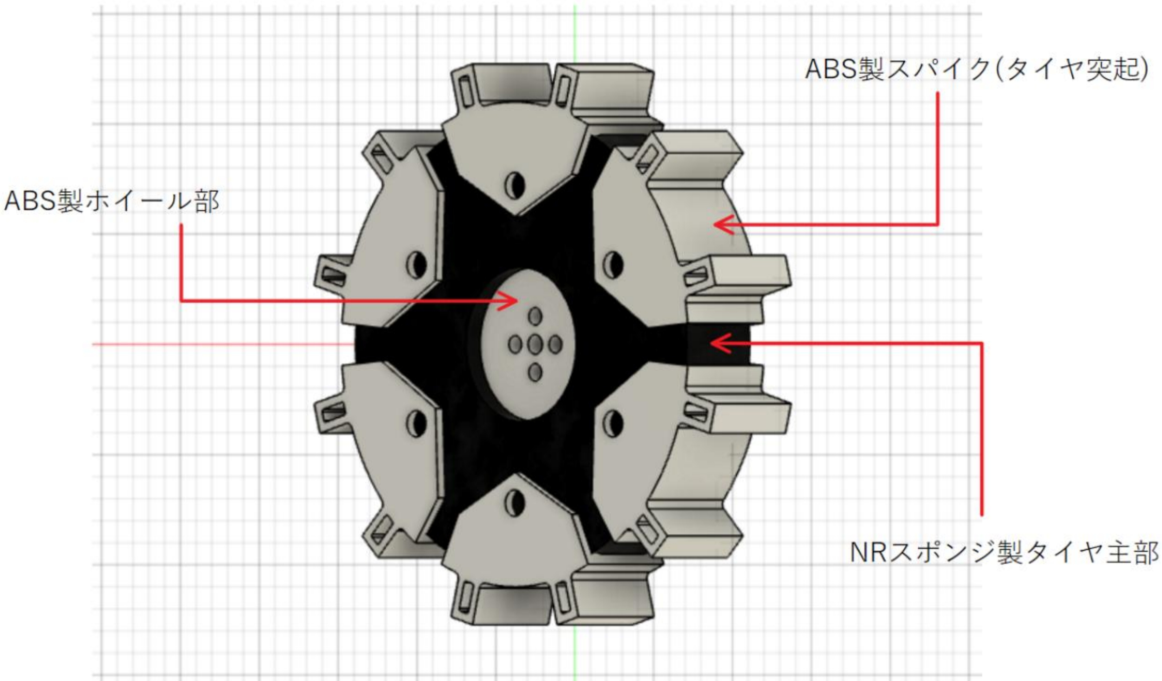

Figure 4.2.3. Tire appearance

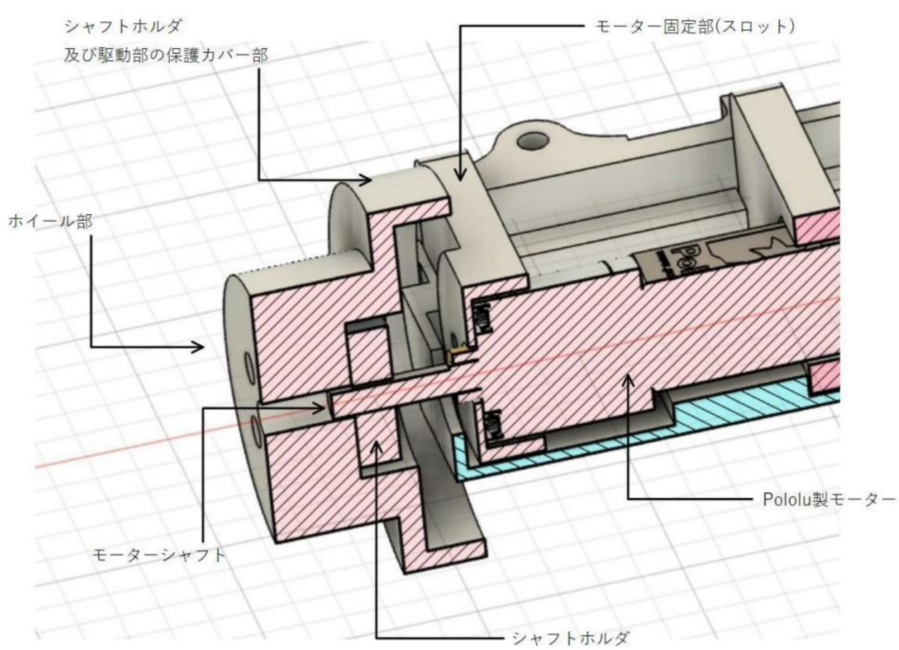

Figure 4.2.4. Connection between tire and chassis

4.3 System diagram

The system diagram is shown below. (Figure 4.3.1)

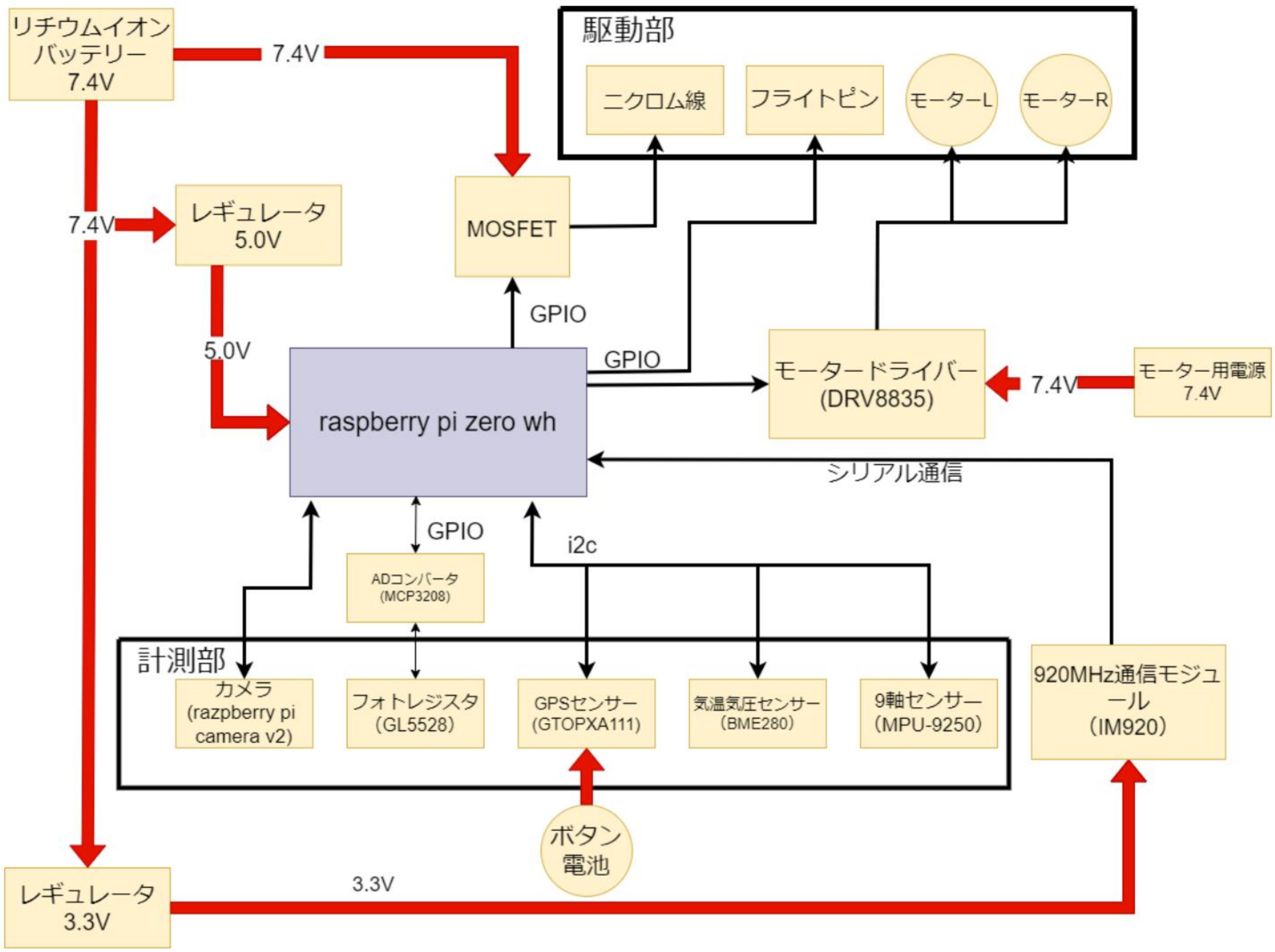

Figure 4.3.1 Aircraft system diagram

The roles of various modules in the system diagram are shown in Table 4.3.1 below.

Table 4.3.1 Role of each module

Module name	Module role
GPS sensor	Acquires GPS data and calculates the direction and distance between the aircraft and the goal based on that information.
9-axis sensor	Obtains the acceleration of the aircraft. Used in vibration tests.
Temperature and pressure sensor	Calculates altitude from temperature and pressure data. Calculate the altitude from that data.
camera	A photo is taken near the goal and final guidance is provided using color recognition.
After confirming that the	nichrome wire has landed, current flows through the MOSFET and burns out the heating wire of the aircraft ejection module.
Photoresistor	Obtains changes in the intensity of surrounding light and detects when the aircraft is released from the carrier.
920MHz communication module	Send the acquired GPS data to the PC. Equipped to prevent loss.

In addition, the list of installed equipment is shown below. (Table 4.3.2)

Table 4.3.2 List of installed equipment

Product name	Model number	Usage	URL
battery	**PACK18650-L35**	power supply	https://item.rakuten.co.jp/blackwolf/blac170101-3500/
Raspberry Pi Zero WH	**Raspberry Pi Zero WH**	Microcontroller	http://akizukidenshi.com/catalog/g/gM-12961/
Raspberrypi camera module v2	**913-2664**	camera	http://akizukidenshi.com/catalog/g/gM-10518/
temperature barometric sensor	**AE-BME280**	For data measurement	https://akizukidenshi.com/catalog/g/gK-09421/
9 axis sensor	**MPU9250**	For data measurement	https://strawberry-linux.com/catalog/items?code=12250
photoresistor	**GL5528**	For data measurement	https://akizukidenshi.com/catalog/g/gI-00110/
GPS sensor	**GTOP XA1110**	For data measurement	https://www.switch-science.com/catalog/3540/
DRV8835	**AE-DRV8835-S**	motor dry bar	https://akizukidenshi.com/catalog/g/gK-09848/
920 MHz wireless module	**IM920c**	For data communication	https://akizukidenshi.com/catalog/g/gM-10138/
Regulator (5.0V) **M78AR05-1**		For power supply	https://akizukidenshi.com/catalog/g/gM-13536/
Regulator (3.3V)	OKI-78SR-3.3/1.5-W36-C	For power supply	https://www.murata.com/ja-jp/products/productdetail?partno=OKI-78SR-3.3%2F1.5-W36-C
12bit 8ch AD converter	**MCP3208-CI/P**	For data conversion	https://akizukidenshi.com/catalog/g/gI-00238/

4.4 Power supply used

The battery used is KT1300/35-2S. Below is a list of the appearance and specifications of the battery used. Shown below (Figure 4.4.1, Table 4.4.1)

Figure 4.4.1 Battery appearance

Table 4.4.1 Battery specifications

Voltage	7.4 [V]
capacity	1300 [mAh]
size	Width 34.0 [mm] x Depth 71.0 [mm] x Height 15.0 [mm]
weight	72 [g]
continuous discharge rate	35 [C] (45.5 [A])
Maximum discharge rate	70 [C] (91.0 [A])
Balancer terminal	JST-XH type installed

Since a lithium polymer battery is used for the battery, safety measures will be described below.

When transporting, use a safety bag for storing lithium polymer batteries as shown in Figures 4.4.2 and 4.4.3. Store and transport in LIPO-SAFE. It is thought that lithium polymer batteries may expand and catch fire due to impact. In that case, grab it with tongs and put it in a bucket containing 3-5% saline.

Figure 4.4.2 Appearance of safety bag for storing lithium polymer batteries

Figure 4.4.3 Safety bag for storing lithium polymer batteries

4.5 Algorithm

The aircraft motion algorithm is shown in Figure 4.5.1 below.

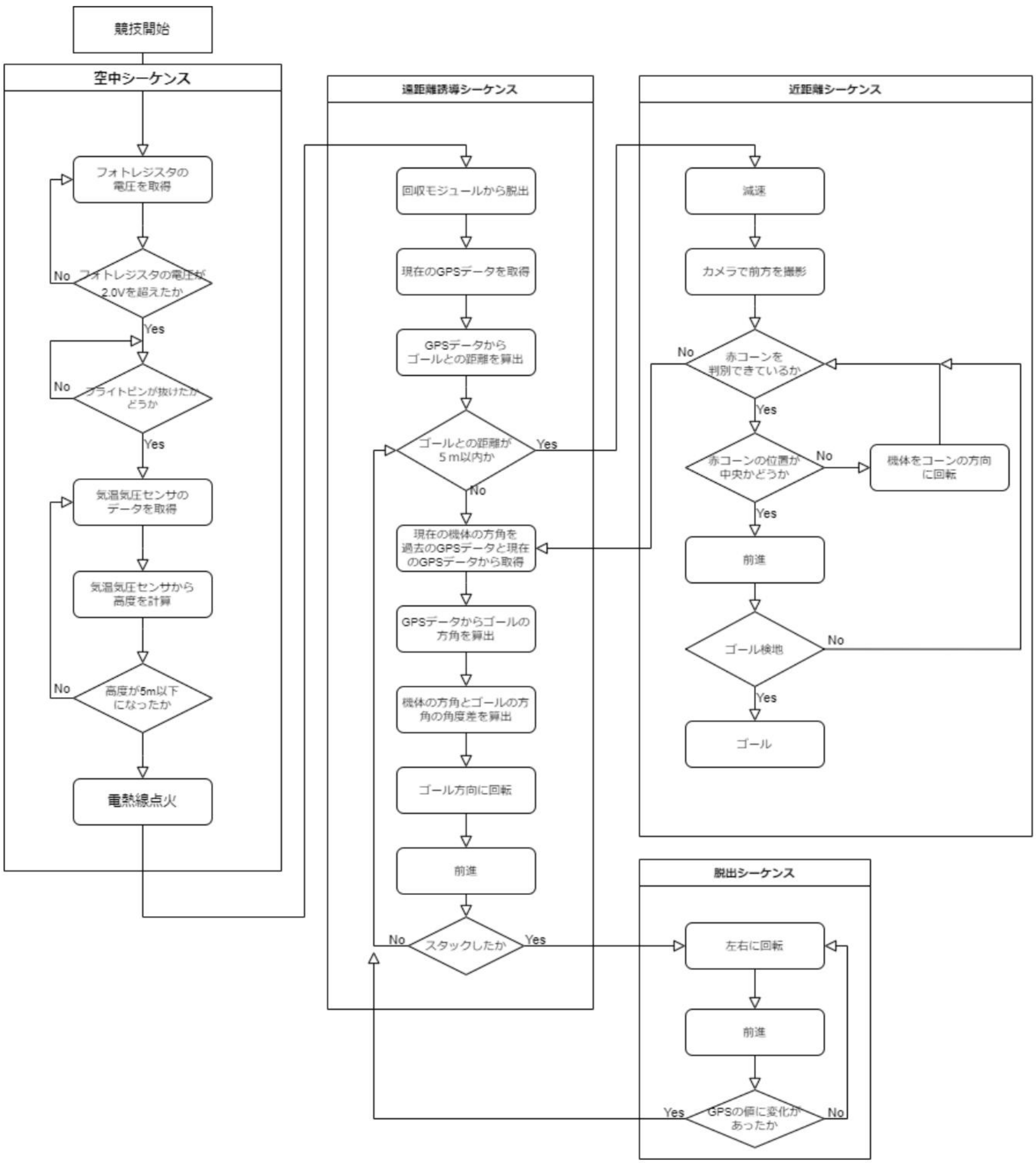

Figure 4.5.1 Aircraft motion algorithm

Other detailed algorithms are shown below.

[Aerial sequence]

<About emission detection>

Emission detection uses light detection using a photoresistor. The one we will use this time is a photoresistor using CdS (cadmium sulfide), which is a resistor whose electrical resistance decreases depending on the intensity of light. Taking advantage of the fact that the bright resistance value is 10 to 20 kÿ and the dark resistance is 1 Mÿ, the circuit was designed to output about 1.0 V inside the drop carrier and about 2.5 V after dropping. Designed. Therefore, the microcomputer determines when the photoresistor voltage exceeds 2.0 V and detects dropping.

<About altitude calculation>

In the troposphere (within 11 [km] above the sky), altitude can be calculated using the following formula. mounted on the aircraft The altitude is calculated based on the temperature and pressure sensor values.

$$ÿ = \frac{(1-(\frac{0}{})^{\frac{1}{15.257}})\times(+273.15)}{0.0065}$$

ÿ : Altitude :

0 Reference point pressure

: Measured atmospheric

pressure : Measured temperature

[Long distance guidance sequence]

<About GPS guidance> When

guiding the aircraft to the goal based on GPS values, the direction of the aircraft and the direction from the aircraft to the goal are determined.
, the distance between the aircraft and the goal is calculated using the following formulas.

•Aircraft angle

$$ÿ_1 = ÿ1\ (\frac{ÿ}{ÿ})$$

ÿ : Difference in longitude between n-1st and nth guidance ÿ :

Difference in latitude between n-1st and nth guidance

•Direction from the aircraft to the goal

$$ÿ_2 = {}^{-1}\left(\frac{ÿ}{ÿ}\right)$$

ÿ : Difference between the longitude of the goal and the aircraft

ÿ : Difference between the latitude of the goal and the aircraft

•Distance between the aircraft and the goal

According to Hübeny's law, if the distance between the aircraft and the goal is

$$= (\sqrt{\quad)^2 + (\quad ())^2}$$

: Difference in longitude between the aircraft and the goal

: Difference between aircraft and goal latitude

:Red radius

:Polar radius

: Average latitude of aircraft and goal

$$= \frac{(1ÿ \quad ^2)}{^3}$$: Meridian radius of curvature

$$= \frac{}{\sqrt{1ÿ \quad ^2 \quad ^2()}}$$:Usagi curvature radius

$$= \sqrt{\frac{2\text{-}2\ \_}{^2}}$$: 1st separation rate

<Image recognition program>

The program analyzes when the GPS approaches the goal, and when the goal is within 5 m, Take a picture with the camera. Extract the red part from the captured image and calculate the position of the red cone

.

Here, we will explain the image recognition program system that we created this time. The camera takes Extract the red part from the shadowed image, surround the red object with a black frame, and mark the center of gravity of the extracted part. Calculate the position coordinates and plot them on the original image. In other words, OpenCV's moments function for images The coordinates of the center of gravity are determined based on the contour. (Coordinates of center of gravity position: The upper left corner of the image is the origin pixel position when the horizontal axis is x to the right and the vertical axis is y to the bottom) and the red object By returning the value of the center of gravity position coordinates, we can confirm that the aircraft has definitely recognized the red object. You can check it from here.

Below is an overview of the image processing program redcorn.py.

Loading the base image (Figure 4.5.2)

ÿ

Convert image colors to HSV format

ÿ

Specify red (Figure 4.5.3)

ÿ

Create a binary image with red and other colors

ÿ

Load the created image

ÿ

Obtain the center of gravity coordinates and outline of the loaded image (Figure 4.5.4)

ÿ

Plot and save the center of gravity position coordinates and outline on the base image

Regarding the HSV color specification method, we referred to document [2] and determined the specific values.

Figure 4.5.2 Base image

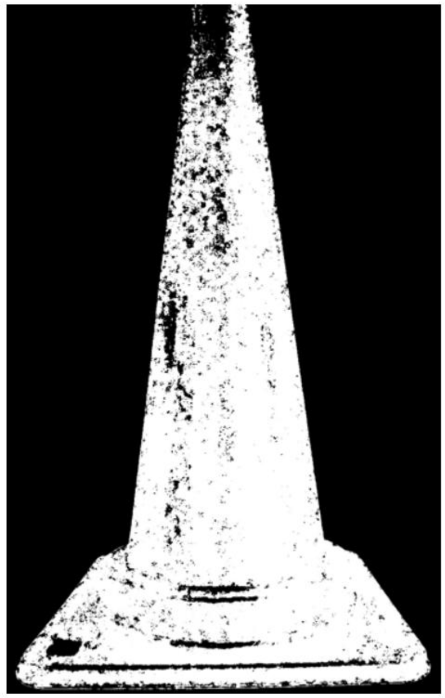

Figure 4.5.3 Image with only the red area selected

Figure 4.5.4 Image of cone outline

Reference materials

[1] Finding the center of gravity with Python+OpenCV, Yuki Mochizuki, https://cvtech.cc/pycvmoment/

[2] hsv hsl hue color sample list, web color conversion, https://colorcodesearch.com/hsv-hsl/

[3] #FB1408, color site.com, https://www.color-site.com/codes/FB1408

Chapter 5 Test item settings

number	Verification item name	Corresponding self-examination items Request number(s)	Implementation date (Scheduled date)
V1	Mass test	S1	6/18
V2	Aircraft storage and release test	S2	6/25
V3	Quasi-static load test	S3	7/12
V4	Vibration test	S4	6/22-24, 8/5
V5	Separation impact test	S5	7/12-19
V6	Opening impact test	S6	8/3
V7	parachute drop test	S7	7/10
V8	Landing impact test	M2	7/1
V9	Tests related to driving performance	M4	7/13
V10	Goal detection test	M6, M7	7/4-5
V11	End-to-End exam	S11, M1, M5, M8	7/12-19, 8/5
V12	Long distance communication test	S8	7/9-17
V13	Control history report test	M9	7/12-19
V14	Parachute separation test	M3	7/8
V15	Communication power ON/OFF test	S9	7/9-17
V16	Communication channel change test	S11	7/17

Chapter 6 Contents of the exam

(V1) Mass test

[Purpose]

The combined mass of CanSat and parachute must meet the specified mass of 1050 [g] or less.
confirm.

ÿcontents of the testÿ

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

ÿresultÿ

The test results are shown in Table 6.1.1.

Table 6.1.1 Mass test results

times	Aircraft body [g]	Collection mechanism [g]	Total weight [g]
1	**687**	**210**	**899 (ÿ897)**
2	**644.5**	**220.0**	**864.5 (ÿ864.5)**

*The value is the sum of the weight of the aircraft body and recovery mechanism. Error compared to total weight measured at the same time
was not confirmed.

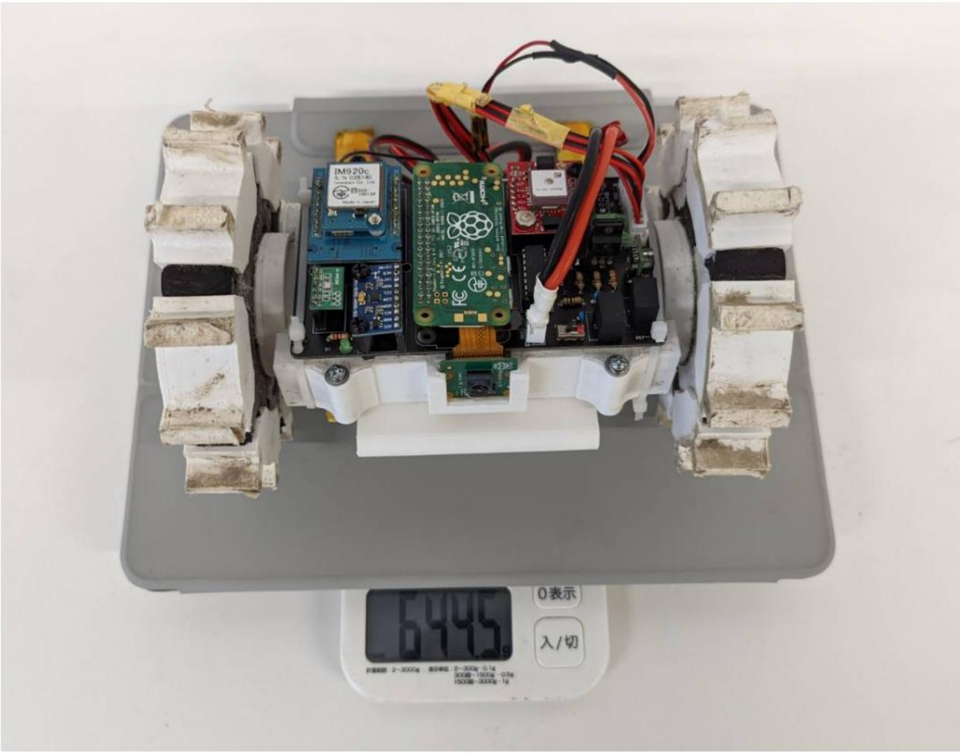

Figure 6.1.1 Weight of the aircraft body (second time)

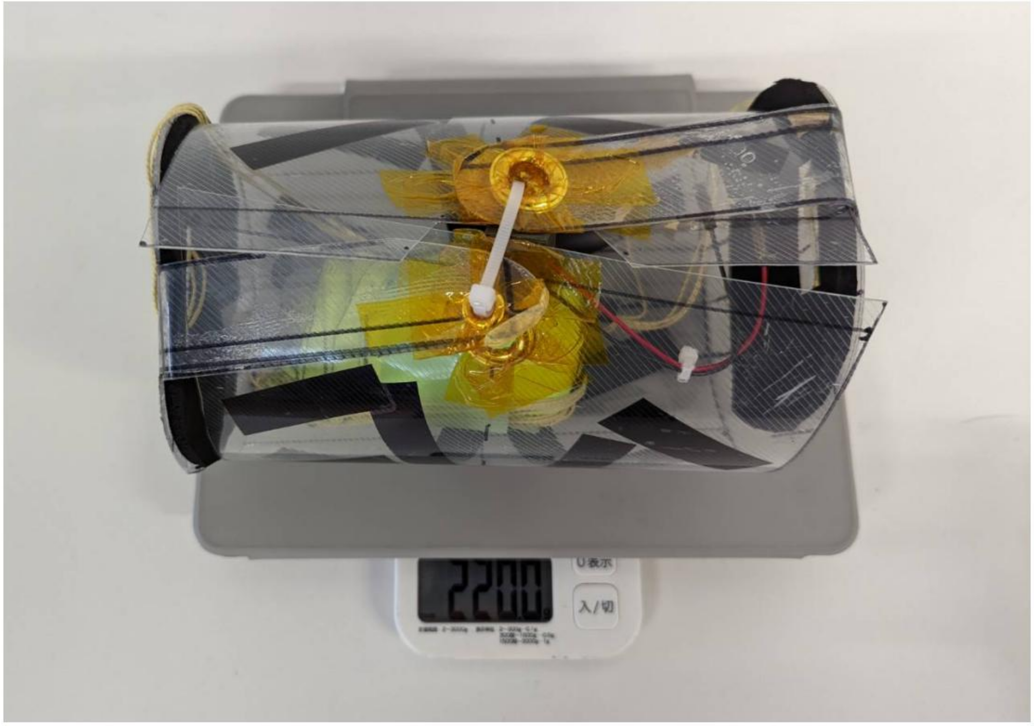

Figure 6.1.2 Weight of recovery mechanism (second time)

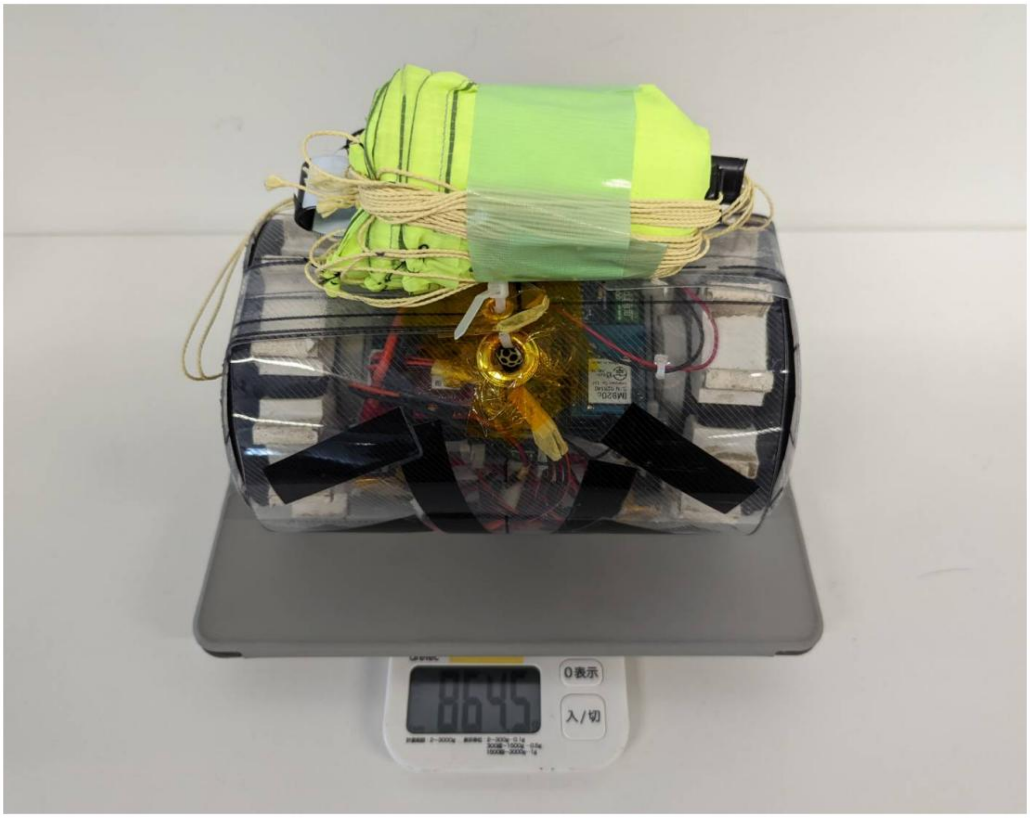

Figure 6.1.3 Recovery mechanism and weight of the aircraft (second time)

[Discussion] It was found that the total weight of the CanSat, including the mass of the recovery mechanism, met the regulations.

(V2) Aircraft stowage/release test [Purpose]

To

confirm that the fuselage stowage module containing the CanSat can be stored in the carrier and released under its own weight.

ÿcontents of the testÿ

CanSat is stored in the aircraft storage module, and the parachute is folded in the carrier.
Then, it is released from the carrier by its own weight.

[Results]

As shown in Table 6.2.1, it was confirmed 3 out of 3 times that the CanSat could be released under its own weight after being stored in the carrier.
The aircraft was placed in the carrier as shown in Figures 6.2.1 and 6.2.2 below.

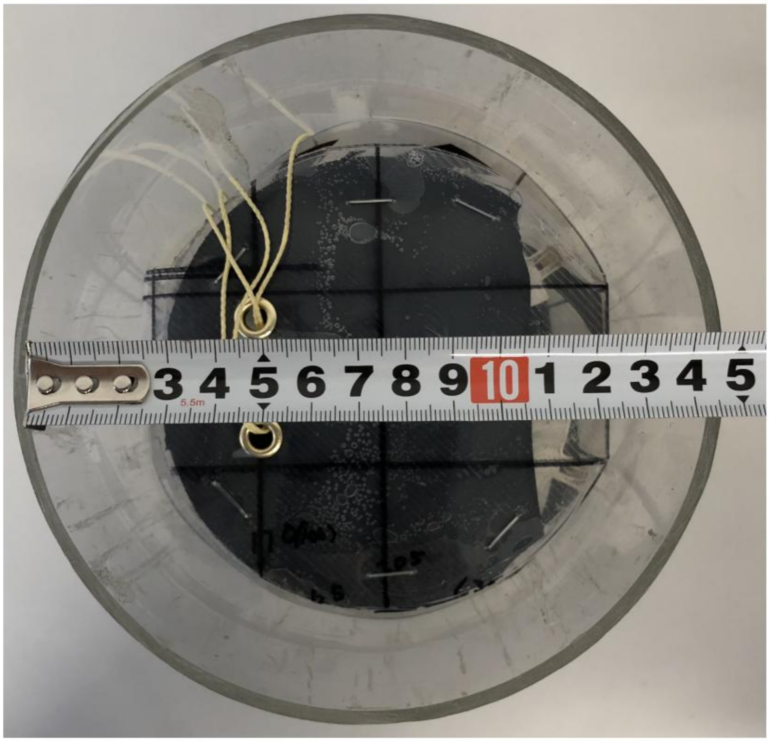

Figure 6.2.1 Storage state 1

Figure 6.2.2 Storage state 2

Table 6.2.1 Results of carrier release test (re-experiment)

number of times	Experiment video	Release judgment
1	https://youtu.be/ubYXK2ZxS6E	was able to release it by itself
2	https://youtu.be/DVnyA_iL6pY	was able to release it by itself
3	https://youtu.be/_htcEmyTjao	was able to release it by itself

[Consideration]

From the above, the aircraft meets the requirements of the regulations and can be stored and released. was shown.

(V3) Quasi-static load test [Purpose]

Assume

the main body of the rocket as the payload. Also, confirm that the main body of the aircraft can withstand the quasi-static loads that are expected to be applied during launch.

ÿcontents of the testÿ

After CanSat receives the static load applied during rocket launch, confirm that the body of the aircraft can withstand the static load. In order to reproduce the static load caused by a rocket, the CanSat carrier, including the body, electrical components, and separation mechanism, is stored in a bag connected to a string to reproduce the state of being mounted on a rocket. I put the carrier in and rotated the bag around the point when my arm was parallel to the ground. According to regulations, the static load is 10 [ ] in the height direction of the carrier. Therefore, a static load of 10 [ ] was applied to the aircraft for more than 10 seconds. After that, the experiment will be shown in the video at the following URL.

In addition, the static load was derived from the following formula. To put the aircraft in a bag and swing it around,] is the angular Acceleration occurs. [axial direction is the length of the velocity in the axial direction, and the acceleration in the arm and the bag, ÿ [= 1. 2 [ ], ÿ = 3 [ ] (15 rotations in 10 seconds)

$$= \frac{2\,ÿ}{9.81} = \frac{1.2 \times (3ÿ)^2}{9.81} ÿ\ 10.8\ [\ ]$$

Therefore, if we can keep the angular velocity constant, we can perform the experiment by applying the required static load.

[Test results]

The test results are shown in Table 6.3.1.

Table 6.3.1 Quasi-static load test results

Experimental result	Aircraft status	URL
1st time ÿ	No damage or defects to the aircraft, electrical equipment, or recovery part	https://youtu.be/n982ynxsb3U

Also, the acquired acceleration data is shown in Figure 6.3.1.

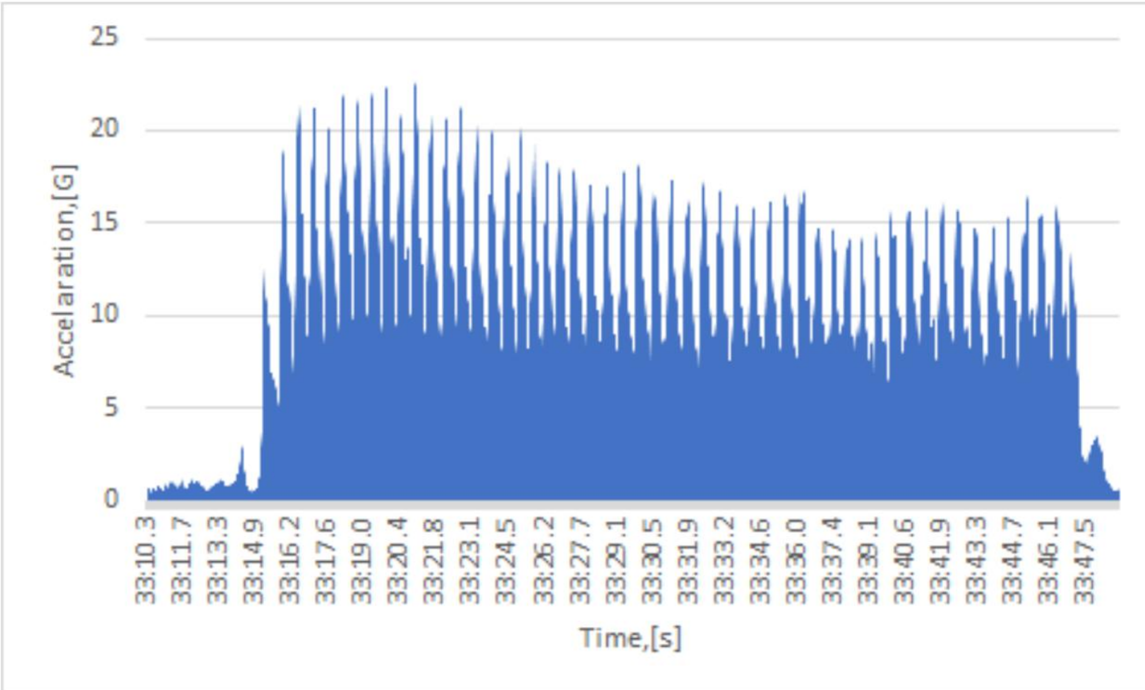

Figure 6.3.1 Acceleration experienced by the aircraft during the quasi-static load test (first time)

[Consideration] From the above, it is possible to apply a quasi-static load that complies with the regulations, and The aircraft was shown to be able to fly even when flying.

(V4) Vibration test [Purpose]

The CanSat can withstand the vibrations and loads applied during a rocket launch, and the CanSat will not be damaged afterward. Make sure that the

[Test/analysis content]

Excite CanSat and the reduction mechanism using a vibration tester. After that, remove the CanSat from the homemade carrier and check that the CanSat is not damaged. The experiment is shown in the video at the URL below. In addition, the excitation conditions were 30 to 2000 [Hz] sweep vibration, 15

Multiply the vibration acceleration by [G].

ÿresultÿ

We conducted a vibration experiment using an exciter (IMV Coporation VE-3202) in the Mechanics Laboratory of Muroran Institute of Technology (Lecturer: Taiki Matsumoto). The results are shown in Table 6.4.1.

The first time, the frequency was changed from 30 [Hz] to approximately 2000 [Hz], but the second and third times,

Changed from 30 [Hz] ÿ 2000 [Hz] ÿ 30 [Hz]. That is, the process of frequency reduction was also added to the test conditions.

Table 6.4.1 Vibration test results

Number of experiments	Result	Aircraft status	URL	
1st time ÿ		No damage or defects to the aircraft, electrical equipment, or recovery part.	https://www.youtube.com/watch?v=dHNc69WSQq4	
2nd time ÿ		No damage or defects to the aircraft, electrical equipment, or recovery part.	https://youtu.be/uW4j hdqEWWo	https://youtu.be/FGL4oV0 uAjA
3rd time ÿ		No damage or defects to the aircraft, electrical equipment, or recovery part.	https://youtu.be/WrLZ vBR1OJY	https://youtu.be/TU1zEM wb-IQ

In addition, the acceleration data obtained from the experiment is shown in Figures 6.4.1 to 3.

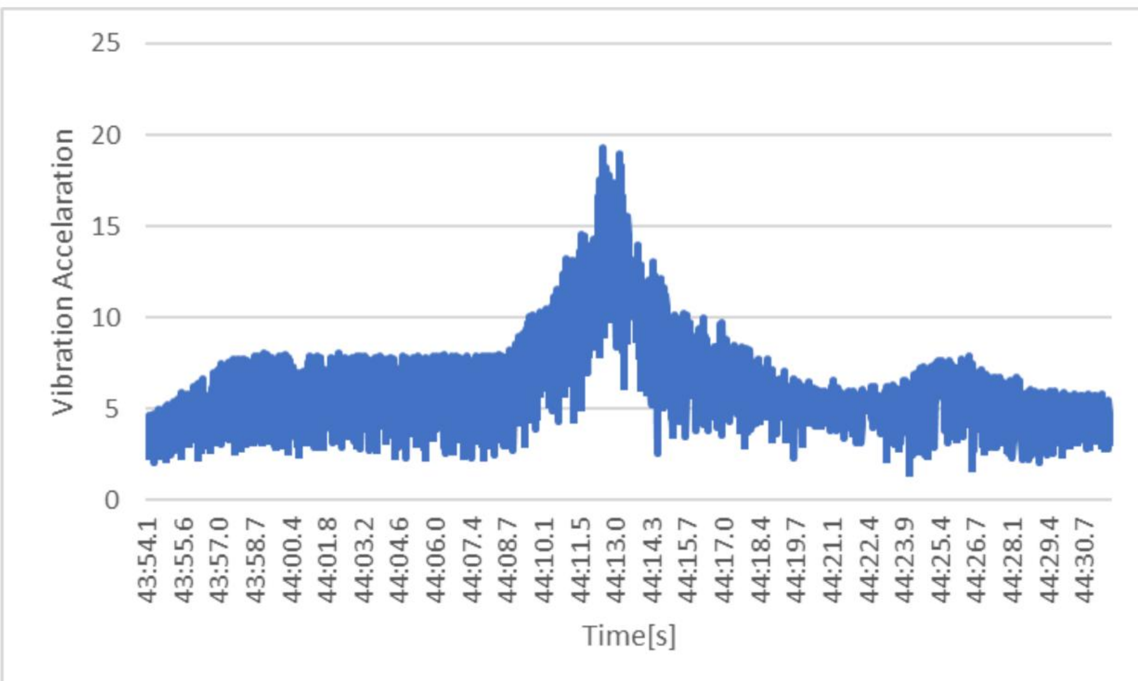

Figure 6.4.1 Vibration acceleration data (first time)

Machine Translated by Google

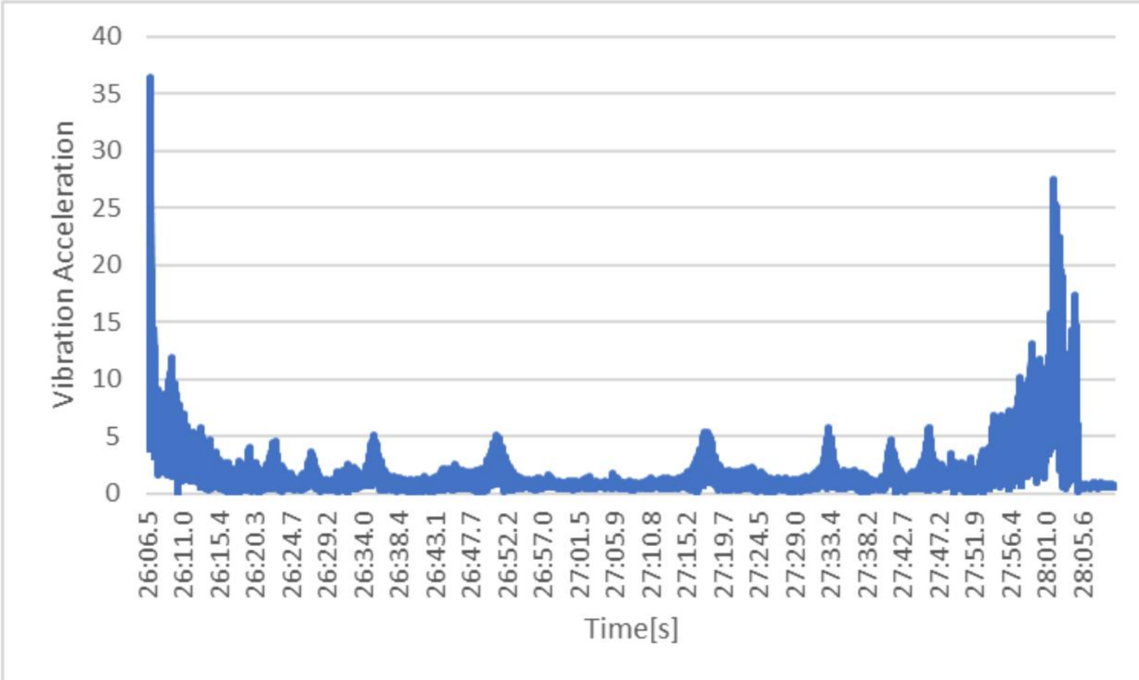

Figure 6.4.2 Vibration acceleration data (second time)

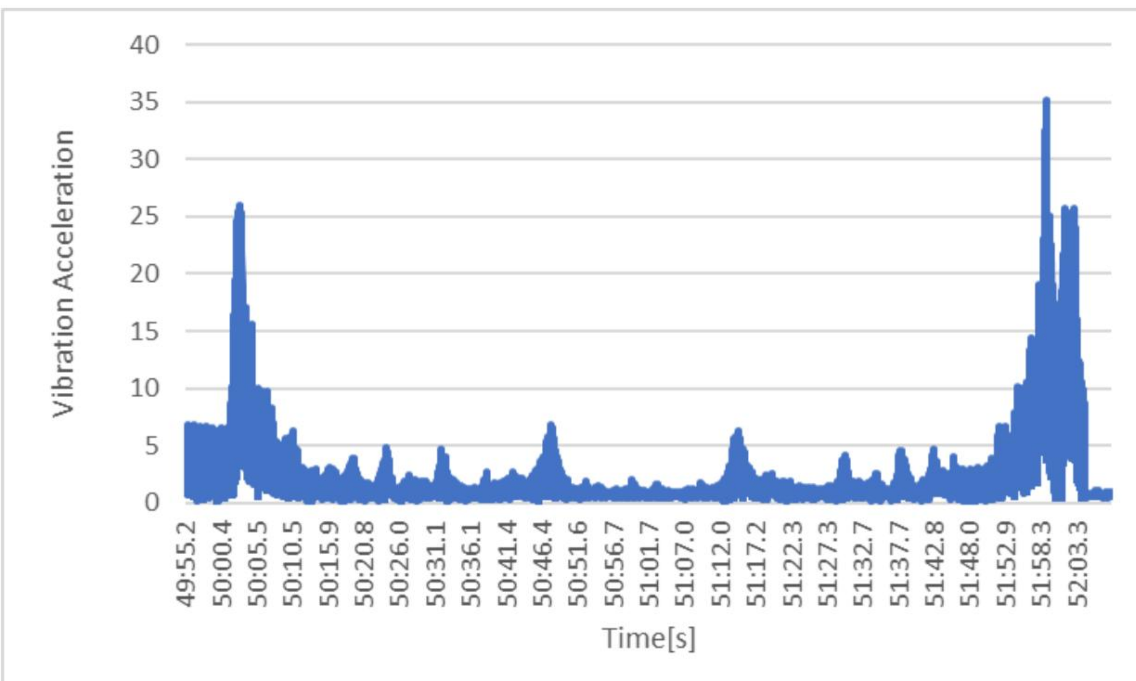

Figure 6.4.2 Vibration acceleration data (3rd time)

[Consideration]

There was no mention in the video of the clear confirmation of damage in the first and second vibration tests. Therefore, in the third experiment, after checking the operation from separation to the start of flight, we checked for loose screws, breakage, and damaged parts of the aircraft, and checked for broken sensors and damaged parts in the electrical equipment. We checked to make sure there was no damage to the recovery mechanism, and to make sure there were no damaged parts. The results showed that there was no damage or malfunction to the aircraft even when it was vibrated under conditions that complied with the regulations.

From the above, it was shown that there was no damage or malfunction to the aircraft even if it was vibrated under conditions that comply with the regulations.

(V5) Separation impact test

[Purpose]

This shows that CanSat can withstand the impact of being ejected into the air from a rocket. After the test, we will confirm that CanSat has a driving function.

[Test details]

1. Store the CanSat in the void tube and tie the void tube with a string. Also, it is connected to a part of the building. Go.
2. Drop a void tube and reproduce the separation impact from the rocket. 3. Measure the impact using an acceleration sensor. 4. Remove the CanSat from the void tube, unfold the fuselage storage cover, and move the fuselage. Evaluate the functionality of CanSat.

[Results]

The results are summarized below as Table 6.5.1. I have also attached the test video as a URL. Actual measurement The vertical impact value is shown in the graph in Figure 6.5.1-2 below.

Table 6.5.1 Separation impact test video

number of times	Procedure	Experiment video	Additional information
1	drop	https://youtu.be/IL2piUQ8JjE	-
	CanSat running performance confirmation	https://youtu.be/3pZIPICnKUI	There is a problem with driving performance. death
2	drop	https://youtu.be/mUJtOpigbZU	-
	CanSat running performance confirmation	https://youtu.be/aqN8GsFRPkM	There is a problem with driving performance. death

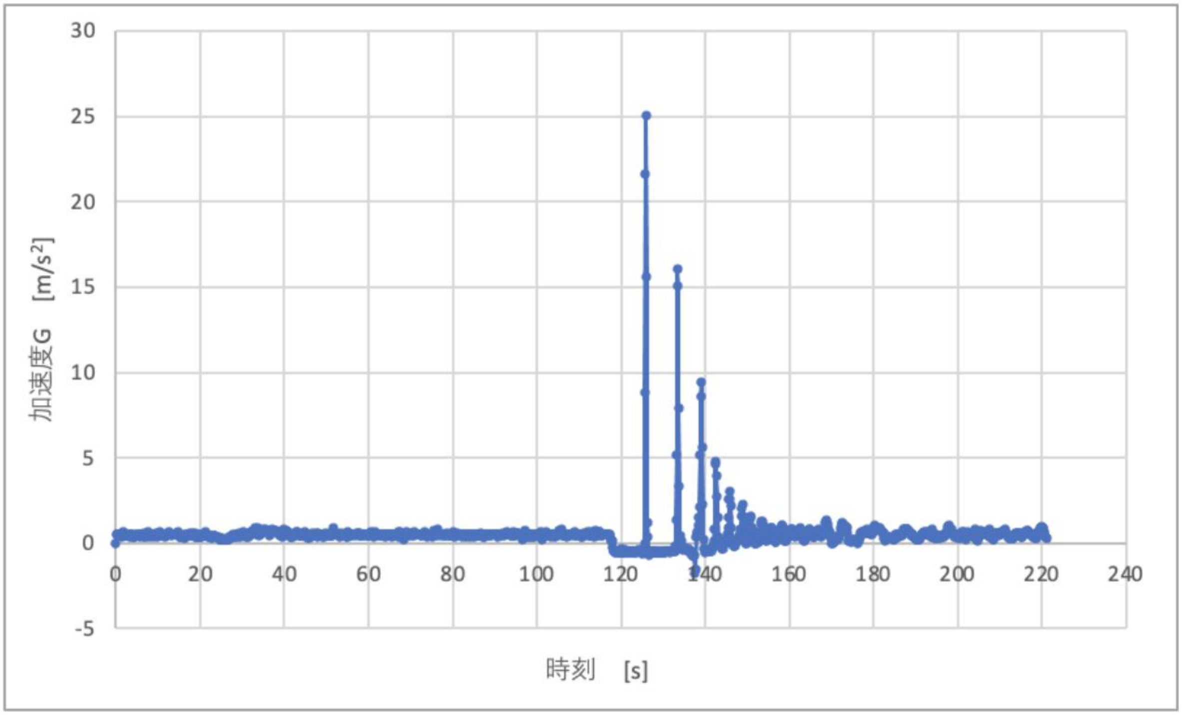

Figure 6.5.1 Impact of the first drop

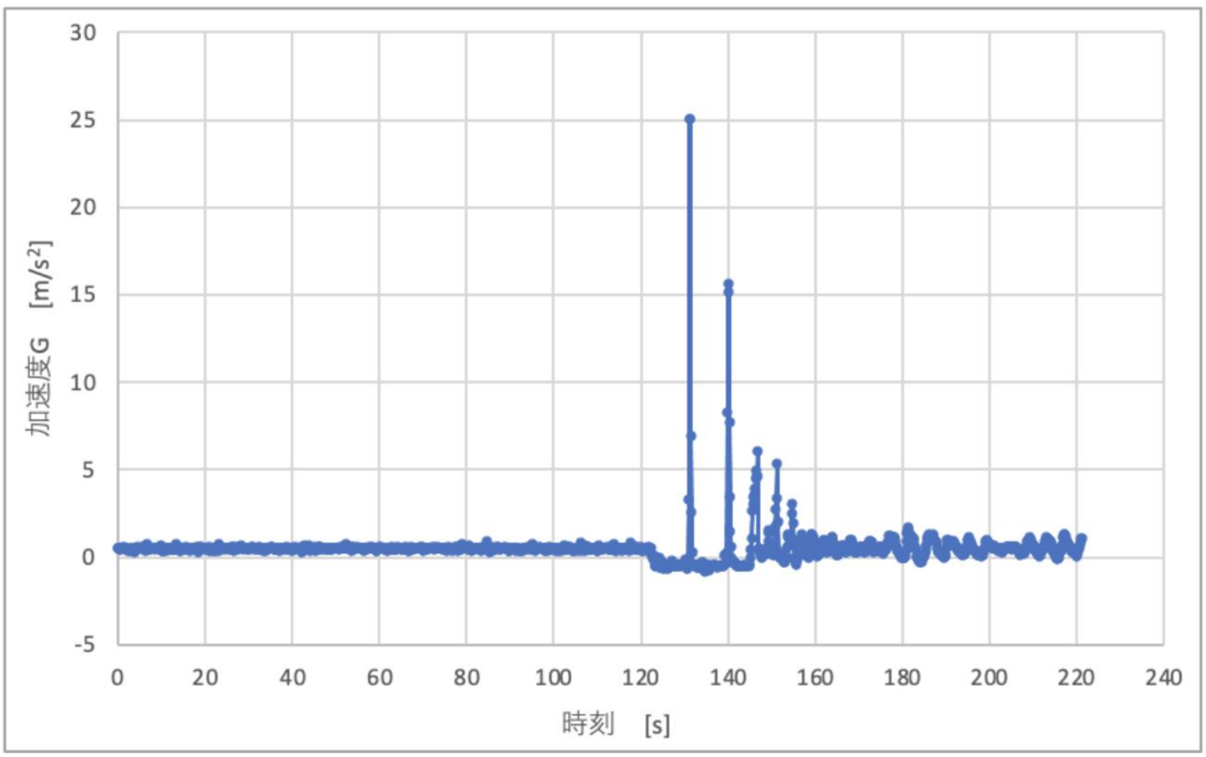

Figure 6.5.2 Impact of second drop

[Consideration]

CanSat withstood the measured separation impact of approximately 25 [G], and there were no problems with the aircraft's flight performance. I found out that.

(V6) Umbrella opening impact test

[Purpose]

This shows that CanSat can withstand the shock that is applied when it opens after being released into the air from a rocket. After the test, we will confirm that CanSat has a driving function.

[Test details] 1.

Store CanSat in the aircraft storage module with an acceleration data logger attached. 2. Holding the canopy side slightly above the base of the paracord, throw the CanSat down (throw it down several times). 3. Measure the impact using an acceleration sensor. 4. Remove the acceleration data logger from CanSat. 5. Using remote control, the CanSat and recovery mechanism are separated and moved, demonstrating that the CanSat is durable against the impact of opening.

[Results]

In this experiment, we threw down four times. The results are summarized below as Table 6.6.1. I have also attached the test video as a URL. Actual measurement The vertical impact values obtained are shown in the graph in Figure 6.6.1 below.

Table 6.6.1 Umbrella opening impact test video

Experiment video	Test results
https://youtu.be/NipTKK3i1OM	**We were able to separate the collection mechanism and launch CanSat without any problems.**

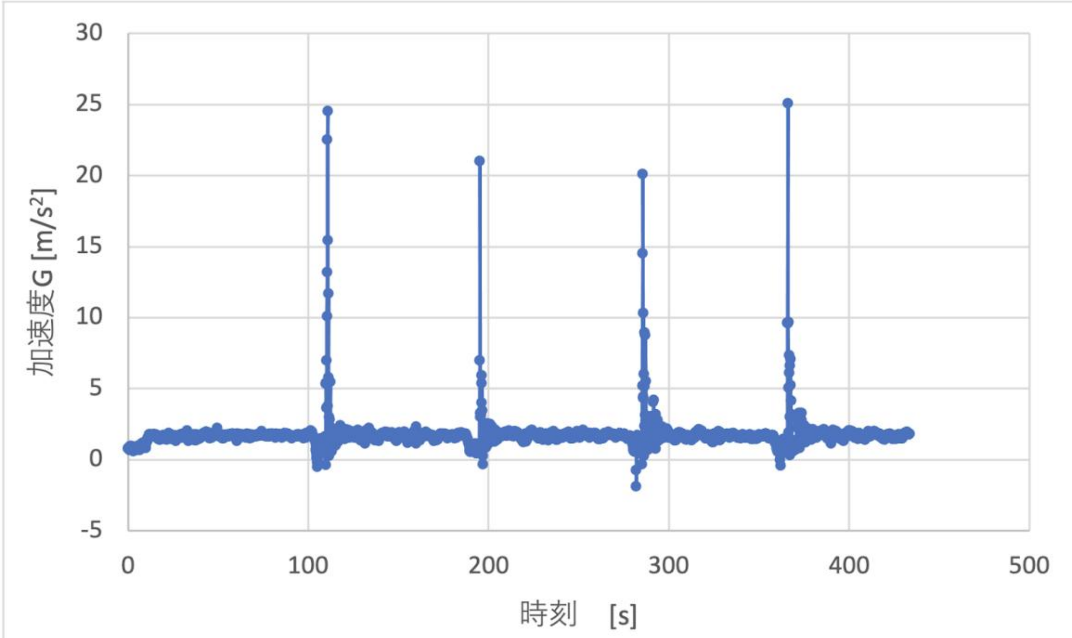

Figure 6.6.1 Opening impact

[Consideration]

It was found that the CanSat withstood the measured opening impact of approximately 25 [G], and there were no problems with the performance of the recovery mechanism or the aircraft itself.

(V7) Parachute drop test [Purpose] 1. The parachute has

opened

and is decelerating 2. Confirm two points: that the terminal velocity is within

about 5 to 6 [m/s].

[Test details] A

parachute with a weight of 1 kg is released from a carrier at an altitude of 25.2 m, and the parachute is dropped. Record the situation below as a video.

[Results]

In this experiment, it was dropped a total of 4 times. The test results are summarized in Table 6.7.1 below. (Watch the test video (attached as URL).

Table 6.7.1 Drop test results

number of times	Result	Terminal velocity [m/s]	Reason for failure judgment	Test video URL
1	success	6.02	-	https://youtu.be/79OinrXIJ28
2	success	5.23	-	https://youtu.be/WLATMfPX0eI
3	success	5.83	-	https://youtu.be/9_TQIfx15Sk
Four	success	5.82	-	https://youtu.be/s8pDzywn8QU

<Experiment location and terminal velocity calculation method>

Here, we will show how to calculate the terminal velocity using data from the third drop. Is it a video you shot? A panoramic image was created using ImageJ. The time interval between photos is 0.3 [s]. distance measurement Using the click measure software, the distance between the red arrows was found to be approximately 1.75 [m]. Also, yellow It was confirmed that the terminal velocity was reached from below the line. From these, the terminal velocity is approximately 5.83 [m/s] Reach.

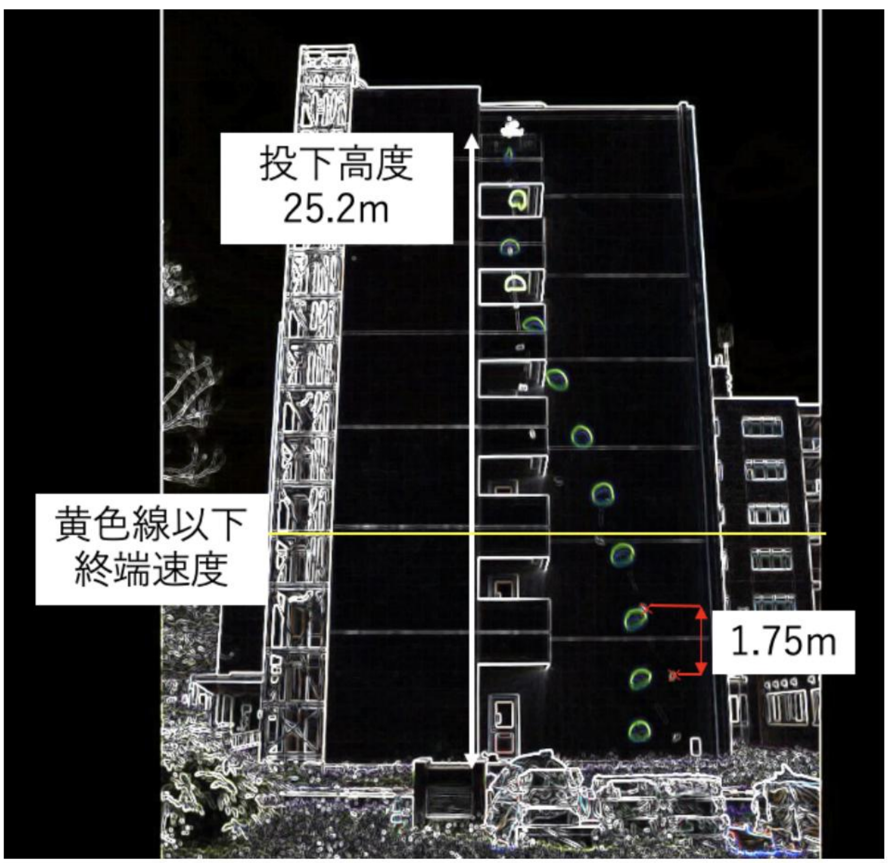

Figure 6.7.1 Terminal velocity calculation method

[Discussion] The parachute opened and decelerated 4 out of 4 times, and the terminal velocity was approximately 5 to 6 [m/s]. ing. Therefore, it can be seen that the parachute satisfies the requirements.

Next, let us consider the difference between the design value and the actual value of the parachute's descent speed. The maximum measured terminal velocity was 6.02 [m/s], which is slightly faster than the set terminal velocity of 5.0 [m/s]. In other words, the actual measurement exceeds the design value. This means that the weight used in this experiment was 1 [kg], whereas the weight of the aircraft used when designing the parachute was 0.90 [kg], and the weight used in the experiment was 0.1 [kg]. This is probably because it was heavy. Other possible influences include manufacturing accuracy, drag coefficient, wind volume, and wind direction.

(V8) Landing impact test [Purpose]

CanSat can withstand the impact when it opens and lands after being released into the air from a rocket. is shown. After the test, we will confirm that **CanSat** has a driving function.

[Test/Analysis Overview]

Conduct the test according to steps I to III below.

ÿ. Measuring the average contact time using an aircraft dummy 1.

Build an aircraft dummy excluding items (motor, base, etc.) that would be harmful if damaged by a fall impact. make.

2. Substitute the terminal velocity in~~to th~~e $\frac{^{2}}{2}$ equation of h =. Drop the aircraft dummy from the determined height h. 3. Take fixed-point photography and calculate the average contact time using the camera's frame rate and the number of consecutive photos.

ÿ. Run the simulation (using the average contact time determined in ÿ)

Confirm that the aircraft can withstand the load based on the simulation results.

ÿ. Dropping the aircraft from a height h that gives a landing shock equivalent to the actual landing shock

Using the terminal velocity of the parachute in the equation of conservation of mechanical energy, find the height h, actually drop from the height h, and check whether the sequence from separation to start of flight can be performed without problems.

[Details of the test content and results of Test I] <Details of the test content of Test I>

Figures 6.8.1 and 6.8.2 below show an overview of the aircraft dummy used in the experiment.

Figure 6.8.1 Aircraft dummy overview

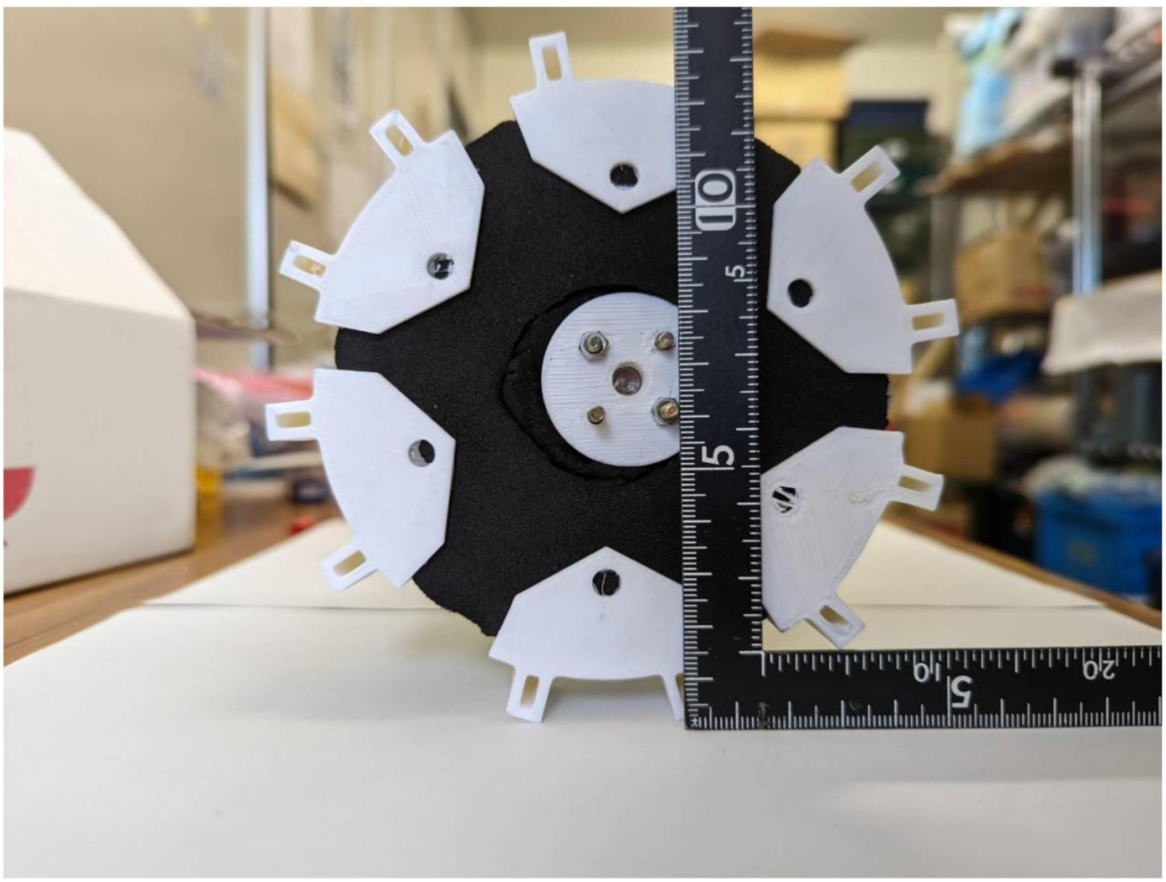

Figure 6.8.2 Aircraft dummy side view

In this experiment, v=10.87[m/s] is used as the terminal velocity. Also, let it fall freely from a height derived from the following formula, and execute the sequence up to separating the parafoil. The height for free fall is determined by the law of conservation of energy.

$$h = \frac{^2}{2}$$

It is. Therefore, from v=10.87[m/s], g (gravitational acceleration)=9.81[m/s 2]

$$\boldsymbol{h} = 6.024 \text{ [m]}$$

was asked. Free

fall from this height and perform a landing impact test. If we conduct an experiment and the CanSat can withstand the landing impact and execute the subsequent sequence without damage, we can say that it is resistant to the landing impact.

<Test results of Test I>

Figure 6.8.3-7 below shows the experimental results of the aircraft dummy falling.

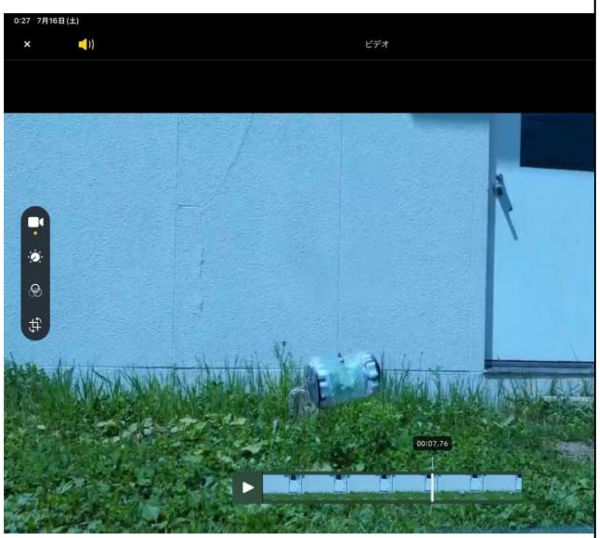	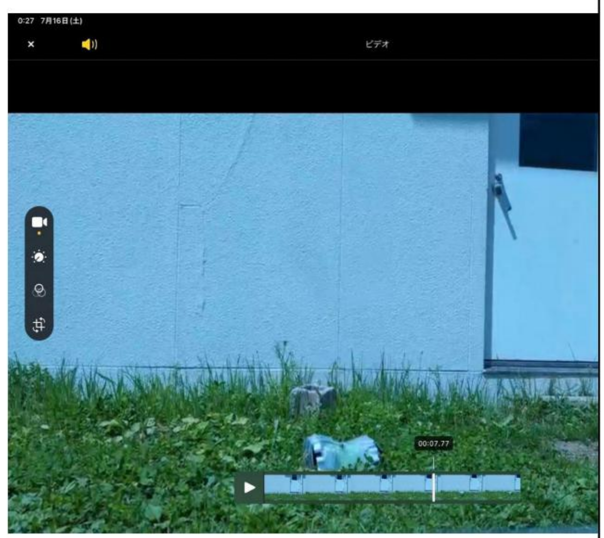
Figure 6.8.3 t = 7.76	**Figure 6.8.4 t = 7.77**

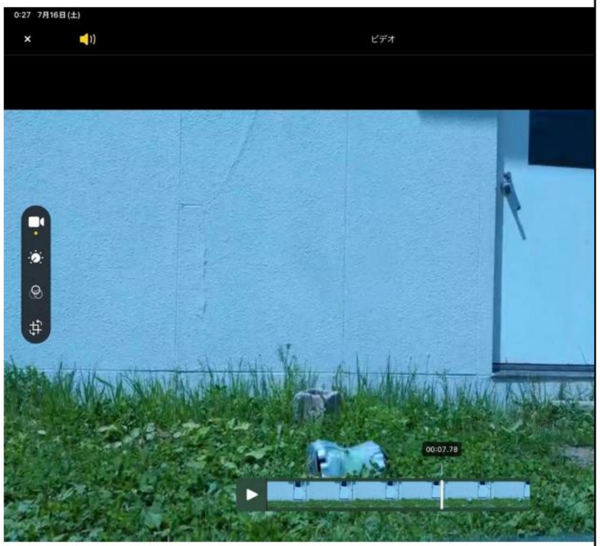

Figure 6.8.5 t = 7.78

Figure 6.8.6 t = 7.79

Figure 6.8.7 t = 7.80

From the above, it can be seen that it makes contact with the ground **from t=7.77 [s] to t=7.79** [s]. Therefore, the contact time of the aircraft body with the ground is 0.03 [s].

[Details and results of analysis of Test II]

When performing a simulation using Fusion360's analysis function, we first calculate the value of the impact that will be applied during a fall. We used 9.66 [m/s] as the terminal velocity of the main body of the aircraft this time based on the average terminal velocity results of the parachute drop test. In addition, the weight of the aircraft body was set to 0.58 [kg], and the contact time was set to 0.03 [s] based on the results of Test I using the aircraft dummy.

First, from the relationship between momentum and force,

$$\times ÿ =$$

Than

$$= 0.58 \times \frac{9.66}{0.03} = 186.76\ ÿ\ 187[\ ] \quad (1.1)$$

Therefore, F = 187 [N] is obtained.

From this, Figure 6.8.8 shows the analysis results when an impact of 187 [N] (from formula 1.1) is applied in a direction perpendicular to the curved surface of the tire in contact with the ground from the bottom of the aircraft. ÿÿ In addition, in the analysis, the four bearing locations were constrained by the X, Y, and Z axes, and the mesh was generated using quadratic elements.

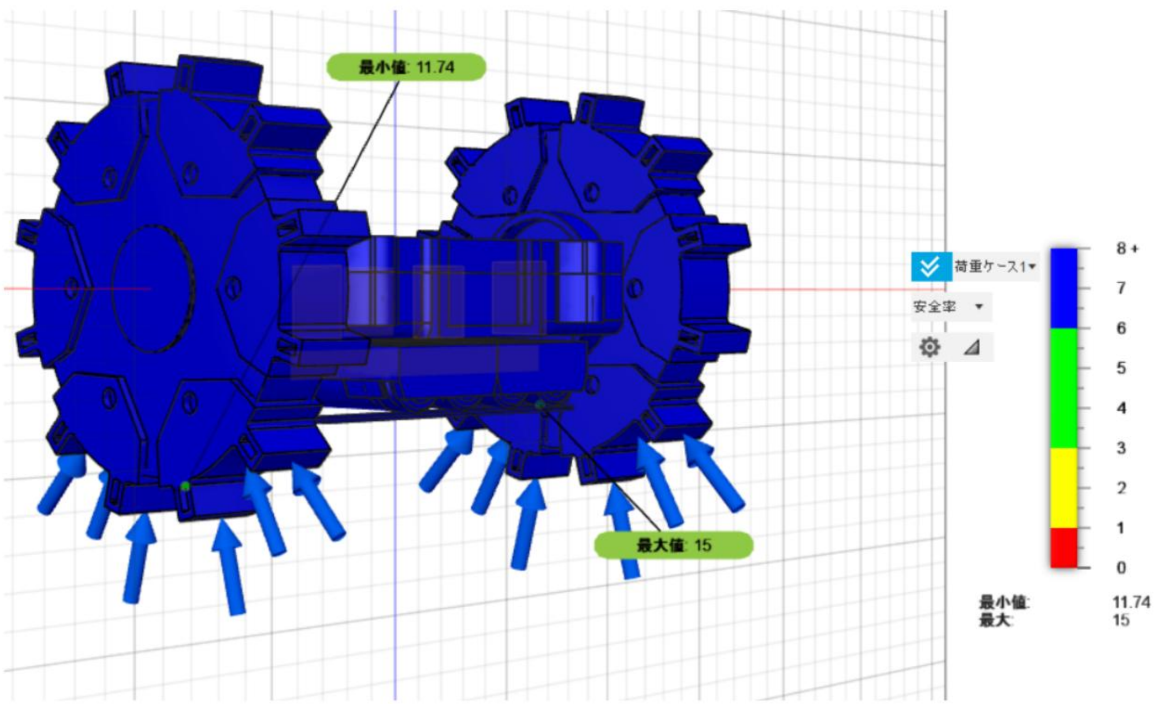

Figure 6.8.8 Strength analysis against landing impact (safety factor)

Here, in order to find the maximum stress from the impact load calculated earlier, we will geometrically find the area where the tire contacts the ground upon landing. As shown in Figure 6.8.9, when the tire contacts the landing surface and collapses

, assume that the contact surface when viewed from directly above is rectangular. In addition, tires are

Calculate excluding the occurrence.

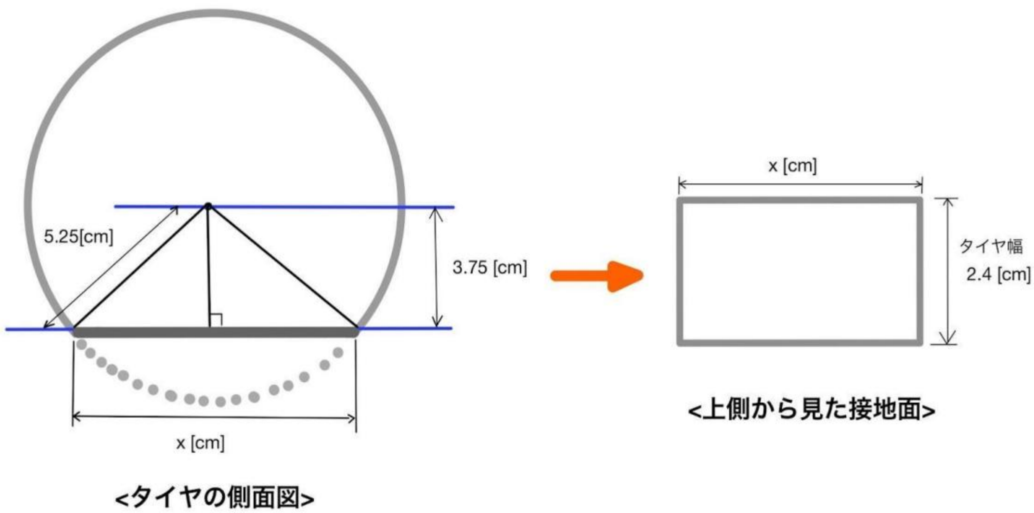

Figure 6.8.9 Overview of tire deformation upon landing

If the horizontal length of the rectangle is X [cm], the tire radius when viewed from the vertical direction is 3.75 [cm]. It is assumed that it has been deformed to Since the radius of the tire is 5.25 [cm], using the Pyramid theorem,

hand

$$(5.25^2 ÿ 3.75^2)^{\frac{1}{2}} = \frac{}{2} = 3.6742326\ldots ÿ 3.67\ [\quad]$$

In other words, it is expressed as X=7.34 [cm].

Also, the width of the aircraft's tires is 2.40 [cm], so the ground contact area is

$$7.34\ [cm] \times 2.40\ [cm] = 17.616\ [\quad^2]\ ÿ\ 1.76\times10^{-3}\ [\quad^2] \tag{1.2}$$

It can be expressed as.

From the above, the stress applied to the tire when landing is calculated using equations (1.1) and (1.2):

$$187\ [\ ] \div 1.76\times10^{-3}\ [\quad^2]=106250\ ÿ\ 0.106[\quad] \tag{1.3}$$

It turned out that.

Next, to investigate the durability of the shaft (Figure 6.8.10) when landing, use the formula for the bending moment of a round bar to find the maximum stress. Regarding the magnitude of the load, we assume that the impact distribution load is applied directly to the entire shaft, and if this is less than the fracture stress of the shaft, we judge that the durability is sufficient.

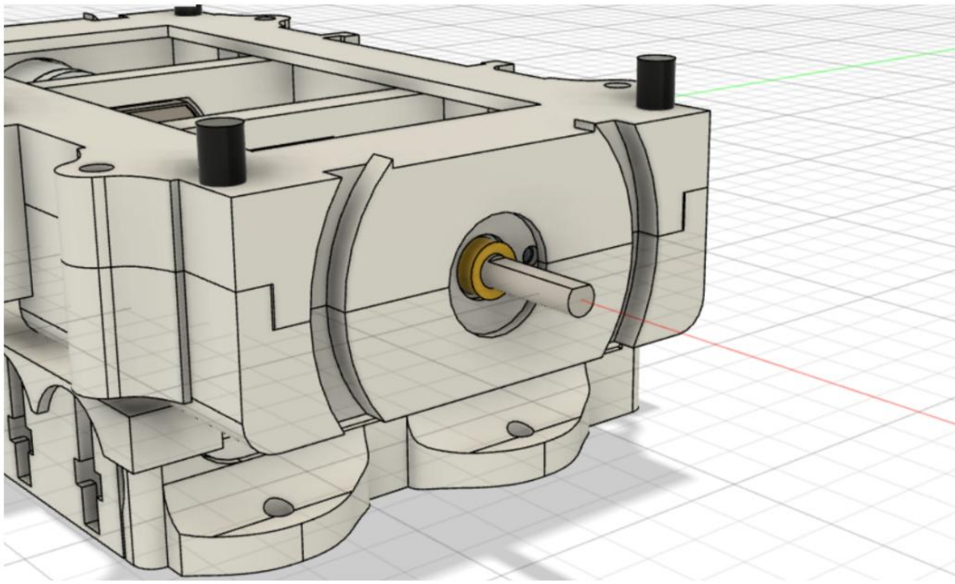

Figure 6.8.10 Shaft appearance

First, from the specifications of the shaft used this time and (1.1)

•Diameter: d = 4.0 [mm]

•Length: l = 12.5 [mm]

•Young's modulus of shaft material (SUS304): E=193 [GPa]*1

•Impact load: P = 187 [N]

, and when the maximum bending moment of the shaft = Mmax,

$$= \frac{}{2}$$

It can be expressed as However, calculations were performed by replacing the distributed load with a concentrated load and setting the load position at the center of the shaft.

Also, since the maximum stress ÿmax applied to the shaft during a fall can be expressed by equation (1.4),

$$ÿ = \frac{}{} = \frac{16}{ÿ^{3}} \quad (1.4)$$

(Z: section modulus)

Than this,

ÿ =186 [ ] (1.5)

is obtained.

SUS304, which is the material of the shaft, has no yield point, so the strain that remains when the load is removed is The stress when the strain becomes 0.2% is the yield point. At this time, according to the data *1, the yield strength of SUS304 (0.2%) = 205 [MPa].

In addition, under the same conditions, a vertically downward load of 211 [N] was applied to the shaft, and a simulation using Fusion360 was performed. Analysis was also performed using the simulation function.

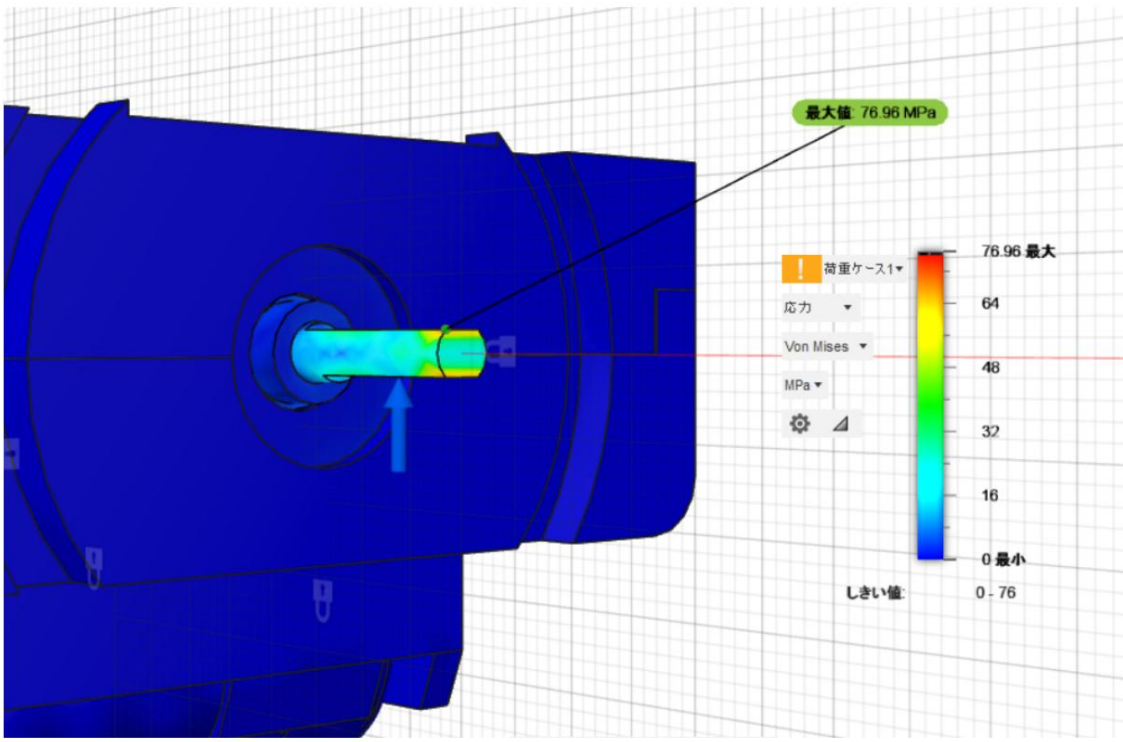

Figure 6.8.11 Strength analysis for shaft (maximum von Mises stress)

<Considerations on Exam II>

1. According to Figure 6.8.8, the minimum safety factor of the aircraft is 11.7, and the possibility of damage to the aircraft is considered to be low. However, it is considered that the design is a little excessive, so the materials used should be reviewed and further improvements should be made. It is necessary to reduce the weight.

2. From equation (1.3), the pressure applied to the tire when landing is 0.120 [MPa], which is the pressure applied to the tire protrusion. The compressive strength of ABS resin is 45 to 52 [MPa]*2. In addition, the 25% compressive load of the NR sponge, which is the material of the tire body, was 0.294~0.588 [MPa]*3, which was smaller than the pressure applied to the tire when landing, so the tire of this aircraft It was confirmed that there was no risk of damage.

3. Regarding the durability of the shaft, from equation (1.5), the maximum stress applied to the shaft during a fall was ÿmax = 186 [MPa]. Additionally, the maximum von Mises stress of 77.96 [MPa] was obtained from the results of strength analysis by simulation shown in Figure 6.8.11. Both of these values were lower than the yield strength of SUS304 (0.2%) = 205 [MPa], so it can be judged that the strength of the shaft is sufficient.

From the above, it was shown that the main body of the aircraft does not break when falling due to landing impact.

Reference

materials *1 Stainless Steel Association, 1 Basic Edition pdf (jssa.gr.jp)

* 2KDA Co., Ltd. (physical properties table)1 https://www.kda1969.com/materials/pla_mate_abs2.htm

*3 Toho Industrial Rubber Co., Ltd.

http://www.tohogomu.co.jp/products/gum_sponge/gum_sheet/

[Details of the test content and results of Test III]

<Details of the test content of Test III> In this test, the altitude h was determined from the terminal velocity of the parachute using the equation of conservation of mechanical energy, and then the actual height was calculated. Drop it from h and check if the sequence from separation to start of travel can be performed without any problems.

Assuming the terminal velocity of the parachute to be 6 [m/s], the height h can be found using the following equation (1.6) using the equation for conservation of mechanical energy.

$$ÿ = \frac{1}{2} \quad {}^{2} \tag{1.6}$$

ÿ ÿ 1. 835 [ ]

Here, assuming a case where the error in the terminal velocity is large, the heights of 1.83 [m], 2.0 [m], The actual aircraft will be dropped three times at a distance of 2.5 m.

Based on the above, in this test, the actual aircraft was dropped through a total of three drop tests, and the expected

Prove that the aircraft can withstand a landing shock that is greater than the landing shock and can start flight without any problems.

<Results of Test III>

Table 6.8.1 below shows the landing impact test results.

Table 6.8.1 Landing impact test results

experiment number of times	h [m]	Aircraft status	result	URL
1	1.83	Successful separation and start of flight	ÿ	https://youtu.be/sMOIzwLNv3A
2	2.0	Separation and successful start of flight	ÿ	https://youtu.be/h2YkMauHxmA
3	2.5	Successful separation and start of flight	ÿ	https://youtu.be/HCs4MAGFUwA

<Considerations on Exam III>

In each of the three experiments, the aircraft was separated from the aircraft storage module and kept up until the start of flight. I was able to perform the sequence without any problems. In addition, check the operation of sensors for electrical components. We also conducted a test and confirmed normal operation. Therefore, the body of the aircraft this time was affected by the expected landing impact. It must have the ability to withstand a load larger than that and operate without problems even on the day of the ARLISS experiment. was confirmed.

(V9) Tests related to driving performance

[Purpose]

In this test, in addition to confirming that the vehicle could run on the field without getting stuck, Investigate the limit value of the flying aircraft's ability to escape from a stuck state, and ensure that it is compatible with ARLISS field conditions. The goal is to create a flying aircraft that can fly.

ÿcontents of the testÿ

Assuming possible hardware stacks on the ARLISS field, each stack is See if you can escape. The measure of success is when the aircraft reaches equilibrium with the ground and resumes normal flight. Let's assume that we can start.

The contents of the experiment are as follows (a to d) (Figure 6.9.1-5).

Figure 6.9.1 Crossing 3-4 [cm] level difference (a-1)

Figure 6.9.2 Crossing 3-4 [cm] level difference (a-2)

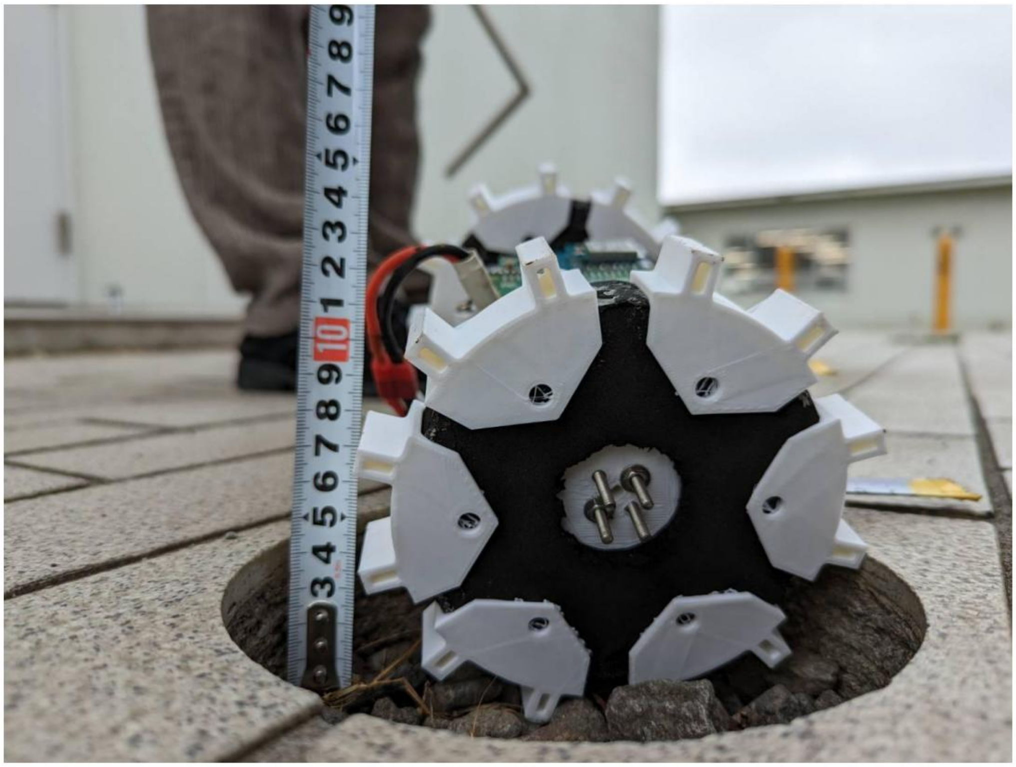

Figure 6.9.3 Stuck escape assuming a 3 to 4 [cm] drop on one side wheel (b)

Figure 6.9.4 Crossing the 6 [cm] step (c)

Figure 6.9.5 Field trip assuming ARLIS2022S field (sandbox) (d)

Figure 6.9.6 Driving assuming car ruts of about 50 [mm] in the ARLISS field (e)

[Results]

The test results are shown in Table 6.9.1.

Table 6.9.1 Test results regarding driving performance

Item	result	Cause of stuck	URL
a-1	ÿ	-	https://youtu.be/Ip0kE4I2D3E
a-2	ÿ	-	https://youtu.be/gX8jELvzgZc
b	ÿ	-	https://youtu.be/aOUFOBD4wrE
c	×	Tire shape, insufficient torque	https://youtu.be/CX6ciclRAEY
d	ÿ	-	https://youtu.be/0BOCRRi81Sg
e	ÿ	-	https://youtu.be/v_TO6y4an7k

[Consideration]

a. Successfully completed the flight without any problems. As a result, the main body of the aircraft has the ability to traverse steps of 3 to 4 cm. It can be said that.

b. Escape was completed without any problems. As a result, the main body of the aircraft assumes a 3~4[cm] level drop on one side wheel. It can be said that it has the ability to escape from a stack.

c. The main body of the aircraft spun on the spot, making it impossible to cross the step. The diameter of the tire is about 130 [mm] I designed the design using 2 degrees, but since the height of the step is close to the radius of the tire, it is difficult to cross the step. was judged to be difficult. With the torque and tire shape, we were able to overcome the difference in conditions under this condition. The hypothesis was that it could be done.

d. For the running test on sandy soil, sand was sprinkled on the ground to simulate a simple sandy soil. tire side shaft Attaching the cover that comes with the motor holder (see Figure 4.2.4) prevents sand from entering the motor. We were able to confirm the dustproof performance, which is unlikely to occur. The aircraft successfully flew through the sandy ground without any problems, and the main body of the aircraft was completely covered with sand. It can be said that it has the ability to run on land.

e. There were ruts around the school grounds that met the experimental conditions, so we used them. Tire protrusion is good It can be said that it has the ability to clear wheel ruts with a depth of 50 mm.

ÿsummaryÿ

In this test, the vehicle was driven under the ground conditions (a, b, d, e) assumed in the ARLISS field. The aircraft was proven to be able to fly without any problems. The 6 [cm] level difference in c is ARLISS feel. Although it is thought that there are almost no such cases on the road, we conducted a test to find out the limits of the flying aircraft. In the unlikely event that the aircraft collides with an obstacle that is higher than the center of the bottom of the aircraft, as shown in c. However, the program attempts to escape from the stack by moving backward and rotating.

Based on the above, the main body of this aircraft is compatible with ARLISS field conditions. It was confirmed that he had the ability to do so.

(V10) Goal detection test

[Purpose]

The mission ``0m goal using camera and image recognition'' was completed using the aircraft's camera. to detect the red cone of the goal and confirm that it is possible to reach the 0m goal.

ÿcontents of the testÿ

The red cone image taken by the camera is recognized by an image processing program. Image processing We tested whether the program could correctly detect a red object from positions 5 [m], 3 [m], and 1 [m] away. Check. It also measures the maximum distance that can be detected.

ÿresultÿ

The test results were as shown in Table 6.10.1 below.

Table 6.10.1 Goal ground test test results

distance [m]	Center of gravity coordinates [x,y]	result
1	371, 205	ÿ
3	330, 180	ÿ
Five	326, 161	ÿ
7	317, 148	ÿ
9	319, 217	ÿ

Figure 6.10.1-5 below shows images taken by the camera from each distance.

Figure 6.10.1 Photo taken near 1 [m]

Figure 6.10.2 Photo taken near 3 [m]

Figure 6.10.3 Photo taken near 5 [m]

Figure 6.10.4 Photo taken near 7 [m]

Figure 6.10.5 Photo taken near 9 [m]

The black part in the above image is the part that the aircraft recognizes as the red cone, and the blue circle is the center of gravity coordinates of the

recognized red cone. The test results show that the current algorithm can detect the goal within 9 [m] because it is recognized as a red cone based on the contrast with the background image and the center of gravity is within the red cone.

(V11) End to End exam (video submission) [Purpose]

We will prove that the entire sequence from dropping to goal detection is executed correctly with ARLISS.

[Experiment details] The CanSat was dropped, parachute deployment, movement, goal determination, and data retrieval were performed in the same manner as in the actual event. Since there is no testing environment nearby that allows us to perform end-to-end testing, we conducted the experiment under the best possible conditions. Therefore, in this experiment, in order to obtain a sufficient height to deploy a parachute inside the school, we dropped it from the research building, which is 25.2 m above the ground.

The surrounding area of this test environment is shown below in Figure 6.11.1.

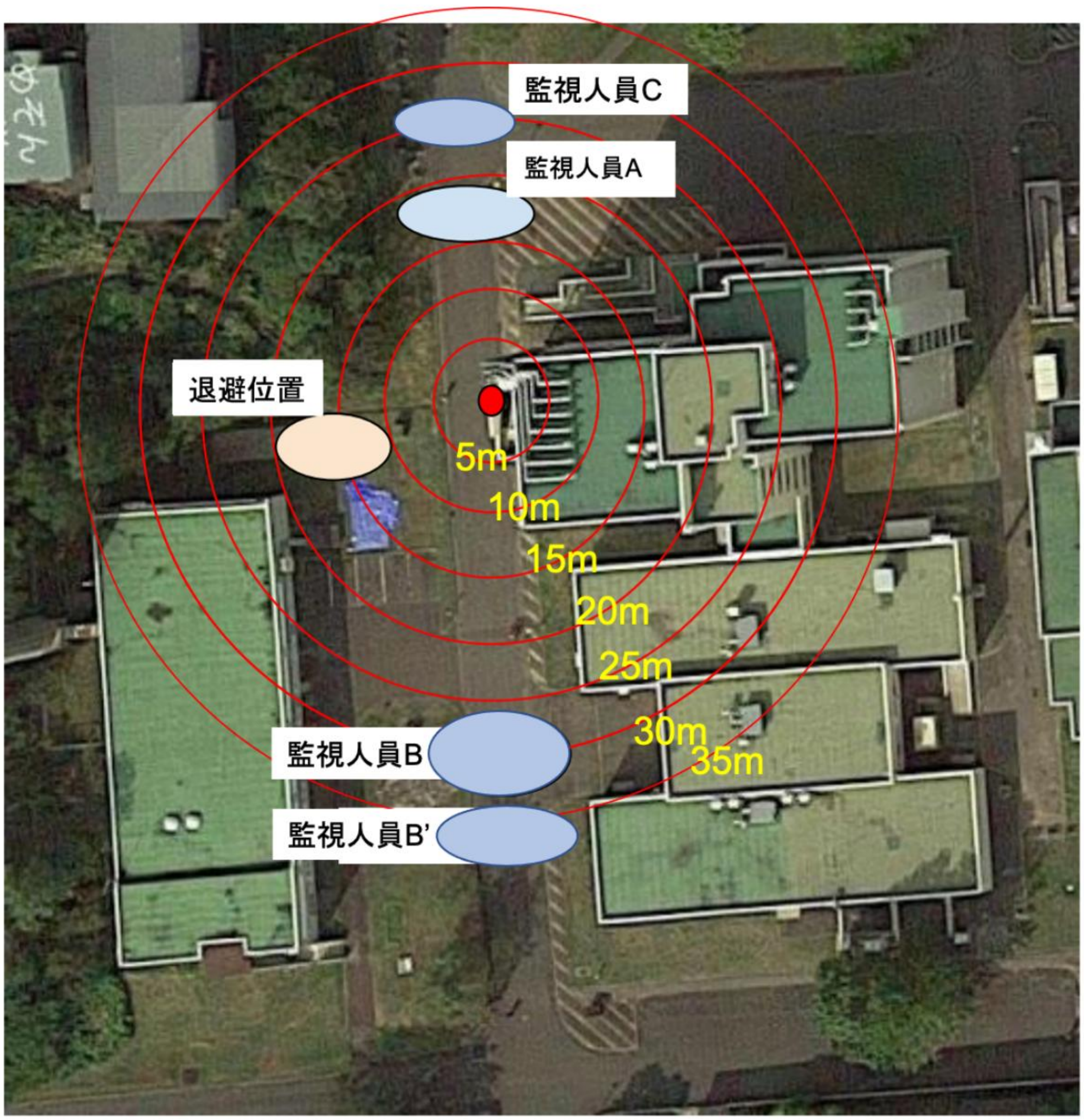

Figure 6.11.1 End to End test venue area map

The flow of the experiment is as follows.

1. The aircraft and

parachute will be dropped from the 25.2m high experimental building, which was also used in the drop-to-landing (V6) parachute drop test. After landing, immediately measure the fall dispersion.

2. Deploying and moving the aircraft storage module

After landing, the aircraft storage module will automatically deploy and confirm that the aircraft body and module are completely separated. Once the main body of the aircraft begins to move towards the target, hold it in your hands and transport it to the field for driving trials. (Because there is not enough walking space under the experimental building.)

3. Start of driving test

Place the aircraft at the driving start position in the driving test field. At that time, take the distance between the goal and the running start position by the amount of fall dispersion measured just before. (The time required from separating the aircraft and storage module to starting flight is approximately 2 minutes)

4. Control by GPS

Calculate the goal coordinates and the vehicle's own coordinates to calculate the goal direction. The machine compares the calculated direction with its own direction, controls the machine to move towards the goal, and advances to the next stage within a certain distance.

5. Control by image recognition

When it is confirmed from GPS data that CanSat is within a certain distance from the goal point, control using image recognition begins. The camera mounted on CanSat starts up and begins to detect red cones. Detection is performed by detecting red color from the acquired image. The CanSat then moves in the detected direction.

ÿresultÿ

Table 6.12.1 shows the results obtained from the first experiment, and Table 6.12.1 shows the results obtained from the second experiment. The results obtained from the third experiment are shown in Table 6.12.2 and Figure 6.12.3, respectively.

Table 6.11.1 End to End test 1st results

experiment	result	URL
Dropping and separation	Successful cutting of cable ties	https://youtu.be/r0pil-6sWHg
Start running	Start running	
Start of running ÿ Goal detected	Goal was detected but did not reach 0m	

Table 6.11.2 EndtoEnd Study 2nd Results

experiment	result	URL
Dropping and separation	Succeeded in cutting the cable ties Due to poor conditions at the landing site, separation from the aircraft storage module failed.	https://youtu.be/_CnW2mlGSHY
Start running	From the above, we waited until the separation was completed, but the goal detection program responded to the red color of the fuselage storage module.	
Start of run ÿ Goal detection	Goal was detected, but it did not reach 0m	https://youtu.be/O79ocnkJRww

Table 6.11.3 End to End test 3rd result

experiment	result	URL
Dropping and separation	Successful cutting of cable ties	**https://youtu.be/g_eHSnhHuH8**
Start running	Start running	
Start running ÿ Goal detection	**After goal detection, 0m goal achieved**	

<1st time>

From drop and separation to start of flight - The parachute deployed without any problems and landed successfully.•After landing, the heating wire activation program was activated and the cable tie was successfully fused.•Successfully started running.

Regarding the process from the start of the drive to goal detection - Experiments on the road are prohibited, so we held the aircraft in our hands and moved it to a safe place, carried it to the driving test field, and performed goal detection. The aircraft was guided to the target point, and its program operated normally.•Although goal detection was performed, the 0 m goal could not be achieved, and the vehicle stopped approximately 2 [m] from the goal and determined the goal.

<2nd time>

From drop and separation to start of flight - The parachute deployed without any problems and landed successfully.•After landing, the heating wire activation program was activated and the cable tie was successfully fused.

•Due to poor conditions at the landing site, separation from the aircraft storage module failed.•The running start program works normally.

About the process from start of flight to goal

detection - After the start of flight, the goal detection program reacts to the red tape on the aircraft storage module. Control by the goal detection program starts from the GPS guidance program. - After landing, testing on the road is prohibited, so I grabbed the aircraft by hand and moved it to a safe location, then carried it to the field for driving tests.•Goal detection was performed on the driving test field, the vehicle was guided to the target point, and the program operated normally.•Although goal detection was performed, the 0 m goal could not be achieved, and the goal was determined by stopping at a point approximately 2 [m] from the goal.

<Third time> From drop and separation to start of flight - The

parachute deployed without any problems and landed successfully.•After landing, the heating wire activation program was activated and the cable tie was successfully fused.•The flying aircraft was completely separated from the aircraft storage module and successfully started flying.

From the start of the drive to the goal detection -

Experiments on the road are prohibited, so we held the aircraft in our hands and moved it to a safe place, carried it to the driving test field, and tried to detect the goal. The aircraft was guided to the target point, and its program operated normally.•The goal detection program is activated and the 0 m goal is achieved.

[Consideration]

From drop and separation to start of flight

In the third ETE test, we were able to successfully complete the sequence from dropping and separation to the start of flight without any human intervention. The experimental results up to this point have shown that it has the ability to operate normally even on the day of the Noshiro Space Event.

From start of run to goal detection

In the first and second ETE tests, the reason why I was not able to achieve the 0 m goal was that after the goal detection program was activated, I moved forward four times and then tried to make a goal determination, but in reality, the goal was not achieved. Because the distance traveled in four advances was insufficient, the goal was judged at the 2 [m] point. In the third ETE test, the entire sequence from dropping to goal detection was executed without any problems, and it can be said that the purpose of this experiment was achieved.

(V12) Long distance communication test

[Purpose]

This experiment will be conducted for the following purposes.

•Assuming an actual competition, we will install a communication module at the same distance as the expected drop point and waiting area.
communication demonstration

ÿcontents of the testÿ

•We will conduct the experiment around Lake Toya, which has few obstacles and is 6.1 [km] away in a straight line.

•Place the aircraft's electrical equipment on the silo observation deck and place the receiving board on Chinkojima.

•Is it possible to send GPS data from the aircraft electrical system and receive the data on the receiving board?
I'll check if that's the case.

The detailed location of the experiment location is shown in Figure 6.11.1, and the detailed wireless characteristics of the communication module are shown in Figure 6.11.1.
The details are listed in Table 7.12.1 below.

Table 6.12.1 IM920c communication module wireless characteristics

Item	Performance specifications
Compatible standards	920MHz specified low power radio (ARIB STD-T108 compliant)
frequency	920.6 to 923.4 [MHz], 200 [kHz] steps 15 channels
Communication method	simplex
Transmission output	10 [mW], 1 [mW], 0.1 [mW] (use 10 [mW])
Modulation method	FSK
Space transmission velocity	High-speed communication modeÿ50 [kbps] Long distance mode: 1.25 [kbps] (Use long distance mode)
antenna	wire antenna
Communication distance	Long distance mode 7 [km] High speed communication mode 400 [m]

Figure 6.12.1 Experiment location and personnel layout

Figure 6.12.2 Experiment scene (aircraft electrical equipment side)

[Results]

There were cases where communication was unstable and GPS data could not be received and latitude data could not be read. However, we were able to receive GPS data and determine the aircraft's location. Figure 6.12.3 below shows the organized data obtained through communication, and Figure 6.12.4 shows readable data ÿ, ÿ, and ÿ plotted on a map.


新しいテキスト ドキュメント.txt - メモ帳

ファイル(F) 編集(E) 書式(O) 表示(V) ヘルプ(H)

```
ɔ'5FD8'
longitude,latitude
'44289,''4.6258978633332'
68766667''140.7980013333332'
'42.62589786666667',73''
',347'970,'03333334','.7997'
'02'42.6'0.0'
666',0733.79.888'2862''3334'
'6'3'61',40.7997741.63','140.9977415'
'45861340.7997'
'42586228333,
.214.99793133379215793333333','0.0'.'166680.7'7978488140.797842.6259053979865'
'429533.098286667'
'0.0',0.0
0
186334'42.6965833333331097626'42.625983334077','12
'4.6259051','10.7998444.680
'42.2595''2.5915133336',1.79713357583262,1.79970'
'426073333336','0.067333','
62591016666665','140.79980543333335'
'0.0,'0.0'
'42.6259127','140.79980715'
'42.625915416666665','140.79980773333332'
'42.6259127','14.9981838333333
42.6259131833333','1.9918383333'
'42.3''140.79'42.0'79'50485','140.7997271'
'49066'140.79972823333333'
'42.25904516666665','140.7933333'
'42.62589538334'94.6258953833334,'14799'
'42.6258405'
'4240.996068652334','140.79960686666666'
'49'140.79956048333332'
'42.62577553333333','140.79955953333334'
333','479466'2686,3333','179537666
```


Figure 6.12.3 Received data log

Figure 6.12.4 GPS data plot diagram

Below is a video of the experiment uploaded to YouTube.

Video title: Long-distance communication experiment 8/29

Shortened version URL : https://youtu.be/ZLzH_oqOod0 :
https://youtu.be/4iCvItCDVQQ

Video title: Long-distance communication experiment 8/29 Uncut version

URL ÿhttps://youtu.be/tVaQX-zh95g : https://
youtu.be/QL7PN4o4w8c

[Discussion] Communication was successful over a distance of approximately 6.1 km, so it can be said that GPS data can be sent and received over long distances without any problems.

(V13) Control history report creation test [Purpose] To be able to

submit a

control history report on the same day.

ÿcontents of the testÿ

Perform an end-to-end test and extract the control history from it.

[Results]

We created a control history using data from the actual **(V12) End to** End test.

<Control history

explanation> The raw data of the control history text file was converted to a csv file and summarized for easy viewing.

A part of the summary is shown in Figure 6.13.1.

The control items are

Column A: Time data

Columns B and C: GPS location information data

Column D: Altitude data

Column E: Optical sensor voltage

Column F: Behavior record

Row G: Aircraft direction

H column: goal direction

Column I: Goal

distance If there is no data, 0 is entered.

	A	B	C	D	E	F	G	H	I
1	dt_now	gps_x	gps_y	altitude	photvoltdiredtion	action	my_angle	goal_angle	goal_destance
2	49:10.2	0	0	0	0	0	0	0	0
3	49:10.5	0	0	357.6947	3.0735	no_release	0	258.97753	14652150.95
4	49:10.7	42.3799	141.0336	22.85114	3.0735	release	0	257.2361535	40.22220721
5	49:10.9	42.37988	141.0335	22.8519	0	descent	0	259.5630822	39.50610934
6	49:11.1	42.37988	141.0335	22.67652	0	descent	0	259.5630822	39.50610934
7	49:11.3	42.37987	141.0335	22.67652	0	descent	0	260.2031125	38.92935774
8	49:11.4	42.37987	141.0335	22.67652	0	descent	0	260.2031125	38.92935774
9	49:11.5	42.37987	141.0335	22.67652	0	descent	0	260.2031125	38.92935774
10	49:11.6	42.37987	141.0335	22.67652	0	descent	0	260.2031125	38.92935774
11	49:11.7	42.37987	141.0335	22.58959	0	descent	0	260.2031125	38.92935774
12	49:11.9	42.37987	141.0335	22.58959	0	descent	0	260.2031125	38.92935774
13	49:12.0	42.37987	141.0335	22.58959	0	descent	0	260.2031125	38.92935774
14	49:12.2	42.37987	141.0335	22.58959	0	descent	0	260.6964498	37.53751882

Figure 6.13.1 Control history in CSV file format

<Altitude history log>

Figure 6.13.2 shows a diagram created from altitude data.

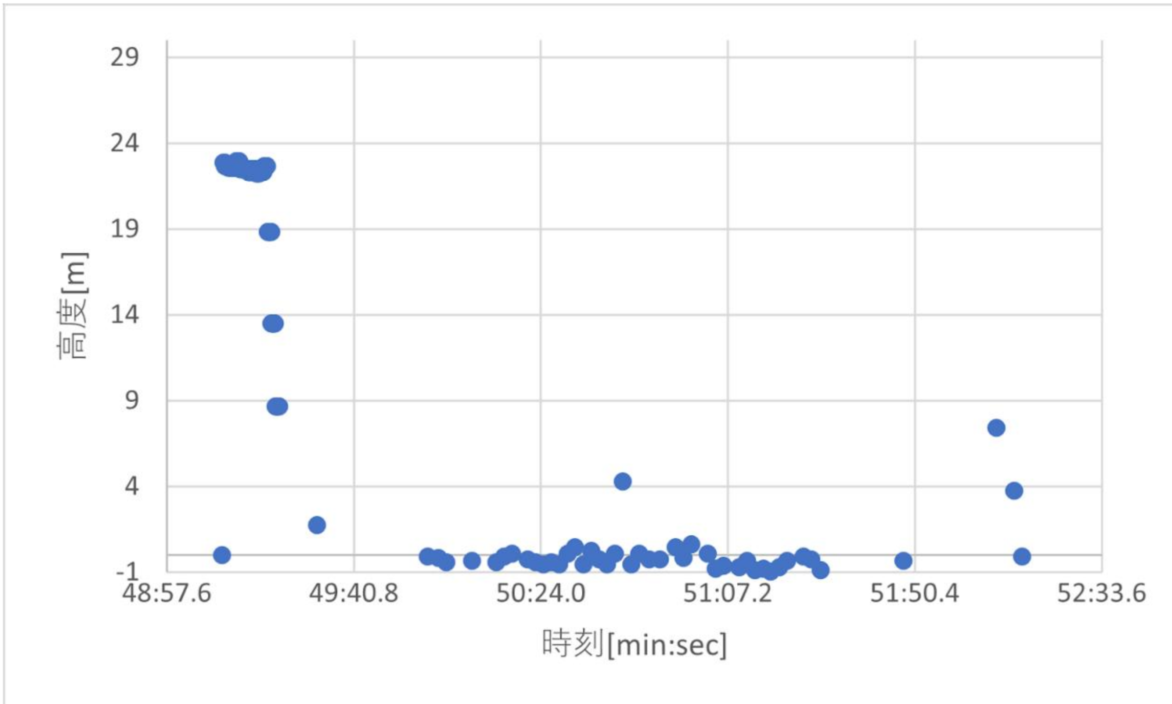

Figure 6.13.2 Advanced time series recording

<GPS log> The

GPS history of the descent trajectory and travel trajectory is shown in Figure 6.13.3 below. Additionally, the starting position of the descent and the goal position of the run are indicated with arrows in the diagram.

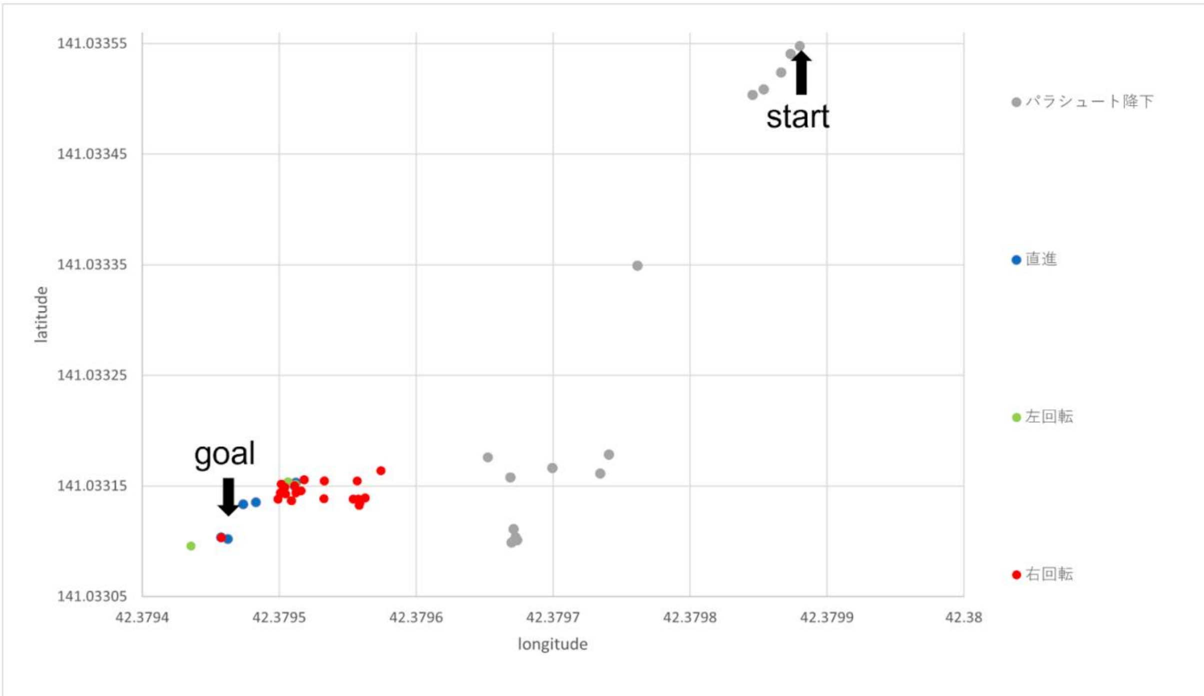

Figure 6.13.3 Descent trajectory and travel trajectory

<Image recognition log>

The image recognition log for guidance using the image recognition program (short-range guidance sequence) is shown below. vinegar. Also, some images were omitted due to the large number of shots taken.

Image log until goal discovery



ÿÿÿÿ 1st shoot 10th shoot 20th shoot

I got stuck on a step that I couldn't get over, so I moved it.


64th shooting 67th shooting

Image log during goal recognition



68th shooting 80th shooting 83rd shoot

On the 68th photo shoot, a red object was recognized in the center, so the camera was controlled to go straight.
At the 80th shooting, a red object was recognized on the right side, so control was performed on the left side.
On the 83rd shooting, a red object was recognized in the center, so we controlled it to go straight.

Figure 6.13.4 Image recognition log

In addition, all log data is shown in the file at the following URL.

URL:

https://drive.google.com/drive/folders/1P1wgvr89aXZ_nK8hSH9tWovlZg5L2359?usp=shari ng

Data content: •Log

raw data logdate.txt •Log csv data

logdate.csv •Image log data

[Discussion] It can be said that guidance using image recognition is successful, but the aircraft curves to the right when going straight. This causes an increase in the number of guidance times and a decrease in guidance accuracy. Therefore, By the time of the ARLISS performance, we would like to improve the straight-line stability and be able to perform accurate guidance.

In addition, since long-distance guidance using GPS is not performed, guidance must be refined before the ARLISS performance. I would like to check the degree and hope for the actual performance.

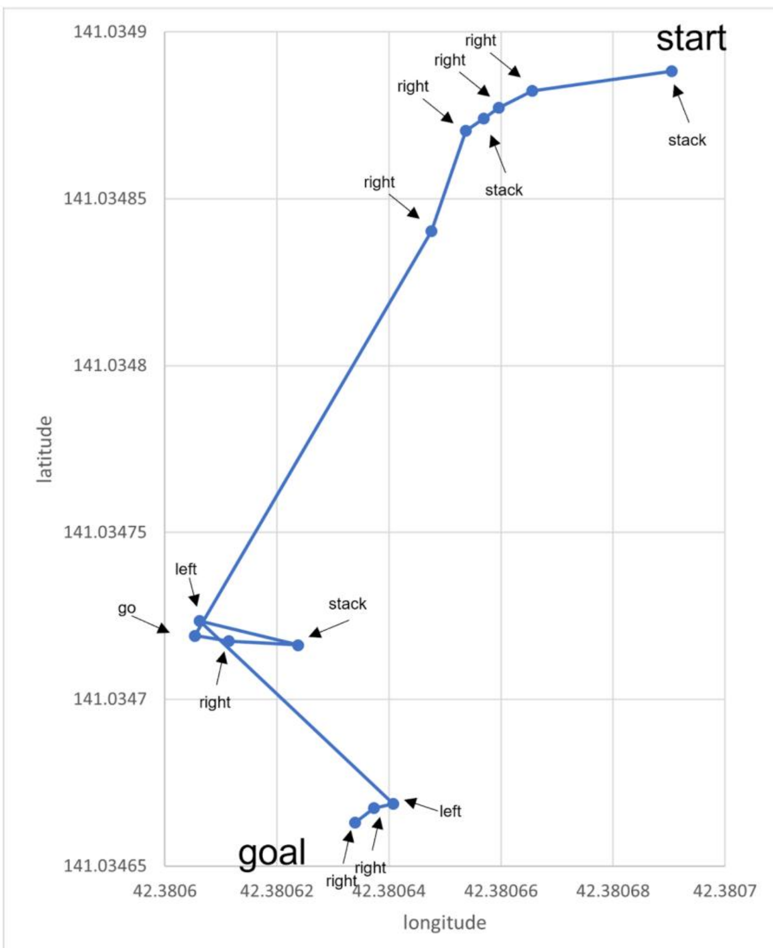

Figure 6.3.15 Travel trajectory and control history

The log data is shown in the file at the following URL.
URL:
https://drive.google.com/file/d/1G0K4Jzw0njna6EE737fPG13glBGbrVk8/view?usp=sharing

Data content: •Log
csv data logdate.csv

[Consideration]

The orientation and angle of the aircraft is estimated based on changes in the GPS as the aircraft moves straight, and control is performed to rotate the aircraft. There are times when the aircraft bends and the aircraft is unable to perform accurate guidance, so we would like to change the guidance method so that it can provide accurate guidance in actual use.

(V14) Parachute separation test [Purpose] Confirm that the recovery mechanism and CanSat are properly separated and can begin flight.

[Test details]

The cable ties that bind the CanSat storage module in the stored state are cut using a heating wire. After that, deploy the aircraft storage module and visually confirm that it will start traveling. Figure 6.14.1 shows the CanSat storage module in the stored state at the start of the test.

[Results]

Table 6.14.1 shows the experimental results.

Table 6.14.1 Parachute separation test results

Number of experiments	result	Exam video URL
1	success	https://youtu.be/XdiE0rBMwKM
2	success	https://youtu.be/TeIJle8Yzog

[Discussion] From the experimental results, CanSat and the parachute are separated by the normal operation of the separation mechanism of the recovery mechanism. It was confirmed that the parts could be separated.

(V15) Communication power ON/OFF test [Purpose]

Verify

that the communication power is turned OFF during launch and turned ON when the aircraft is released from the rocket.

[Test details]

In this aircraft, the release from the rocket will be detected by light detection using a photoresistor. Therefore, assuming that the aircraft is inside the rocket, store the aircraft's electrical components in the carrier and confirm that the communication module is not communicating. After that, release the aircraft's electrical equipment from the carrier and check whether the communication module is powered on and can receive communications.

[Result]

The light sensor detected the emission, the communication module was powered on, and communication started. Below is a video of the experiment uploaded to YouTube.

Video title: Communication power ON/OFF experiment
8/29 URL : https://youtu.be/6oI8BJUxIcs

[Consideration] The release was detected, the communication power was turned on without any problems, and communication started, so the release from the rocket It is thought that it is possible to detect the emission and start communication in the same way.

(V16) Communication channel change test [Purpose] It

is

necessary to respond to wireless channel adjustment, and to confirm that adjustment can actually be made.

[Test details]

Wireless module used (920MHz communication module IM920c manufactured by Interplan Co., Ltd.)

) on the program to change the channel by sending the command [STCH number of channels]. Use this function to check whether communication is possible after changing the channel.

[Results]

In the experiment, the number of channels was changed from 01 to 02. Communication was possible without any problems on both 01 and 02.

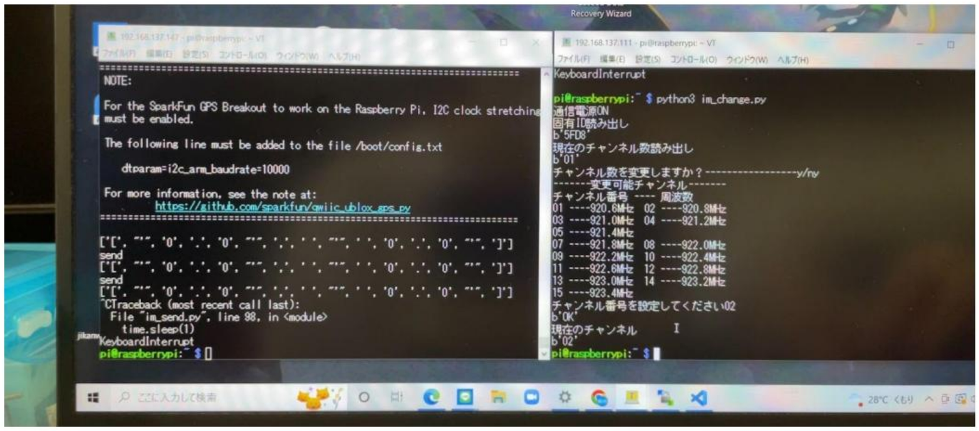

Figure 6.15.1 Channel change

Below is a video of the experiment uploaded to YouTube.

Video title: Communication channel change experiment 8/08 URL :

https://youtu.be/6KL6FqEa29w

[Consideration]

The channels of IM920c range from 01 to 15, and other universities are using the same type of communication module. Even in such cases, it is thought that communication can be performed without problems by changing the channel.

Chapter 7 Gantt chart (process management)

A part of the Gantt chart (7/21 version) is divided and shown below. (Figure 9.1-2)

However, since it is not possible to check the whole thing with the attached image file, please submit a PDF file of the Gantt chart (July 21 edition) along with the main review report below.

220721 Noshiro / ARLISS2022 Gantt_SARD.pdf

June 2022: 27 28 29 30 — July 2022: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

100%					
WBS	班	タスクの説明	開始日	終了日	進捗
3		タイヤの組み合わせ(完成)	2022/4/22	2022/6/3	100%
4		機体本体設計担当：福田	2022/4/22	2022/6/3	100%
5		機体本体の製作：全員	2022/4/22	2022/6/10	100%
6		応力解析計画：阿部	2022/4/22	2022/6/5	100%
7		シュミレーションの実行・完了	2022/4/22	2022/6/15	100%
8		シュミレーションの結果（審査書）	2022/4/22	2022/6/18	100%
9		必要物品注文：福田	2022/4/22	2022/6/3	100%
10		機体設計完了福田	2022/4/22	2022/6/12	100%
11		機体スペア1作成	2022/4/22	2022/7/16	100%
12		機体スペア2作成	2022/8/2	2022/8/8	0%
	電装班				
13		赤GPSプログラム完成	2022-05-20	2022-06-12	100%
14		通信プログラム完成	2022-06-06	2022-06-17	100%
15		メインプログラム	2022-05-01	2022-06-24	100%
16		基板設計	2022-05-20	2022-05-27	100%
17		基板試験	2022-05-20	2022-06-10	100%
18		基板発注	2022-06-10	2022-06-12	100%
19		通信試験	2022-06-18	2022-07-17	100%
20		地上誘導試験	2022-06-02	2022-07-08	100%
21		通信試験計画書	2022-06-10	2022-06-11	100%
22		ETE試験実験書類記入	2022-05-01	2022-05-31	100%
23		物品購入	2022-05-01	2022-05-21	100%
24		物品リスト作成	2022-05-01	2022-05-20	100%

Figure 7.1 Gantt chart 1 (7/21 version)

100%

WBS	班	タスクの説明	開始日	終了日	進捗
	回収班				
25		機体収納用モジュール設計	2022-06-08	2022-06-17	100%
26		機体収納用モジュール本番機作成	2022-06-17	2022-06-19	100%
27		機体収納用モジュール改良・調整	2022-06-20	2022-09-06	100%
28		パラシュート設計	2022-05-01	2022-06-17	100%
29		パラシュート製作	2022-06-10	2022-06-12	100%
30		パラシュート改良・調整	2022-06-13	2022-09-06	100%
31		分離機構設計	2022-05-01	2022-06-12	100%
32		分離機構製作	2022-06-17	2022-06-19	100%
33		分離機構改良・調整	2022-06-20	2022-09-06	60%
	試験				
34		質量試験	2022-06-12	2022-06-18	100%
35		機体の収納・放出試験	2022-06-12	2022-06-25	100%
36		パラシュート分離試験	2022-06-12	2022-07-08	100%
37		開傘衝撃試験	2022-07-12	2022-07-19	100%
38		パラシュート投下試験（実測）	2022-06-12	2022-07-10	100%
39		End to End試験	2022-07-12	2022-07-19	100%
40		着地衝撃試験	2022-06-12	2022-07-01	100%
41		走行性能試験	2022-06-12	2022-07-13	100%
42		準静的荷重試験	2022-06-22	2022-07-12	100%
43		振動試験	2022-06-12	2022-06-24	100%
44		ゴール検知試験	2022-07-04	2022-07-05	100%
45		長距離通信試験	2022-07-09	2022-07-17	100%
46		制御履歴レポート作成試験	2022-07-12	2022-07-19	100%
47		通信電源ON/OFF試験	2022-06-12	2022-07-17	100%
48		通信チャンネル変更試験	2022-07-16	2022-07-17	100%
49		再End To End試験	2022-08-02	2022-08-09	0%
	審査書				
50		能代安全予備審査書	2022-06-05	2022-06-30	100%
51		能代安全本審査書	2022-06-30	2022-07-21	100%
52		ARLISSミッションレビュー	2022-05-23	2022-06-06	100%
53		ARLISS本審査 1	2022-06-06	2022-07-07	100%
54		ARLISS本審査 2	2022-07-07	2022-08-08	70%

Figure 7.2 Gantt chart 2 (7/21 version)

Chapter 8 Impressions of the responsible teacher

Safety standards examination

request number	Self-examination items	Self-examination results	Comments from the responsible teacher (if there are any noteworthy items)
	ARLISS2022 Safety Standards		
S1	The mass of the aircraft to be dropped meets the standards	ÿ	
S2	volume meets carrier standards	ÿ	
S3	Tests have confirmed that the quasi-static loads during launch do not impair the functionality required to meet safety standards.	ÿ	
S4	Tests have confirmed that the vibration load during launch does not impair the functionality required to meet safety standards.	ÿ	
S5	Tests have confirmed that the functionality required to meet safety standards is not impaired by the impact load during the rocket separation (when the parachute is deployed).	ÿ	
S6	Has a deceleration mechanism to prevent it from falling at dangerous speeds near the ground, and its performance has been confirmed through testing.	ÿ	
S7	Countermeasures against loss have been implemented, and their effectiveness has been confirmed through testing (examples of countermeasures: location information transmission, beacons, fluorescent color paint, etc.)	ÿ	
S8	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 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 necessary to comply with the regulations for turning off the power of radio equipment at the time of launch. things that can be turned off in the witch)	ÿ	
S9	I am willing to adjust the wireless channel, and I have confirmed that I can actually make the adjustment.	ÿ	
S10	The mission begins by loading the rocket, We have been able to conduct an end-to-end test simulating the process from launch to recovery, and there will be no major design changes in the future.	ÿ	

	If you wish to participate in the Comeback Competition, please be sure to meet the following requirements:		
It has been confirmed that autonomous control without human intervention is performed during M3 missions.		ÿ	
After the M4 mission, we will be able to submit the specified control history report to the management and examiners and explain the logs and acquired data.		ÿ	

Responsible teacher's impressions

We found that various efforts were made to meet multiple mission requirements. I think it was a great experience to create Cansat through actual manufacturing rather than just calculations on paper. I look forward to the future review and progress of the mission. Last but not least, I am sorry for being late.

Chapter 9 Tournament Results Report

(i) Purpose

There are two main reasons why we participated in ARLISS this year. The first is actual human hygiene. This is because it allows testing to be conducted under harsh conditions similar to those experienced when a star is launched. The second is domestic Achieving results at ARLISS, which is a stepping stone for astronautics engineers, will help them win the CanSat competition in the Hokkaido region. This is because we thought it would lead to increased recognition of the technique.

(ii) Results/discussion

A total of three drops were made. Evaluation of success criteria for each investment opportunity in Table 9.2.1 below I did this. Please refer to Table 2.1 in Chapter 2 for the evaluation criteria.

Table 9.2.1 Success Criteria Evaluation

•: Achieved, ×: Not achieved

	Content	1st drop	2nd drop	3rd drop
Minimum Success	Detects release and landing and stores the aircraft module (including parachute)) and start moving.	×	×	●
Middle Success	Move the aircraft within a 5m radius of the goal. Induce.	×	×	×
	Avoid getting stuck due to steps or obstacles. Detection and return to driving.	×	×	×
Full Success	Cone (goal) by camera By color recognition, we can identify the flying aircraft. Guide to the goal and reach the 0m goal Achieve.	×	×	×
Advanced Success	The aircraft reached the target point without any damage. Reach.	×	×	×

The results for each investment opportunity are shown below.

[First drop]

<result>

The first drop resulted in a successful landing with no damage to the aircraft, but the recovery mechanism failed to separate. I retired from the mission. After that, restart the program and run the running experiment. Ta. The results will also be described.

Figure 9.2.1, in which GPS records are color-coded by sequence, is shown below. Each color and sequence The corresponding responses are shown in Table 9.2.2 below.

Table 9.2.2 Correspondence between each sequence and color

sequence name	Corresponding color
Aerial sequence (standby state inside the rocket)	blue
Aerial sequence (parachute deployment state)	orange
Parachute separation/escape sequence	Black
Long distance guidance sequence (GPS guidance)	green
Short-range guidance sequence (red recognition guidance)	red

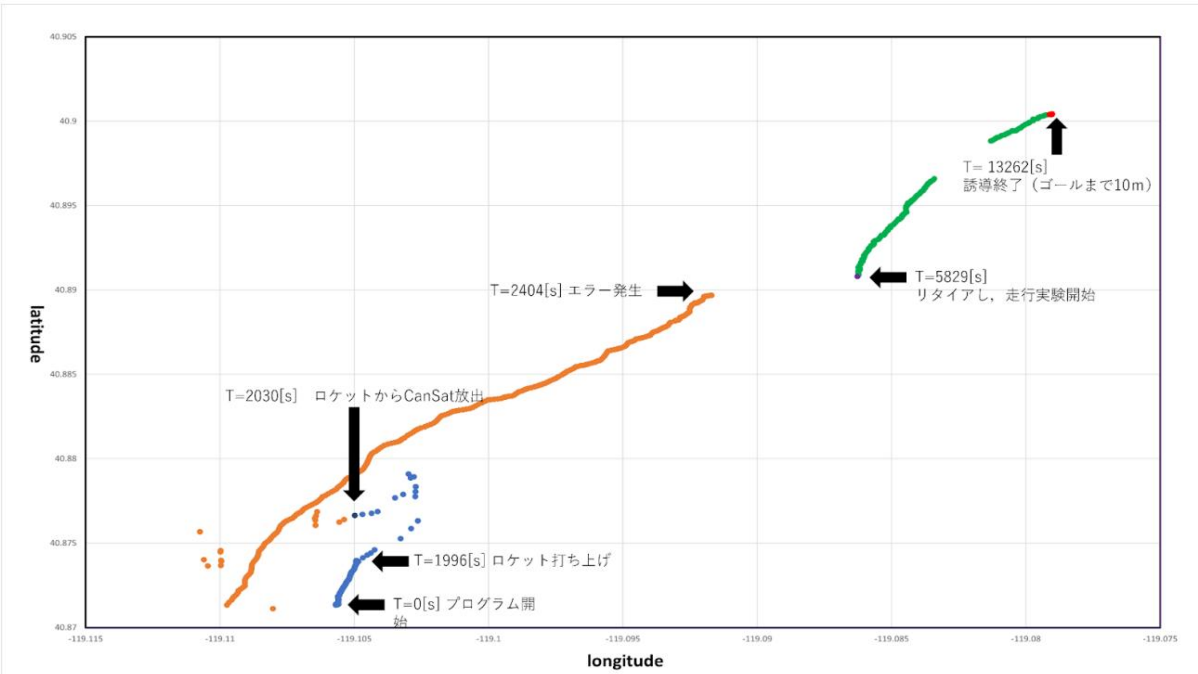

Figure 9.2.1 GPS recorded data (first time and running experiment)

After CanSat was released from the rocket, GPS data acquisition failed for a certain period of time.

Some parts are discontinuous due to the It can also be used for log recording in long-distance guidance sequences.

Some data is corrupted because the file was overwritten by mistake.

<Cause>

The cause was that the program stopped due to an OS error. This OS error is

This occurred when the OS file limit was exceeded due to too many files being opened.

<Measures taken on site>

Based on the above causes, restart the program when it terminates abnormally.

I changed the script to do so.

<Discussion> The reason why I was not able to notice the existence of this error is because I had not had the opportunity to operate it continuously for a long period of time. For example, at the Noshiro Space Event, the competition time was approximately 15 minutes, so this error did not occur and the system operated without any problems. Furthermore, we believe that the on-site response to this error was not appropriate, as it did not fundamentally resolve the program's flaws. A process should have been added to identify which files are not closed and ensure that the files are closed. The first throw was retired due

to the above error, but the subsequent

In the driving experiment, we were able to demonstrate guidance using GPS for approximately 1.3 km to the goal, and it can be said that there were no problems with the guidance program.

[Second Drop]

<Results> As with the first drop, the mission was retired because the second drop succeeded in landing without damaging the aircraft, and failed to separate the parachute and the fuselage storage module.

Additionally, because the waiting time was long and the program stopped immediately after launch, we were unable to obtain any records. Therefore, GPS recording will be omitted.

<Cause>

The cause is also the same as the first drop.

<Countermeasures taken

on-site> Based on the above causes, we made the following program changes before conducting the third drop. - Commented out the program that was thought to be the cause of the error and made corrections to prevent the error from occurring.

- Commented out two programs, the aerial sequence log acquisition program and the communication program, so that they would not be executed.

[Third Drop]

<Results>

The third drop succeeded in landing and separating the recovery mechanism. In addition, after separation of the collection mechanism, GPS-guided navigation was also successful. However, the aircraft stopped approximately 50m from the landing point, and it was determined that the mission could not continue, so the aircraft was retired. Because I

commented out the program for acquiring the log of the aerial sequence, when running

Shows only GPS data.

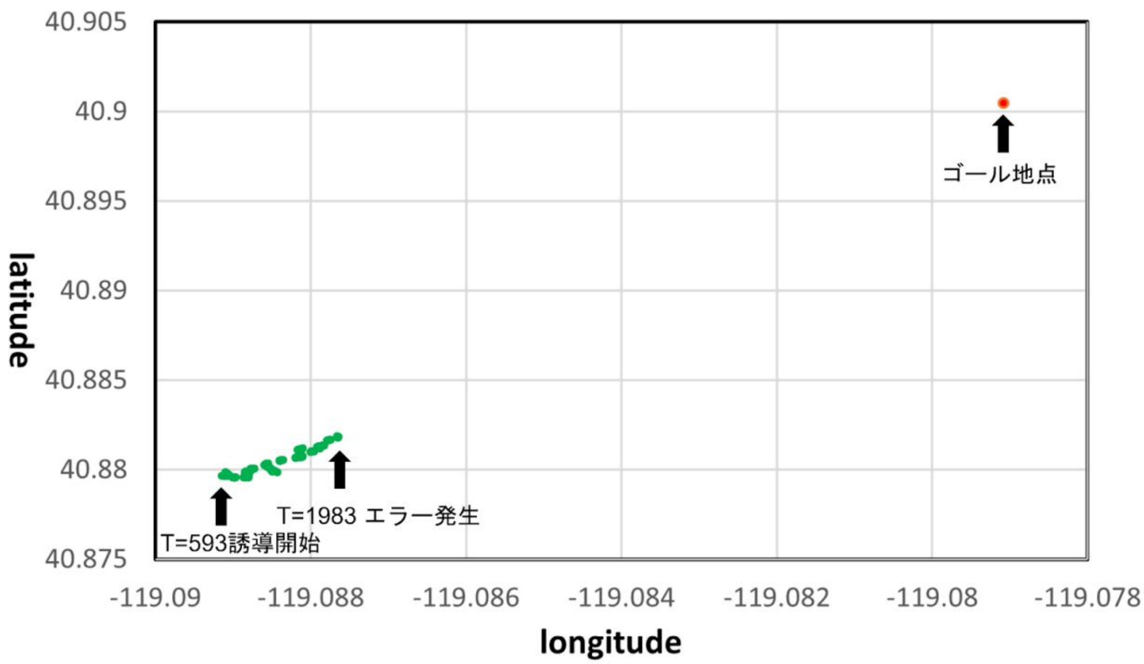

Figure 9.2.2 GPS recorded data

<Cause>

The aerial sequence log acquisition program was commented out, so the aerial sequence The test was carried out without any problems, and we were able to successfully transition to the long-distance guidance sequence. However, it is thought that an error similar to the first and second errors occurred in the log acquisition program for the long-distance guidance sequence.

<Discussion> Regarding the guidance program, we repeatedly experimented and improved it through the preparation of review documents and the Noshiro Space Event, and were able to create a program that could achieve the success criteria. However, the time it took to create programs related to communications and records was short, so we were unable to conduct sufficient tests and decided to wait until the competition. As a result, long-distance communication with CansSat was not possible, and the status of CanSat could not be accurately determined. Based on this experience, we believe that in the future we should create a communication and recording system that will allow us to accurately grasp the status of CanSat.

Chapter 10 Summary

(i) Points of improvement/effort (all aspects of hardware, software, and management)

[Hardware]

<Traveling

Airframe> This time, the airframe team was mainly responsible for the hardware aspects of the aircraft body, and carried out design and manufacturing work with a focus on reducing weight and improving impact resistance.

Improvements:

Emphasizing the weight reduction and impact resistance of the entire aircraft, NR sponge was used for the tires, and other improvements were made. The entire body of the car was manufactured using a 3D printer.

As for the tires, we boldly used NR sponge in the main part to improve impact resistance and reduce weight. By installing ABS spikes (protrusions) distributed around the tire, we aimed to create a tire that takes advantage of the strengths of NR sponge while maintaining its grip and other crash performance. In addition, by applying a commercially available rubber spray to the ABS spikes of the tires, grip performance was further improved.As for the method of securing the motor, following the previous model, we changed the method of securing the motor to the conventional method. Sandwich

Changed from a push-in method to a slot method.

Regarding experiments, we conducted experiments to further increase reliability using our own unique method. In particular, the aircraft team established its own unique methods for landing impact tests and tests related to flight performance.

What went well:

Similar to the experimental results, the actual launch was successful without any damage to the aircraft. A total of three launches were conducted, and no damage was found to the aircraft body in any of the launches, and the exact same aircraft could be used all three times. Furthermore, during the third launch, the aircraft ran without any problems, confirming that the aircraft had overall high impact resistance due to the excellent parachute performance and the impact resistance of the aircraft itself.

In addition, by using a full-scale 3D printer to manufacture the parts, we were able to create highly flexible designs and produce parts that were optimized for strength, lightness, space, and other aspects. In addition, by improving the method of fixing the motor, maintainability has been greatly improved compared to past aircraft, making it easier to maintain even when design changes are made, such as changing the motor used. It was easy to deal with in a short time.

What we struggled

with: As a result of our efforts to create something better than the current technology within the time period, we had a very difficult time deciding where to give up on the possibility of achieving it. In addition, when devising a unique experimental method, there was no precedent for it, so various ingenuity was necessary.

<Recovery mechanism> The recovery team is in charge of developing the aircraft storage module and parachute. The recovery mechanism refers to a module that combines the aircraft storage module and parachute. Below, we will discuss the improvements we made, the things that worked well, and the things we struggled with regarding the fuselage storage module and parachute.

[Module for aircraft storage]

Improvements:
- Simplified internal structure
- Placed NR sponge rubber in the tire contact area
- Shortened storage time using cable ties

Points that worked well:
- Volume and weight could be allocated to the main body of the aircraft.
- We were able to reduce the impact on the motor shaft.
- We were able to shorten setup time and increase the number of experiments.

Points I struggled with:
- Because I got tired quickly, I had to redo it many times.
- Because it is molded from a single piece of PP board, even if the damage was small, it was impossible to partially repair it and it was necessary to rebuild it.
- There was a possibility that there was a leak in the eyelet.

[Parachute]

Improvements:
- Improved stability by making it hemispherical
- Reconsidered the drag coefficient
- Incorporated a convex into the paracord.
- Increased paracord to provide redundancy.
- Easily connect the paracord to the carabiner to easily attach the canopy and the module for storing the aircraft.

It can be decomposed into

Points that worked well:
- By stabilizing the descent attitude, the phenomenon of the aircraft shaking like a pendulum during descent was reduced. became.
- By reviewing the drag coefficient, we were able to downsize the parachute and shorten the time required to deploy it.
- When the canopy got wet during an experiment, it could be replaced in a short time.

Points we struggled with:
- When storing the carrier, the restoring force of the convex made it time consuming to store it.

Points of failure:
- Because the color of the canopy was close to the color of the red cone, the image recognition guidance sequence misidentified the canopy as a red cone.
- The aircraft became unable to fly because the convex and stabilizer of the aircraft became entangled.

[Software]

Improvements:

The following points were devised when creating the CanSat control program.

•Improved program readability When

programming, we established a naming convention for function names. Specifically, the words used for functions and variables are written without abbreviations, so that the role of the function or variable can be understood at a glance. In addition, by using VScode's predictive conversion function and extensions, we have created an environment where you can program without worrying about trivial details.

•Flexible code Multiple guidance

sequences are prepared, and sequences can be branched and deleted. This has made it possible to respond flexibly to situations by combining guidance sequences according to the aircraft and field conditions. Additionally, it is compatible with multiple sensor modules, so even if the sensor module is changed, it can be handled by replacing the functions. We plan to add more compatible sensor modules in the future.

•Creating programs other than the CanSat control program

In addition to the control program, there are two programs that allow CanSat competitions and various tests to run smoothly. I created a ram.

``Setup program set_up.py'' This program is a program

to make the settings necessary for guiding CanSat. Specifically, the registration of GPS coordinates, altitude settings, and geomagnetic correction values can be set semi-automatically. You can also check the operation of the sensor module. Therefore, preparations for dropping the aircraft can be completed simply by starting this program. As a side effect, by not directly manipulating the main program, it is possible to reduce the risk of errors occurring due to program manipulation immediately before the experiment. On the day of the test, we were able to increase drop opportunities by significantly shortening preparation time.

``Program for radio control operation with motor adjustment function m++.py'' We had

originally created a program that could be remotely controlled from a computer, but we implemented a motor adjustment function into that program. After running the program, you can now adjust the motor power and balance between the left and right motors by pressing a button.

What we tried to

do: The CanSat we used this time is made by bonding ABS protrusions to sponge tires, so the tires are easily deformed and the contact area with the ground is small, so we input the command to go straight. There was a problem in which the aircraft would turn even when force was applied. Therefore, the rotation speed of the left and right motors was adjusted at the beginning of each experiment. It is very time-consuming to make this adjustment before every experiment, so we created the motor adjustment program mentioned above.

ÿmanagementÿ

The development of CanSat was carried out divided into the airframe team, electrical equipment team, and recovery team. Work that each group is responsible for The details are as follows.

- •Airframe team: Design and manufacture of the hard parts of the flying aircraft (excluding the board)
- •Electrical equipment team: Main program and board design and production
- •Recovery team: Design and manufacture of aircraft storage modules and parachutes

Use a RACI chart (responsibility allocation chart) to determine the roles/task allocation for each group. I will explain. The names of each role in the chart are as follows.

Responsible (person responsible for execution): Person responsible for creating or reviewing a certain process
Accountable: Person who provides explanations to outside parties
Consulted: Worker
Informed: Persons such as PMs who do not know the information, which will cause problems in future operations.

<Aircraft group>

The RACI chart for the aircraft group is shown in Table 10.1.1 below.

Table 10.1.1 Aircraft team roles/responsibilities (RACI chart)

task	Hikaru Kitamura PM	Yoko Miyashita Aircraft unit leader	Takamitsu Fukuda Designer	Natsuteru Abe	Hiroshi Arai
Determining the concept of the traveling aircraft	I, R	I, R	C	C	C
Motor selection	I	R			
Conceptual design of the traveling aircraft	I	R	C	C	C
scheduling	I	R			
Detailed tire design	I	I C	R,C	C	
Detailed design of the fuselage body	I	I C	R,C	C	
tire production	I	I C	R,C	C	
Fabrication of the fuselage body part	I	I C	R,C	C	
Advance preparation for the test	I, R, A	R	C	C	C
(*) Implementation of	I, R	R	C	C	C
the test (*) Summary of test (*) results	I, R	R	C	C	C
Aircraft load simulation				R, C	
tour conductor	I				R

•Designer Fukuda handles the design and production of the traveling aircraft, and the aircraft team leader handles various experiments. Miyashita took command, and the roles of those in charge were divided appropriately.

•Because we relied on Designer Fukuda for the design and production of the aircraft, we were unable to assemble the aircraft on the day. This could only be done by humans, and there was insufficient backup in case of an emergency.

•For the remaining personnel in the aircraft group, we will select and reserve transportation and accommodation for participation in the tournament. I was asked to work as a tour conductor.

-All members of the aircraft team shared roles in advance preparation for the experiment and sorting out the results.

•The aircraft team is in charge of preparing for the tests and summarizing the results, including the results in the review report. It was smooth.

<Electrical equipment team>

The RACI chart for the electrical equipment team is shown in Table 10.1.2.

Table 10.1.2 Roles/Responsibilities of Electrical Equipment Team (RACI Chart)

task	Hikaru Kitamura PM	Yuya Kato Electrical equipment team leader	Kiyoshi Mizusawa
Operation sequence design	I	R, C	
Creating the main program	I	R, C	
Creating an image recognition program Growth	I	R, C	
Module selection	I	I	R, C
Board design	I	I	R, C
Manufacturing of the board	I	I	R, C
Advance preparation for the	I, R, A	R	C
test (*) Implementation	I, R	R	C
of the test (*) Summary of test (*) results	I, R	R	C

•As there were two people in the electrical equipment team, development was divided into one person in charge of programming and one person in charge of circuit boards. Ta. (Directly check the progress of each in the overall MTG etc.)

•The electrical equipment team is in charge of preparing for the tests and summarizing the results, including the results in the examination report. It was smooth.

•By frequently conducting MTG within the electrical equipment team, we were always able to keep track of each other's progress.

•As there was no backup personnel, we would respond in the unlikely event that a staff member was absent due to trouble. It was difficult to do.

<Collection team>

The RACI chart of the collection team is shown in Table 10.1.3.

Table 10.1.3 Collection team roles/responsibilities (RACI chart)

task	Hikaru Kitamura PM	Soichiro Saito Collection team leader
Aircraft storage module design	**I**	**R, C**
parachute design	**I**	**R, C**
Aircraft storage module Production	**I**	**R, C**
Making a parachute	**I**	**R, C**
Preparation for the exam (*)	**I, R, A**	**R, C**
Implementation of exam (*)	**I, R**	**R, C**
Summary of test (*) results	**I, R**	**R, C**

- Since the collection team only had one person, the collection team leader did most of the design and manufacturing himself.
•Insufficient personnel to prepare for the test (creating an experiment plan, etc.) and conduct the test will be filled by other teams. Ta.

<Assignment of various tests>

The various tests required for the safety review report were allocated as follows.

•Parachute drop test recovery team (all teams involved)
•Long distance communication test electrical equipment group
•Mass test aircraft group (all groups involved)
•Aircraft storage and release test recovery team
•Parachute separation test recovery team & electrical equipment team
- Umbrella opening impact test recovery team (all teams involved)
•Quasi-static load test aircraft group (all groups involved)
•GPS data downlink test electrical equipment team
•Communication equipment power ON/OFF test electrical equipment team
•Communication frequency change test electrical equipment team
•Separate impact test aircraft group (all groups involved)
•Vibration test aircraft group (all groups involved)
•End to End test recovery team & aircraft team (all teams involved)
•Landing impact test aircraft team (all teams involved)
•Control history report test electrical equipment team
•Gal detection test electrical equipment team
•Rough road test aircraft group (all groups involved)

(ii) Issues : During

the originally planned two launches, no results could be considered successful. The cause of both was a program error due to long-term operation, but it was not possible to fundamentally improve the malfunction during the tournament period. ÿDuring the experiment and analysis stages, we
should have taken measures to acquire data during long-term operation and to prepare for any problems that might occur.

•At the design stage, as a result of trying to design something at a higher level, the schedule became overcrowded just before the competition. ÿWe
should have thoroughly managed the schedule and aimed for a schedule that would not overwhelm the analysis and experiments.

•A large difference arose in the assignment of work to workers. ÿSince some of
the work such as design and production was done by one person, the person in charge should have divided the work appropriately. I think we would have been able to create a better aircraft if we had divided parts and other parts that could be divided into parts, and if each member had been ingenious and particular about the parts they were responsible for.

- Regarding analysis and experiments, there were many parts where the experimental conditions were not set (why the values were used, how the values were determined, etc.).
ÿFor example, the experimental conditions should have been set based on scientific and quantitative data, such as data on the quasi-static loads actually applied to the aircraft during launch.

(iii) Future outlook

For the members who participated in ARLISS2022, this was the last competition. Therefore, the future direction will be up to the next members, but the wishes of the members participating in this conference are listed below.

[Hopes of ARLISS2022 participating members]
We have four major hopes.

1. A more original and technologically advanced mission As
stated in this mission statement, “3. Be versatile enough to be applied to a variety of missions,” this aircraft has a very orthodox form as a CanSat. It can be applied to various missions. Therefore, I would like to see the aircraft used in this competition be used as a reference for more creative and technically advanced missions.

2. Education for juniors
In our generation, it took a great deal of time and effort to recover from loss-based technology, but restarting a project once it has been discontinued requires an enormous amount of energy. Therefore, I would like them to provide sufficient education to their junior colleagues and continue working on CanSat development in the future.

Achieving 3.0m goal

Although we were able to receive 2nd place in the "Best Mission Award" this time, there are still many areas where we are inferior to other teams in terms of technology. Therefore, I hope future generations will create a CanSat that is highly evaluated from a technical standpoint and achieve the long-awaited 0m goal. Also, in recent years, there have been a large number of two-wheeled rovers, but I would like to see them actively working on producing mission-specific CanSats in addition to the Comeback model. CanSat is originally a simulated artificial satellite, and should take various forms depending on the mission. We are looking forward to CanSat, which is not bound by precedent or common sense.

Four. External Funding Our group

did not raise funds from external sources, so we did not have to raise funds from members such as travel expenses. The financial burden was extremely heavy. Therefore, if you have sufficient staff, I would like you to proactively engage in fundraising through crowdfunding and other means.