ARLISS2022 **development review report**

Submission date: November 21, 2022

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Other words	

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table of contents

Chapter 1 **Mission Statement**

For the purpose of safe route selection and research value for CanSat, we will generate a 3D model of the terrain around the goal using images taken with the camera mounted on the rover.

<Significance and overview of the mission>

In order for rovers such as CanSat to continue traveling for longer periods of time, they are required to have high traversal performance and the ability to select appropriate travel routes. There have also been cases in which actual rovers have taken the wrong route, resulting in their wheels getting stuck and making it difficult to navigate, so selecting an appropriate route is an important issue for rovers traveling in unknown areas. In route selection, 3D modeling of the terrain can be said to be an effective means of understanding the undulations of the terrain .

In addition, 3D modeling of terrain has great scientific significance in actual planetary/satellite exploration. **This is because these landforms represent the history of weathering, erosion, and collisions of planets and satellites.** From **a scientific and practical perspective, 3D modeling using images is considered to have great significance in space exploration.**

~~**However, there are challenges when actually generating 3D models from images. Terrain modeling using image processing requires high hardware costs. Modeling using stereo vision requires multiple cameras, and image processing requires high processing power from the onboard computer. Due to weight and size limitations, it is difficult to add computer resources or cameras.**~~

However, it is difficult to perform image processing to create a three-dimensional map with the processing power of the spacecraft's processor currently in use, so the recording medium will be recovered in the same way that a subsequent spacecraft will collect samples in the Mars sample return mission. It is conceivable to adopt a method that communicates a large amount of images over time.

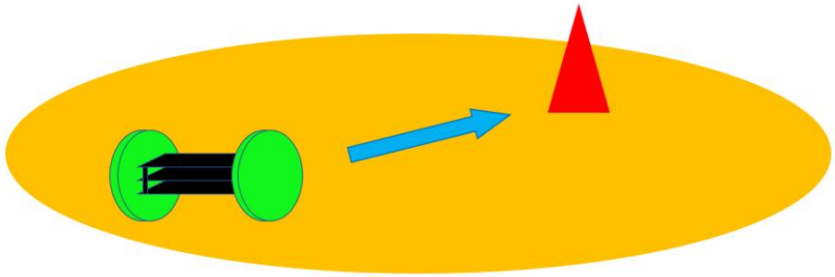
In order to establish the foundation of the above technology, we define a mission with the following steps.

1. Obtaining images from multiple angles using a monocular camera mounted on the rover2 .
Se~~nd images from the rover to the ground station Save~~ images with the rover 3. Similar to the Mars sample return, the SD card containing images will be recovered later, image processing will be performed at a ground station, and a 3D model of the terrain will be created.

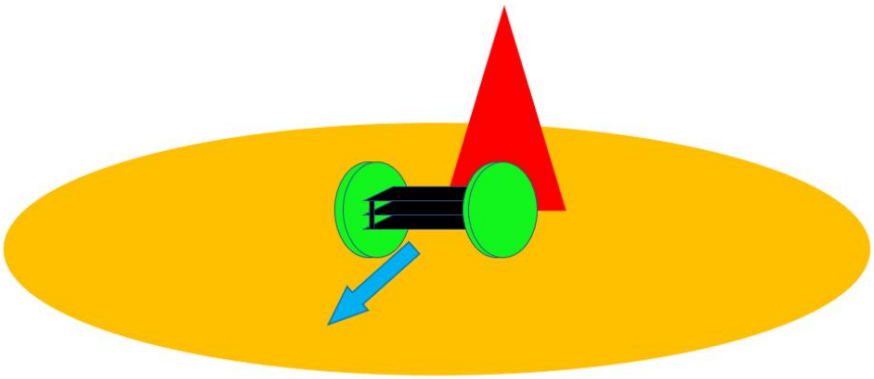
By performing these missions, Visual SLAM (Visual Simultaneous
It is believed that through the use of localization and mapping, it will be possible to lay the foundation for automatic control technology for unmanned robots and technology for constructing manned bases for the Moon and Mars development, which is expected to accelerate in the future .

Based on these backgrounds and rationales, we set up the above mission, and as a research, we will demonstrate that it is possible to generate a 3D model from images taken by the camera mounted on the rover.

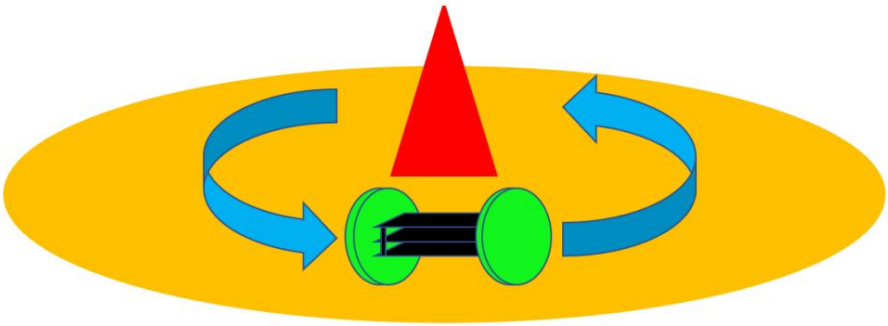
<Mission sequence>



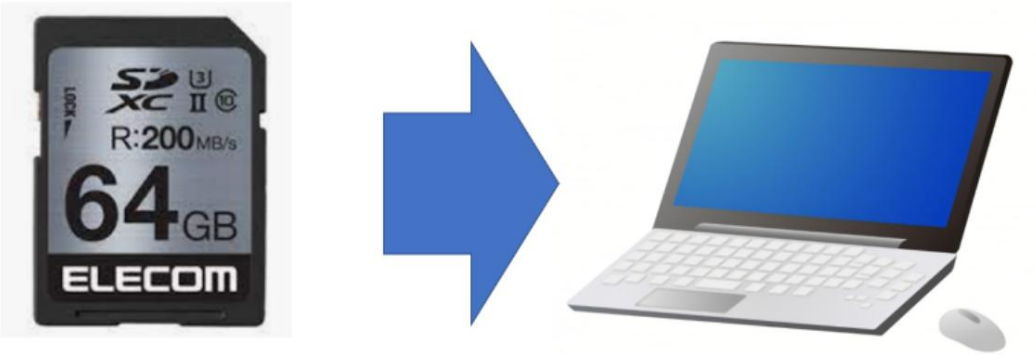
1. GPSとカメラを用いて0mゴールを達成する



2. 0mゴール達成後、ローバーをゴールから3m近く離れる方向へ直進する



3. ゴール周辺3mを周回・停止・撮影・送信を繰り返しながら2枚以上の画像を撮影する



4. 地上局(PC)で画像を読み込み、3Dモデルを形成する

Chapter 2 **Success Criteria**

minimum success	~~**Achieve the 0m goal where you can capture images**~~ **while circling around the goal.**
middle success	~~Captured images can be sent to the ground~~ station **Images can be saved to an SD card**
full success	**A 3D model can be generated using images collected at the ground station.**
~~**advanced success**~~	~~It performs a series of operations from minimum success to full success, and can generate a 3D model in 20 minutes from image acquisition.~~

Chapter 3 **Setting requirements**

3.1 System requirements (requirements for ensuring safety and regulation)

Request number	System requirements (ARLISS launch safety standards)
S1	The mass of the aircraft dropping **meets the standards**
S2	**volume meets carrier standards**
S3	Quasi-static loads during **launch may impair functionality to meet safety standards. Tests have confirmed that there is no**
S4	**Tests have confirmed that the vibration loads during** launch did 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 functionality to meet safety standards.**
S6	The shock load when the **parachute is deployed may impair its functionality to meet safety standards. Tests have confirmed that this is not the case.**
S7	Has **a deceleration mechanism to prevent it from falling at a dangerous speed near the ground, and its performance has been confirmed in tests. is made of**
S8	**We have implemented countermeasures against** Lost, and their effectiveness has been confirmed through testing **(examples of countermeasures: location information transmission, beacons, fluorescent color paint, etc.)**
S9	**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 FCC certified and requires a software or hardware switch . things that can be turned off)**
S10	**We have confirmed that you are willing and able to adjust the** radio channel. **There is**
S11	**The communication distance between** the rover and the ground station is 5km or more.
S12	**We have been able to conduct an end-to-end test that simulates loading the** rocket, starting the mission, and recovering it after launch, and there will be no major design changes in the future.

3.2 Mission requirements

number	Mission requirements
	The ground station can receive signals from the rover when released from the M1 carrier.
	You can save two or more images to an SD card while circling around the M2 goal.
	M3 **ground station can generate 3D models of terrain**
	If you wish to participate in the Comeback Competition, please be sure to meet the following requirements:
	It has M4 **running ability and has been confirmed to be able to escape even if stuck.**
	It has been confirmed that autonomous control without human intervention will be implemented during the M5 mission.
	It can be confirmed that the envelope can be expanded after M5-1 lands.
	M5-2 **Can get as close as 5m near the goal using GPS and 9-axis sensor**
	Goal recognition using the M5-3 camera makes it possible to reach the 0m goal from around 5m.
	After the M6 **mission, the specified control history report was submitted to the management and examiners and logged/obtained. Data can be explained**

Chapter 4 **System Specifications**

4.1 External appearance of the aircraft

The external appearance of the aircraft is shown in Figures 4.1.1 and 4.1.2 below .

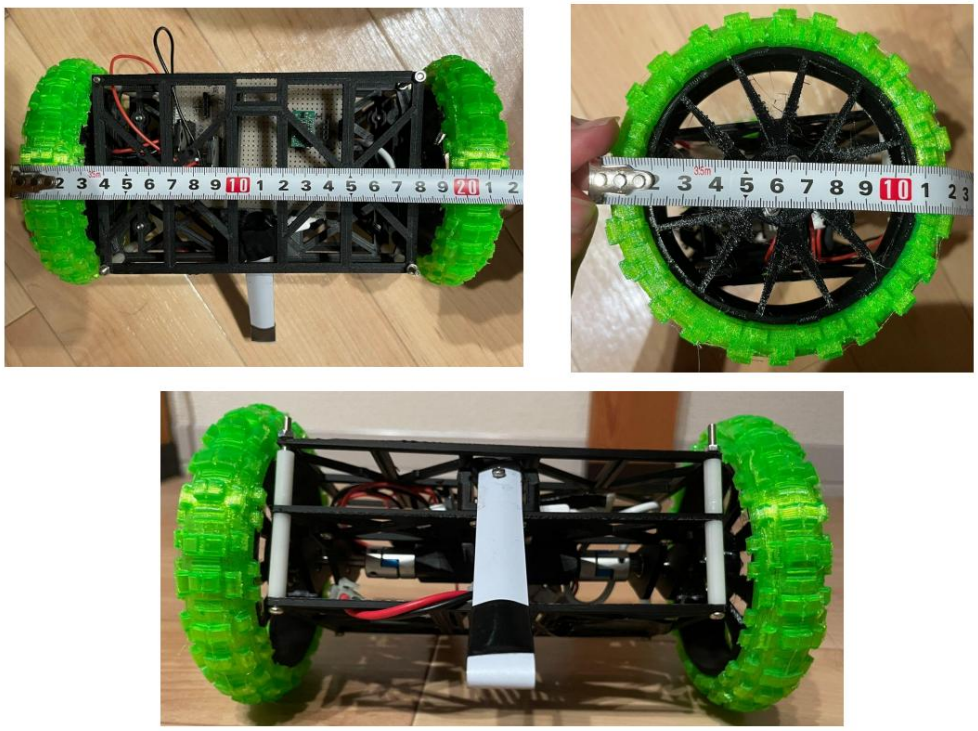


Figure 4.1.1 **View of the aircraft from three sides**

Figure 4.1.2 **Envelope and parachute**

The diameter when wrapped in an envelope can be perfectly aligned with the rover.

Diameter [mm]	**145**
Height [mm]	**220**

Mass [g]	**760.0**

4.2 Aircraft interior/mechanism

1. Structure

- **Three-layer**

structure The structure of the aircraft is constructed from three plates, each using a 20mm spacer to form a three-dimensional structure . Each plate uses ABS as the material and was produced using a 3D printer. Below is the role of each plate.

Upper layer: **Install** GPS sensor, 9-axis sensor, and camera
Middle layer: Install printed circuit board and
motor Lower layer: Install lipo battery

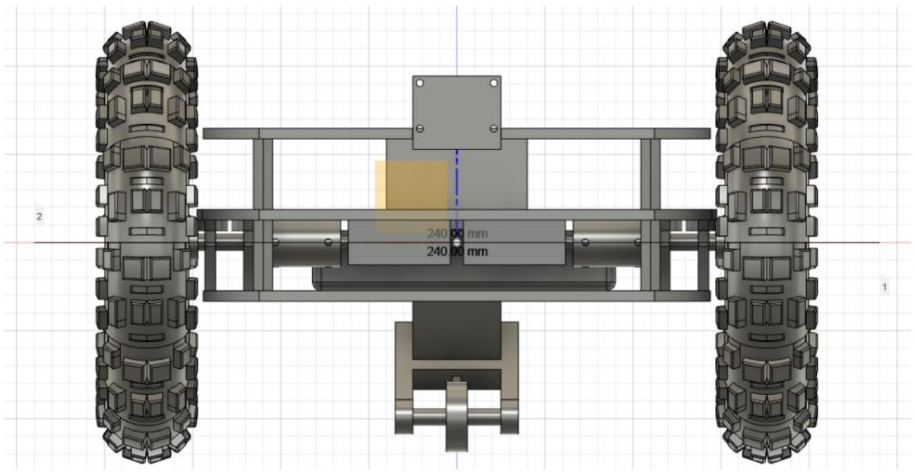


Figure 4.2.1 **Three-layer structure of the rover**

2. Drive structure

- **Tire structure We**

created a block-shaped tire as shown in Figure 4.2.2, which is designed for driving on unpaved land in the desert. Both the tires and wheels are made of TPU, and the shaft that connects the motor and wheels is designed to avoid shocks when landing or driving.

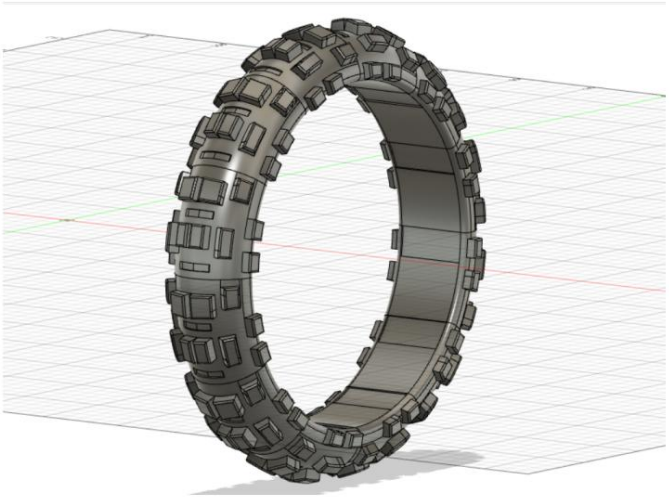


Figure 4.2.2 **Block type tire**

• **Connection structure between motor and wheel**

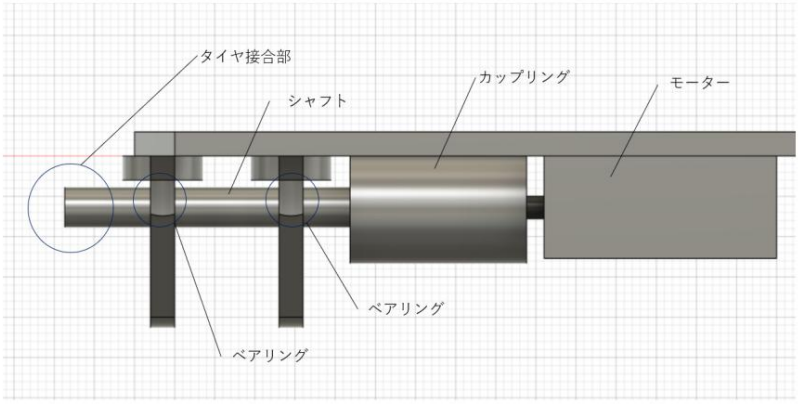


Figure 4.2.3 **Wheel and motor connection structure**

A mechanism was adopted to prevent the shock from being applied to the motor when dropped, making it impossible to drive. In order to prevent the shaft connected to the wheel from deforming due to the impact of landing, the shaft is supported at two fulcrums using two bearings. A coupling was used to connect **this shaft and motor in order to minimize loss and absorb vibrations during running.**

3ÿ Electrical

system • Printed circuit

boardA printed circuit board is ordered and installed in the middle layer.

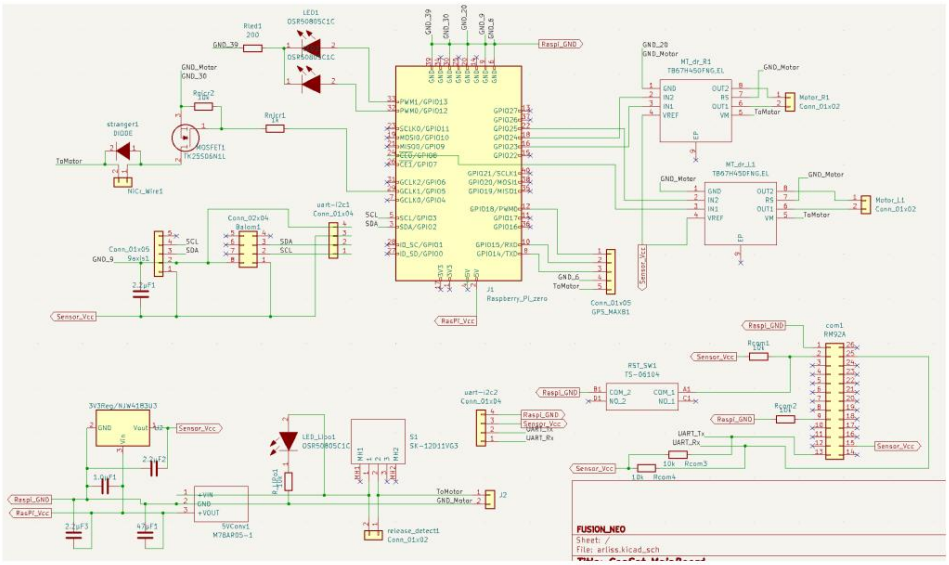
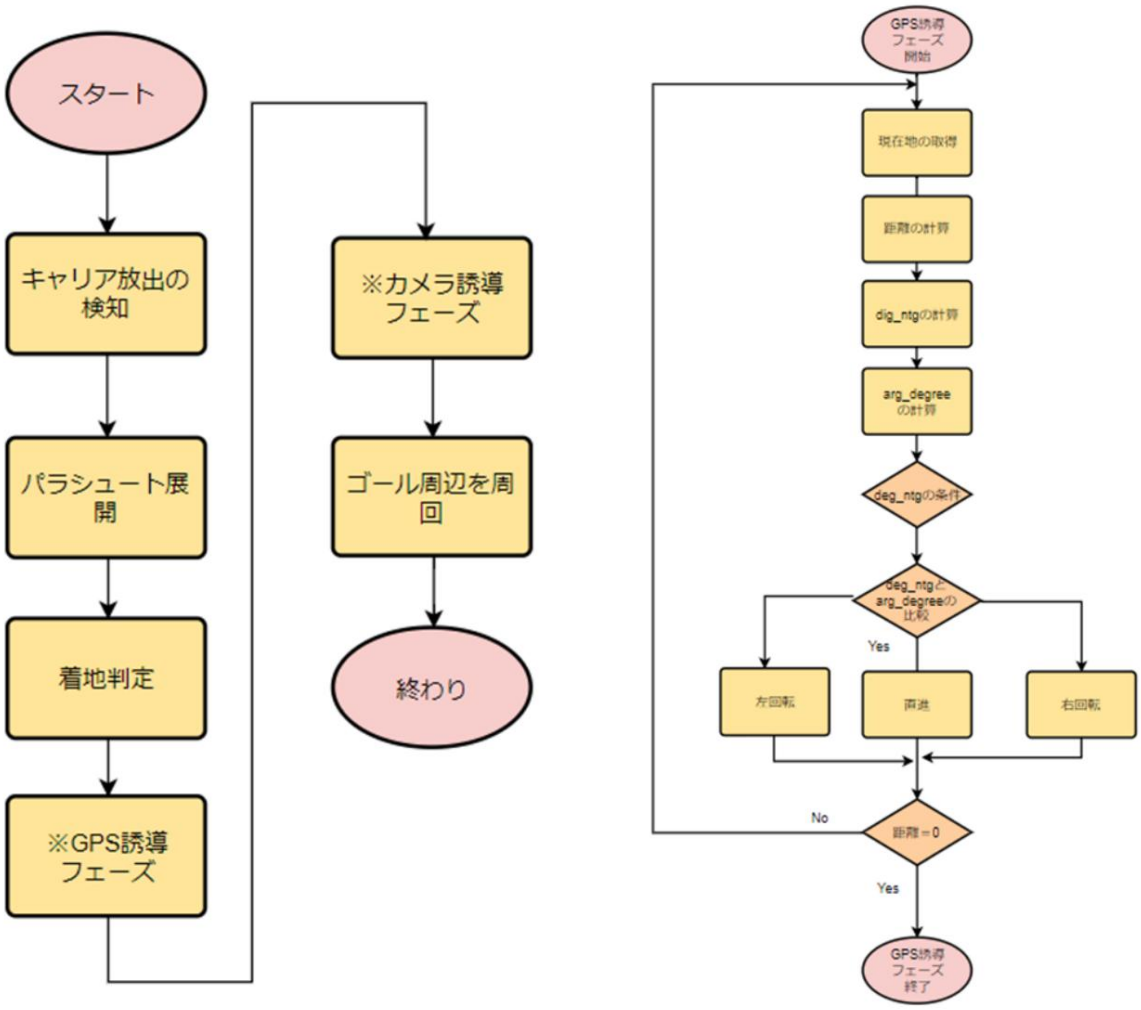


Figure 4.3.1 CanSat circuit diagram

~~*The communication test was successful, but we are currently improving the design around the communication~~ module.

4. control system



• The control flow is shown above. Guidance is mainly divided into “GPS guidance phase” and “image guidance phase”.

It will be done.

• A system diagram showing the relationship between the rover's various sensors and actuators is shown above.

Chapter 5 **Test item settings**

number	Verification item name	Corresponding self-examination items Request number(s)	Scheduled implementation date
V1	**Mass test**	S1	**Performed**
V2	**Aircraft storage and release test**	S2	7/26

V3	**Quasi-static load test**	S3	7/30
V4	**Vibration test**	S4	7/28
V5	**Separation impact test**	S5	7/30
V6	**Parachute opening impact test**	S6	7/29
V7	**drop test**	S7	7/30
V8	**Landing impact test**	S7, M5-1	7/30
V9	**GPS data downlink test**	S8	7/20
V10	**Communication start test**	S9, M1	7/19
V11	**Long distance communication test**	S8, S10, S11	7/12
V12	End-to-end exam	S12	8/1
V13	**3D model generation test**	M4	7/30
0m goal test using V14 camera		M2, M5-3	8/7
V15	**Control history report creation test**	M6	8/9
V16	**GPS driving test**	M5-2	8/8
V17	**stack test**	M7	7/14
V18	**Image acquisition and storage test**	M2	8/29

v1. Mass test

- **Confirm**
  that the total mass of the rover and parachute stored in the target carrier meets the regulations.

- **Test details**
  Place the rover body and parachute on a scale with the carrier set to zero, and confirm that the mass meets the regulation of 1050g or less.

- **Results**
  The total weight of the rover and parachute was 760.0 g, confirming that the mass met the regulations. Figure 6.1.1 **shows the mass measurement results.**

Figure 6.1.1 **Total mass of parachute and entire rover**

v2. Aircraft storage and release test

• Confirm
that the overall size of **the objective rover and parachute meets regulations. Also, confirm that the rover and parachute are released smoothly after the carrier opens.**

• **Test details**
Create a carrier that meets the regulations of height 240 mm and inner diameter 146 mm, and check whether the entire rover and parachute can be stored. **Next, shake the carrier slightly to confirm that the aircraft and parachute are released. Confirm the release** three times, and if all releases are possible, it is considered a success.

• **Test results : The**
entire rover and parachute could be stored in the carrier without any problems, confirming that the regulations were met. Figure 6.2.1 shows how the rover and parachute were stored.Also, the release from the carrier three times without any problems. I was able to do it.

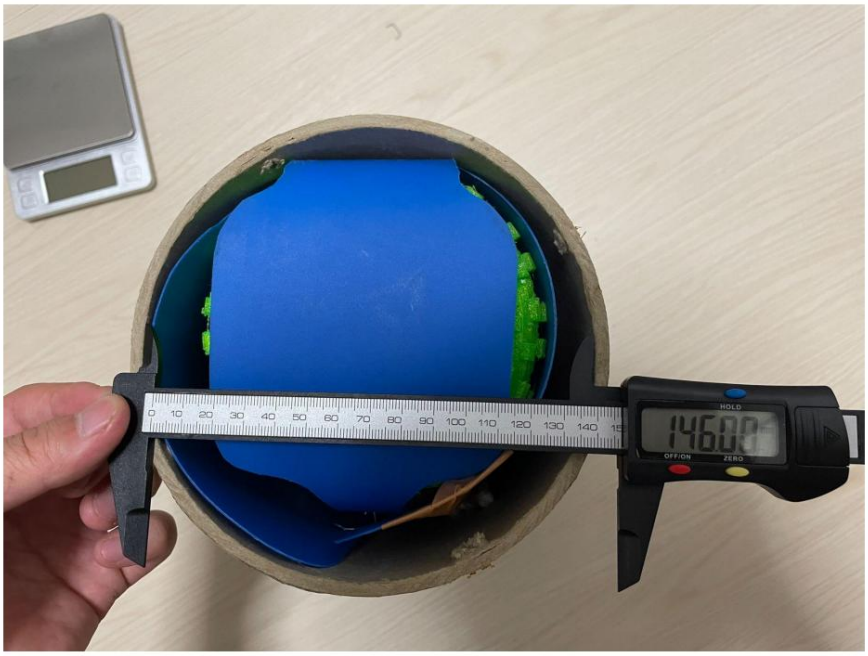


Figure 6.2.1 **Confirmation of storage in carrier**

Table 6.2.1 **Release test results**

number of times	Scene of release	Exam video
First time	**Smooth**	https://youtu.be/fu7ZdQUpYlk
Second time	**Smooth**	https://youtu.be/tggXJjRhbxE
Third time	**Smooth**	https://youtu.be/Mbk6rgwEg4Q

v3. Quasi-static load test

• A static
load of the size expected to be applied during the launch of **the target rocket will be applied to the rover to check for structural damage and failure of sensors.**

• **Test details A test**
will be conducted that simulates the mechanical environment during a rocket launch using an exciter in the Waseda University Faculty of Science and Engineering Materials Laboratory. With the entire rover and parachute stored in the carrier, the vehicle was operated under an acceleration of 10G according to the regulations. Apply 20 **Hz sinusoidal vibration for 10 s. After the vibration has finished, check for structural damage and failure of sensors. The experiment is performed three times.**

• **Test Results In all**
three experiments, after the experiment was completed, we visually confirmed that there was no structural damage, that there were no abnormalities in the 9-axis sensor through SSH connection, and that the motor was operating normally. **Below are graphs of the acceleration measured during the quasi-static load test (Figures 6.3.1, 6.3.2, 6.3.3) and the video URL of the experiment.**

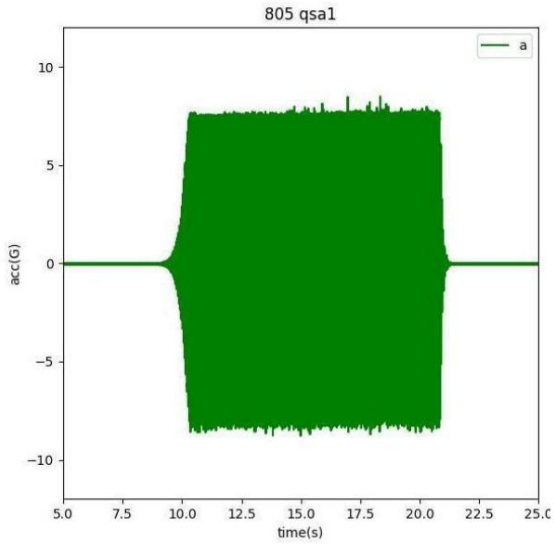


Figure 6.3.1 **First test results**

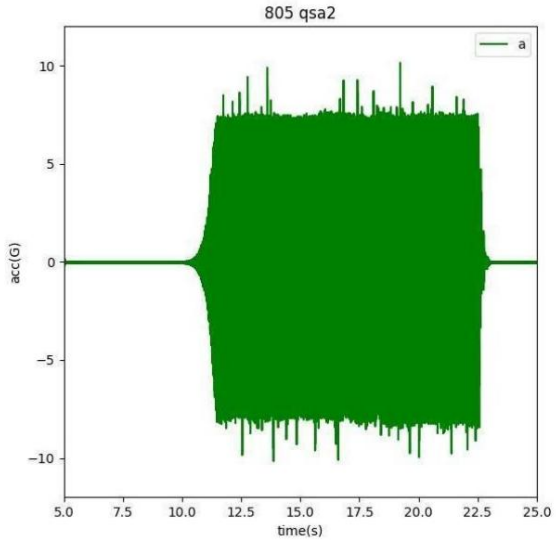


Figure 6.3.2 **Second test results**

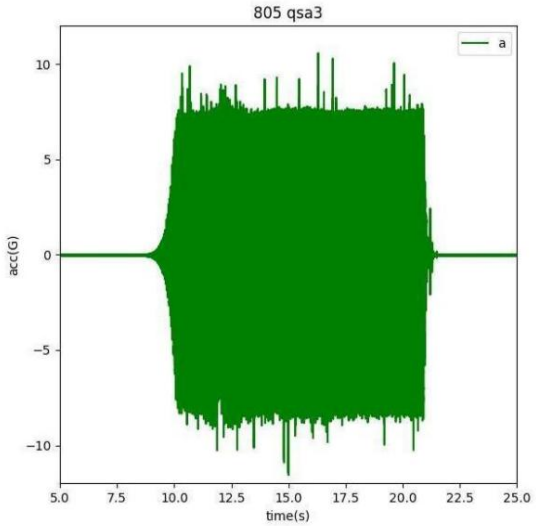


Figure 6.3.3 **Third test result**

Table 6.3.1 **Quasi-static load test results**

	Maximum acceleration (absolute value)	**Existence of external damage**	**Sensor operation**	**motor operation**
1	8.78805637G	**No damage**	**normal**	**normal**
2	10.1640499G	**No damage**	**normal**	**normal**
3	11.5617907G	**No damage**	**normal**	**normal**

In both cases, vibration started approximately 10 s after the start and continued for 10 s. In Figure 6.3.1, there are cases where the acceleration does not reach 10G , but this is thought to be because the carrier partially absorbed the shock. Since **the output of the vibrator, which is an external force, is 10G , there is no problem in testing according to regulations.**

Quasi-static load test video URL: https://youtu.be/XnOuAT_HIVc

v4.Vibration test

- **Apply**

  vibrations to the rover that are expected to occur during propulsion of the target rocket, and check for structural damage and failure of sensors.

- **Test details A test**

  will be conducted that simulates the mechanical environment during rocket propulsion using an exciter in the Waseda University Faculty of Science and Engineering Materials Laboratory. With the entire rover and parachute stored in the carrier, we apply a sine wave vibration that sweeps from 30 Hz to 2000 Hz at an acceleration of 15 G according to regulations. **The sweep time is 30** s, and the sweep **is performed by** sweeping down from 2000 Hz . **After the vibration ends, check for structural damage and failure of sensors. The experiment is performed three times.**

- **Test Results In all**

  three experiments, we visually confirmed that there was no structural damage after the experiment, and confirmed through SSH connection that there were no abnormalities in the 9-axis sensor and that the motor was operating normally . Below are graphs of the acceleration measured during the vibration test (Figures 6.4.1, 6.4.2, 6.4.3) and the video URL of the experiment.

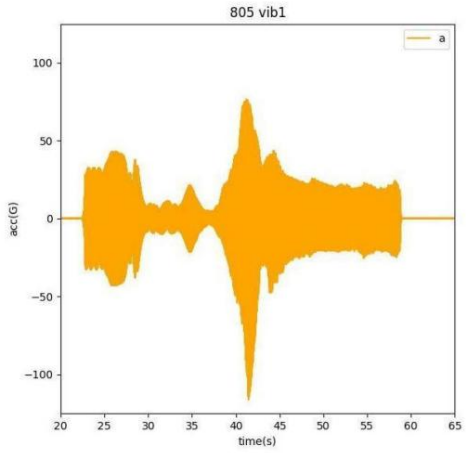


Figure 6.4.1 **First test results**

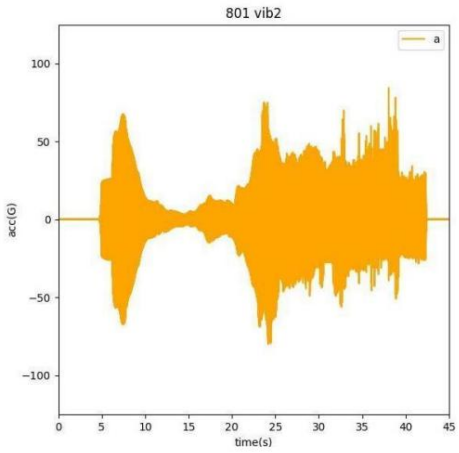


Figure 6.4.2 **Second test results**

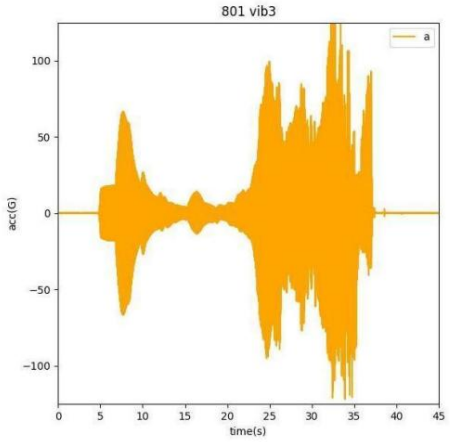


Figure 6.4.3 **Third test result**

Table 6.4.1 **Vibration test results**

Maximum acceleration (absolute value)	**Existence of external damage**	**Sensor operation**	**motor operation**
1	116.453762G	**No damage**	**normal**	**normal**
2	84.3831825G	**No damage**	**normal**	**normal**
3	141.421309G	**No damage**	**normal**	**normal**

The first time was 22 s to 52 **s, the second time was 5** s to 35 **s, the third time was 10** s to 40 s, and **the sweep was performed at a constant speed for 30** s from 2000 **Hz to 30** Hz. **Although the output of the vibrator was 15G, the acceleration applied to the aircraft due to the sine wave vibration was extremely large , reaching a maximum of 141G . Since an acceleration of 15G or more is always applied at any frequency, it can be said that the experiment was successful as it met the regulations.**

Vibration test video URL: https://youtu.be/uX3d7q7iMEI

v5. Separation impact test

• Apply

vibrations to the rover that are expected to occur when it separates from the target rocket, and check for structural damage and sensor failure.

• Test details A test will

be conducted that simulates the mechanical environment during a rocket launch using an exciter in the Waseda University Faculty of Science and Engineering Materials Laboratory. With the entire rover and parachute stored in the carrier, the vehicle was operated under an acceleration of 40G according to the regulations.

Apply 20 **Hz sinusoidal vibration for a short time.** Initially , **we assumed that the shock would be applied for 5 seconds, but because the strong vibration caused the shaker to auto-lock in about 2 to 3 seconds, we decided to apply the shock for a short period of time until it automatically locked. After the vibrations have finished, check the rover for structural damage and sensor failure. The experiment is performed three times.**

• Test Results In all

three experiments, we visually confirmed that there was no structural damage after the experiment, and confirmed through SSH connection that there were no abnormalities in the 9-axis sensor and that the motor was operating normally . Below are graphs of the acceleration measured during the impact test (Figures 6.5.1, 6.5.2, 6.5.3) and the video URL of the experiment.

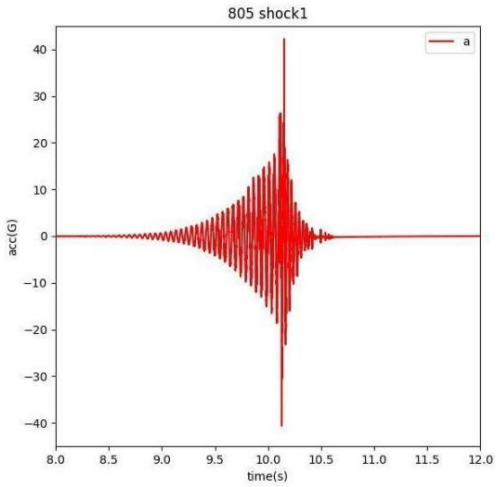


Figure 6.5.1 **First test results**

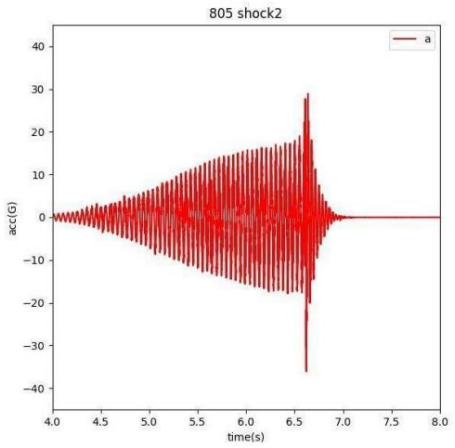


Figure 6.5.2 **Second test results**

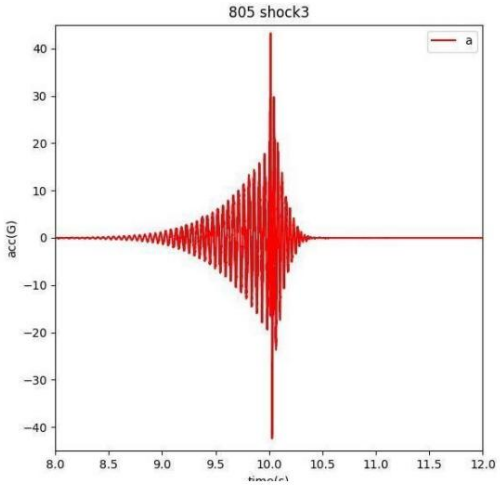


Figure 6.5.3 **Third test result**

Table 6.5.1 **Impact test results**

number of times	Maximum acceleration (absolute value)	**Damage to structure**	**Sensor operation**	**Motor operation**
1	116.453762G	**No damage**	**normal**	**normal**
2	84.3831825G	**No damage**	**normal**	**normal**
3	141.421309G	**No damage**	**normal**	**normal**

In the second experiment, the acceleration did not reach 40G, but in the first and third experiments, the acceleration exceeded 40G as per regulations.
I was able to give this to my carrier. It can be said that the experiment was a success.

Impact test video URL: https://youtu.be/Eo3BUaDv2YY

v6. Parachute opening test

• Purpose

When the rover was released from the carrier, it fell along with the parachute attached as a deceleration mechanism, and fell freely until it opened.
Later, the rover opens and an upward force is applied to the rover and the envelope. In this experiment, the umbrella was opened under conditions similar to the actual competition.
Make sure that the envelope and parachute do not separate when a shock is applied, and that the rover inside the envelope
The purpose is to confirm whether the system operates normally after an impact when the umbrella is opened.

• Test content

An experiment was conducted by dropping an envelope and rover with a parachute from a height of 11 meters to see if the parachute would deploy.
ÿÿ Also, after landing, check for structural damage and sensor failure.

• Test results

The result was that the umbrella was successfully opened 7 times out of 10 times. Folding of the parachute is the reason why it did not open
It is thought that the parachute did not fully open after falling 11 meters due to poor accuracy. Also, when the wind is strong,
We also confirmed that it took a long time for the chute to open. Therefore, 3 out of 10 times the parachute did not deploy.
However, given the altitude, it is thought that it would have been fully opened. In the actual event, the falling distance is expected to be approximately 4km, so paralysis occurs during the fall.
I thought there was a high possibility that the chute would open. In addition, there was no structural damage in any of the results, and the sensor and motor were damaged.
Since we were able to confirm the operation, we were able to confirm that the rover is highly reliable and reproducible.
The results of the experiment and the URL of the video taken are shown below.

Table 6.6.1 **Parachute opening test results**

Number of times the parachute Did you open your umbrella?	Is there any damage to the structure? Is the sensor or motor operating? Made by	movie
First time	ÿ	No damage	normal	https://youtu.be/LxjdRriK-v0
Second time	ÿ	No damage	normal	https://youtu.be/XhazXHmEmt8
Third time	ÿ	No damage	normal	https://youtu.be/u66pyZJxLnM
4th	ÿ	No damage	normal	https://youtu.be/cNx8dqTYR88
5th time	ÿ	No damage	normal	https://youtu.be/9LZ-cxGztO0
6th time	ÿ	No damage	normal	https://youtu.be/uNx8vtsGEpM
7th time	ÿ	No damage	normal	https://youtu.be/dSSM-Cq0O3g

8th time	**ÿ**	**No damage**	**normal**	https://youtu.be/BUta-RxIVIc
9th time	**ÿ**	**No damage**	**normal**	https://youtu.be/it6UmpsF_Ws
10th time	**ÿ**	**No damage**	**normal**	https://youtu.be/-FPoXi4h8bc]

v6.Parachute opening impact test

the purpose

On the day of release, when the rover is released, strong tension will be exerted between the envelope and the parachute cord. In this exam , The aim is to check whether the parachute cord can withstand shocks of 25~30G.
Target.

contents of the test

In this experiment, instead of applying a 25-30G shock, a 28.5kg weight was suspended at the end of the parachute to apply a static load. , **confirm that the parachute, cord, and the base of the envelope can withstand about** 1 s without being damaged. **en**
The experiment was conducted by holding the base of the bellow so that it did not touch the cord.

Test results

The experiment was conducted three times. The respective results are shown in Table 6.7.1 below. Also, parachutes, cords, and envelopes.
The situation is shown in the video below. Figure 6.7.1 shows how the mass of the weight used was measured.

Table 6.7.1

	result	Video URL
First time	**No damage**	https://youtu.be/qm_ILJTYJ0I
Second time	**No damage**	https://youtu.be/y5f2mGDxM1A
Third time	**No damage**	https://youtu.be/4sKTn5UBm4M

Figure 6.7.1 Weight mass

v7. Drop test

Objective : On the day of the competition, it is assumed that the rover will be released from the carrier and fall while being decelerated by the parachute's deceleration mechanism. The purpose of this experiment was to confirm whether the deceleration by the parachute was sufficient.

.

Test details In

this experiment, the rover is dropped from a height of around 11m with the parachute open. The altitude is determined from the results of the temperature and pressure sensor of the falling rover, and the approximate falling speed is measured from this temporal change. Estimating the falling speed using these values and the video, we confirm that the speed can be reduced to around 5m/s.

Test Results The

action of dropping the aircraft from an 11m-high bridge was repeated three times, and the altitude in each situation was recorded. (Figure 6.7.1)

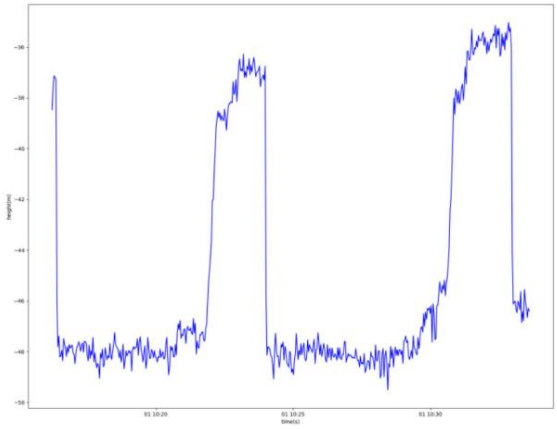


Figure 6.7.1 **Altitude change during the experiment**

The first drop was made at around 10:17, the second at around 10:23, and the third at around 10:32. **This time series corresponds well to the graph in Figure 6.7.1. Additionally, the altitude difference between the bridge and the landing position was about 11m, so it can be said that** the altitude was accurately determined.
Use these results to determine the speed of the fall. Figures
6.7.2, **6.7.3, and 6.7.4 are graphs of the speed measured from altitude changes and time changes using the results in Figure 6.7.1. The time it is considered to be falling is the period between the blue lines in each figure, and the velocity in the falling direction is taken as positive.**

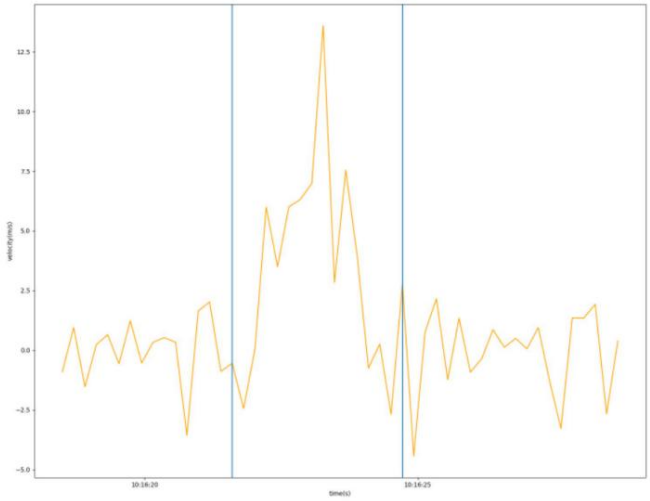


Figure 6.7.2 **Velocity change curve for the first fall**

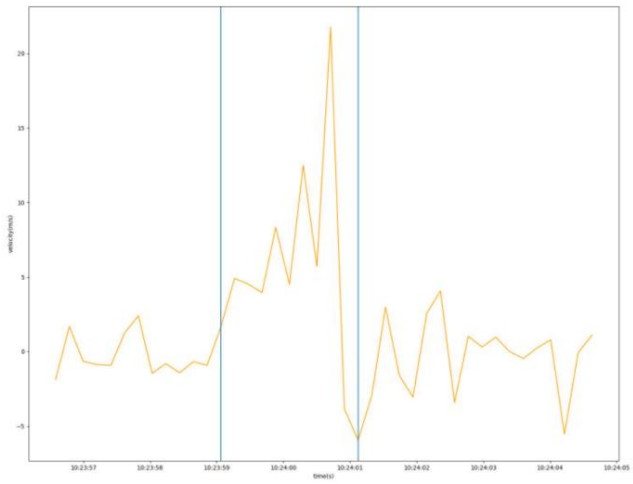


Figure 6.7.3 **Velocity change curve for second fall**

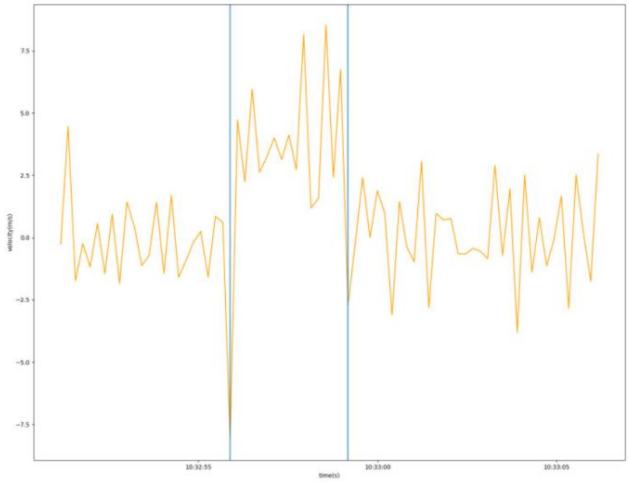


Figure 6.7.4 **Velocity change curve for the third fall**

The falling speed calculated using these results is as follows.

Table. 6.7.1 **Speed measurement results by experiment (calculated from altitude changes)**

number of times	**Falling speed judgment (m/s)**	Speed evaluation (is it less than 5m/s)
1	6.986	**ÿ**
2	8.974	**ÿ**
3	4.091	**ÿ**

In addition to these results, we also estimated the speed using video footage.

Table. 6.7.2 **Approximate speed estimation results by experiment (estimated from falling video)**

Number of times	**Estimated falling speed (m/s)**	Speed evaluation (is it less than 5 m/s)	**movie**
1	Approximately 7m/s	ÿ	https://youtu.be/OMDm orax8xk
2	Approximately 6m/s	ÿ	https://youtu.be/ggAg7 otJMu0
3	Approximately 4.5m/s	ÿ	https://youtu.be/Il1aN1 4RFJM

It seems that the falling speed for the first and second times did not meet the requirements, but when you check the video, you can see that the parachute is fully opened. It can be seen that it is falling without any damage. From the third video, it is observed that the parachute is definitely open.

Therefore, it is thought that the speed will be less than 5m/s when it is sufficiently decelerated.

postscript:

We additionally conducted multiple opening experiments and determined the terminal velocity from the video. As a result, the speed evaluation was met 4 out of 5 times.

Therefore, it is thought that the speed will be less than 5m/s when it is sufficiently decelerated.

number of times	**terminal velocity**	**movie**
1	Approximately 5m/s	https://youtu.be/2rmXSmJOQtw
2	Approximately 5m/s	https://youtu.be/0ZzXP-hU1DM
3	Approximately 4m/s	https://www.youtube.com/watch?v= dSSM-Cq0Q3g
Four	Approximately 10m/s	https://www.youtube.com/watch?v=it 6UmpsF_Ws
Five	Approximately 4m/s	https://www.youtube.com/watch?v= XhazXHmEmt8

v8. Landing impact test

• Purpose

When the rover is decelerated by the parachute and falls at a constant speed, a shock is applied to the rover due to that speed. Book
The test will confirm whether the rover still operates normally even after receiving the impact of landing. Also, at this time,
Landing determination and envelope expansion will be simultaneously demonstrated using sensors mounted on the bar.

• Test content

1)Rover landing resistance test
Drop the rover from a height of 11 m with various initial velocities. After dropping it, check if the rover is working properly.
In addition to the normal free fall, we also performed a lateral fall in which initial velocity was added to the horizontal direction to simulate crosswinds in the desert.Three free falls were performed.
The plan was to perform a horizontal drop and three lateral drops, but due to damage to the rover, only one lateral drop was performed.

postscript:
To ensure that the rover's electrical equipment is working properly, a program that records the altitude and timing of landing judgment is carried out before the rover falls for the first time.
Confirm that the program is running continuously until after the rover falls for the third time.
In addition, in the v4 vibration test, the rover was subjected to an impact that greatly exceeded the impact that would be applied to the aircraft when it landed at terminal velocity.
We confirmed that the structure of the motor was not damaged and the motor rotated normally. Therefore, from the results of v4, after the landing impact, the hard part of the rover is
Indicates that it will not be damaged.

2) Landing judgment test
Confirm that the rover's landing can be detected by the temperature and pressure sensor, and that it will not judge the landing while it is falling.
Conduct a test with a purpose. First, a rover running a landing determination program was dropped from a height of 11 m, and the rover was dropped for 5 minutes after landing.
Put the rover on standby. Repeat these actions a total of three times. After the experiment is completed, by analyzing the saved data,
Confirm whether the landing judgment is accurate.

postscript:
It has been confirmed through the end-to- end test that the envelope can be expanded after landing judgment, so landing judgment and envelope expansion are possible.
The objective of demonstrating envelope expansion has been achieved.

• Test results

1) Rover impact resistance test
The impact resistance test was conducted at Shin-Arakawa Ohashi Bridge on July 23rd.
Table 6.8.1 shows the results and video URLs for three free fall experiments and one lateral fall experiment.

Table 6.8.1

number of times	structure	motor operation	movie
1st free fall	No damage	normal	https://youtu.be/JRzH wDmqmgc
2nd free fall	No damage	normal	https://youtu.be/izyMk ge-yo8
3rd free fall	No damage	normal	https://youtu.be/EPyr jveevE
1st horizontal fall	Corruption	unmeasurable	https://youtu.be/IraiO

			E8LteA

There was no damage to the rover due to the impact during the free fall.During the lateral fall, the bearing stand and stabilizer stand were cracked in the direction of the 3D printed stack, making it impossible to confirm the operation of the motor.After this experiment, the rover was The structural strength of the aircraft was improved by printing in the vertical direction.

P.S.:

The rover's electrical equipment is working properly if the " program to log the altitude and landing judgment timing" is activated before the rover falls for the first time, and the program continues to operate until after the rover falls for the third time. This was confirmed by the fact that The graph in Figure 6.8.2 is the altitude change log from the first to third fall in the above Table 6.8.1 Fall video. **It was confirmed that the program did not stop from the first to third drops, confirming that there was no failure of the electrical equipment due to the impact of the fall. Additionally, it is expected that an impact of 5.6 G will be applied to the rover when it touches down at terminal velocity.** This was **predicted** based on the fact that the acceleration log measured by the acceleration sensor **during the parachute fall in the same experiment** showed that an average impact of 5.6 G was applied after the fall (Figure 6.8.1~~). In the v4 vibration test , it was confirmed that there was no hardware failure as the rover's structure remained undamaged and the motor rotated normally after applying shocks of 80G to 140G, which is much higher than 5.6G~~ .

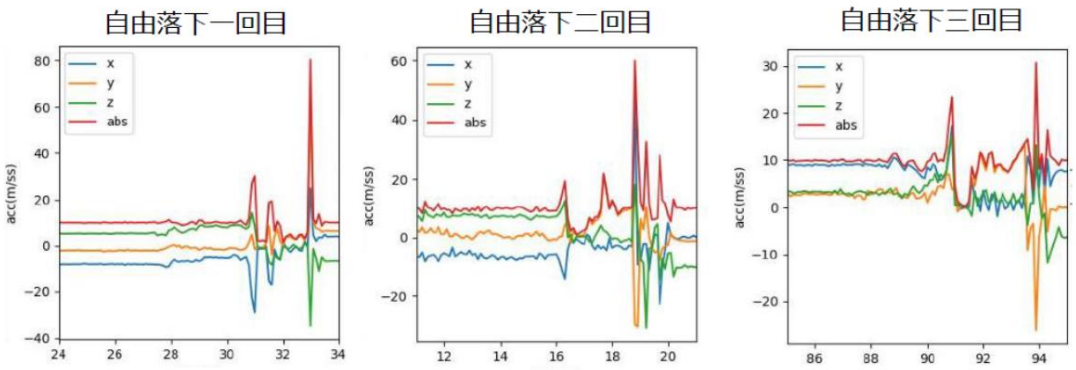


Figure 6.8.1 **Acceleration log of 1st to 3rd free fall**

2) Landing Judgment

Test The landing judgment test was conducted in conjunction with the V7 drop test at Shin-Arakawa Ohashi Bridge.Chapter 4 "System Specifications" 4. A landing determination program was constructed based on the landing determination algorithm in the control system, and a program to measure the time and altitude of the fall determination was executed at the same time as the program to measure the rover's altitude and time shown in V7 . The results are shown in 6.8.2. The relationship between the rover's altitude and time is plotted in orange, and the time and altitude at which landing was determined are shown as blue dots.

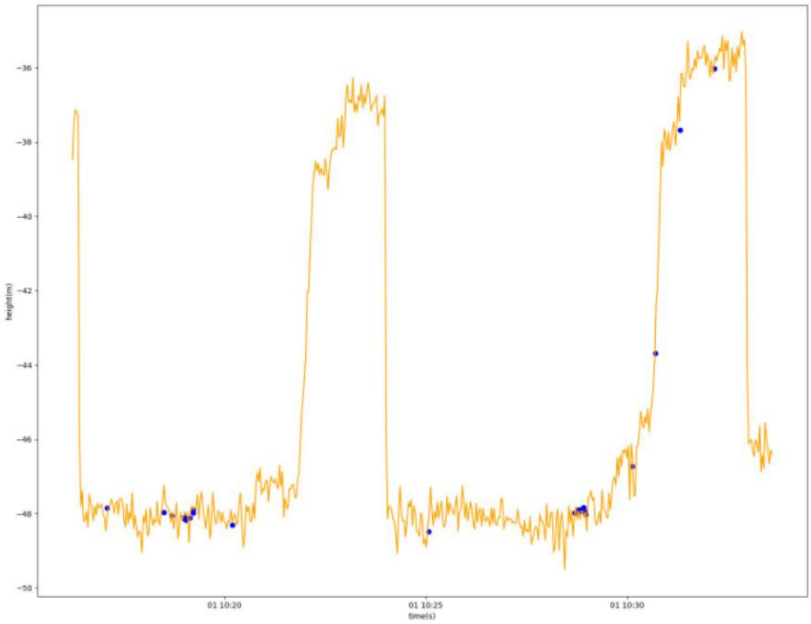


Figure 6.8.2 **Rover altitude change and landing determination**

Based on the above data, the timing of landing judgment is as shown in Table 6.8.2.

Table 6.8.2 Timing and number of landing judgments

number of times	**Falling**	2 minutes after landing	5 minutes after landing
1	0	1	8
2	0	1	12
3	0	**Not measurable***	**unmeasurable**

***Measurement stopped after the third fall, so it was impossible to measure the number of landing judgments.**

As shown in Table 6.8.1, it was confirmed that landing judgment is not made during a fall, but about 10 landing judgments are made within 5 minutes after landing.Therefore, the current landing judgment algorithm is consistent. The validity has been demonstrated.

Addendum (9/2)

After applying a landing impact due to a fall, a test was conducted to confirm that there were no structural or hardware failures by determining the landing and causing the motor to rotate and move forward.

Test details: In
this test, the aircraft was dropped from a height of about 11 meters, and after determining the landing, it was controlled to start running, and it was demonstrated that it could run without any
problems. The experimental procedure is shown below.

1. **Drop the aircraft from a bridge approximately 11m high with the parachute open. At the same time, run a program to determine landing and run.** 2. **After falling, manually open the**
envelope. 3. **Check the aircraft for damage and check if the motor is**
working properly.

Additionally, at a height of about 11 m, the parachute may not be able to sufficiently decelerate, and the impact may be weakened by grass growing on the ground from which it falls. Therefore, we conducted a drop impact test on Hamura Ohashi Bridge, which is approximately 30 meters high and has a rocky ground , to be closer to the actual test . Confirm that the structure can withstand the impact of a fall and that the vehicle can be driven without problems. The experimental procedure is
shown below.

1. **Drop the aircraft from a bridge approximately 30m high with the parachute open.** 2. **After falling, manually**
open the envelope. 3. **Check the aircraft for damage and check if the**
motor is working properly.

Results:
The program used this time is controlled to start running after determining the landing. After a total of three drops, two from a height of 11 m and one from 30 m, it was possible to see the vehicle start running, indicating that there was no damage to the structure or hardware due to the landing impact . It was done. (Table 6.8.3)

Table 6.8.3

number of times	structure	motor operation	movie
11m drop (1) (9/1 **Shin-Arakawa Bridge)**	**No damage**	**normal**	https://youtu.be/4AEqSY_p-uDs
11m drop (2) (9/1 **Shin-Arakawa Bridge)**	**No damage**	**normal**	https://youtu.be/IEyxYt7-tQ8
30m drop (1) (8/31 **Hamura Bridge)**	**No damage**	**normal**	https://youtu.be/tCLAqa7_E9VQ

v9.GPS data downlink test

As a
countermeasure against loss **of purpose ,** after the rover is dropped, the location data will be sent to the ground station using LoRa communication. **Test whether GPS data can be sent to the ground station without being lost as text data .**

contents of the test

Check whether the time, longitude, latitude, and altitude values obtained from GPS can be sent and received as text data.

1. Elemental test

We will perform the GPS data downlink test by dividing it into two elements.

1) Obtaining GPS values via I2C communication using Raspberry Pi
Pico 2) Sending and receiving text using Raspberry Pi Pico and LoRa communication module

1) **Use raspberrypi pico between raspberrypi zero and communication module . The communication module acquires the GPS sensor value via raspberrypi pico and communicates with the ground station, so the step in such a system is `` Send** the GPS sensor value received by raspberrypi zero to raspberrypi pico using I2C communication." We **will demonstrate that communication via Raspberry Pi Pico is actually possible.**

2) Connect the Raspberry Pi Pico and the communication module, and conduct a test to send arbitrary text to the ground station in order to confirm that the GPS information obtained by the Raspberry Pi Pico can be communicated to the ground station.

2. integrated exam

The two phases of element-specific testing are linked to confirm a series of operations from GPS acquisition to ground station reception.

Test results

1. Elemental test

1) We successfully connected Raspberry Pi Pico and Raspberry Pi 0, sent the GPS data received by Raspberry Pi zero to Raspberry Pi Pico via I2C communication , and displayed it on the serial monitor.

2) Connection and wireless communication between the Raspberry Pi Pico and the communication module have already been successful in V11 (long distance communication test) .

2.Integrated exam

We actually obtained GPS values with OBC and demonstrated wireless communication with a ground station using the Raspberry Pi Pico based on that information .

Exam details: https://youtu.be/NVggaSY2N80

Through the above tests, we succeeded in transmitting data to the ground station using GPS data values.

V9.GPS data downlink test (retest)

As a
countermeasure against loss **of purpose ,** after the rover is dropped, the location data will be sent to the ground station using LoRa communication. **Test whether GPS data can be sent to the ground station without being lost as text data .**

Test Content

Check whether latitude and longitude values obtained from GPS can be sent and received as text data. Create a transmitting unit (Figure 6.9.1) and a receiving unit (Figure 6.9.2) for testing, obtain GPS values from the transmitting unit, **transmit ,** and check whether data is being received from the receiving side. ÿÿ

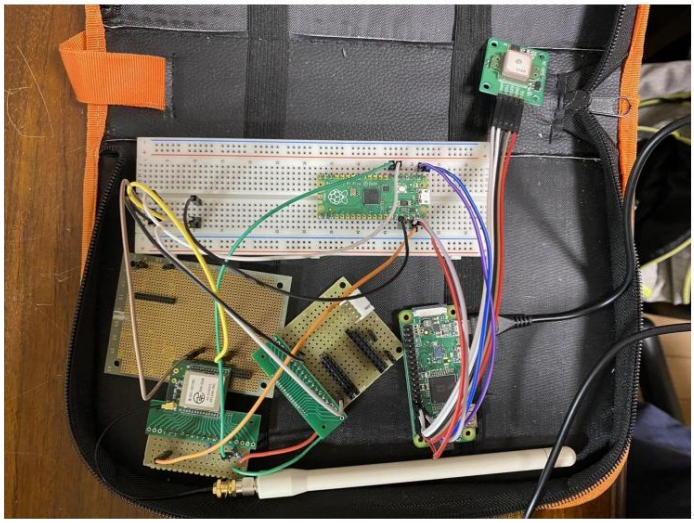


Figure 6.9.1 **Transmission unit (GPS, Raspberry Pi 0, Raspberry Pi Pico, communication module)**

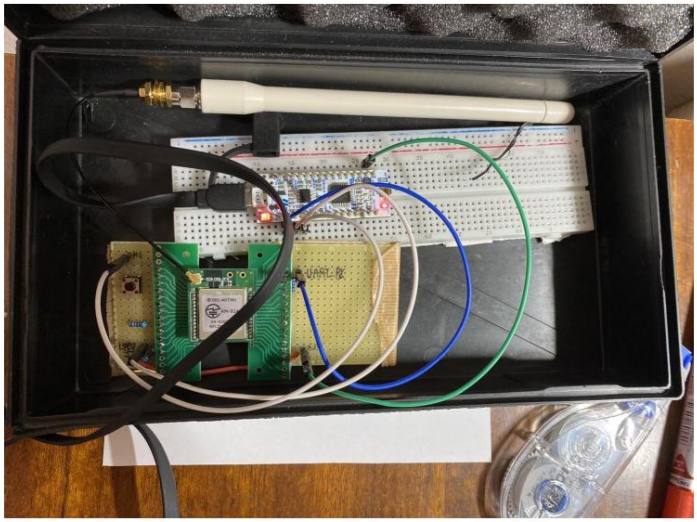


Figure 6.9.2 **Receiving unit (mbed, communication module)**

Test results

Place the transmitting unit outdoors with the power turned on and the GPS acquiring location information, and connect the indoor receiving unit. I confirmed that I was able to receive data from the connected PC.

sending unit	**receiving unit**
https://youtu.be/Z2yP_xLyCWE	https://youtu.be/dy0a6QnjI8Q

v10. Communication start test

Purpose Our rover is equipped with communication functions to prevent loss and carry out missions. However, communication cannot be performed while it is stored in the carrier, and communication with the ground station must begin as soon as it begins to fall. In this experiment, we will confirm whether the communication initiation system using the flight pin as a trigger

Test details :

We will create a circuit on a breadboard using the LoRa communication module and flight pin that will be used in this rover, and check whether communication will start when the flight pin is removed. Our team's rover is released from the carrier and the flight pin is removed when the parachute opens. This turns on the circuit **and supplies power to Raspberry Pi Zero, various sensors, and communication modules. Therefore, in this test, by removing the flight pin, we will confirm that power is supplied to the communication module and communication begins through the Raspberry Pi PICO . To confirm, connect the receiving module to the PC serving as the ground station and monitor with Teraterm to confirm that communication has started.**

Test results We

were able to confirm that power was supplied to the rover's raspberrypi zero, sensor, raspberrypi pico, and communication module **by removing the flight pin . It was confirmed on the PC serving as the ground station that communication started approximately 14 seconds after power was supplied to the communication module .**

Communication start test: https://youtu.be/FCyhDffzZLc

:

v11. Long distance communication test

We

believe that after the rover is dropped, the rover and the ground station near the headquarters will be separated by a maximum of several kilometers . Therefore, we need to make sure that the wireless communication module we use is capable of communicating over several kilometers. Therefore, the purpose of this study is to verify how far communication is possible between two points using the communication module that will actually be used.

Test details

Confirm whether communication is possible at points on the Arakawa riverbed with distances of 1300m, 1700m, and 2000m. In this test, for simplicity, we determined whether wireless communication was possible by sending and receiving dummy data. We also confirmed whether it was possible to change the radio channel in parallel with the experiment.

Test results

<Communication module used in this test> In this

test, Green House Co., Ltd.'s RM-92A series is used as the communication module at the ground station and rover .

1) Channel change The

images before (Figure 11.3.1) and after (Figure 11.3.2) the channel change are shown. The results of the communication test are also **shown** in the table below .

Figure 6.11.1 Before changing channel

Figure 6.11.2 After changing channelÿÿÿÿÿÿ

2) Long distance communication test

Figure 6.11.3 1300m point between two points

Figure 6.11.4 1700m point between two points

Figure 6.11.5 2000m point between two points

The above diagram shows the positional relationship of the sender and receiver in communication tests when the distance between two points is 1300m, 1700m, and 2000m. Shown in 6.11.3~5.

Table 6.11.1 shows the test results for each communication distance.

Table 6.11.1 **Communication results**

Communication distance (m)	Possibility of communication
1300	**Possible**
1700	**Possible**
2000	**Possible**

Therefore, this test demonstrated that communication over a distance of at least 2 km is possible.

In addition, this communication module has been applied to stratospheric balloons at other organizations to which our members belong.

Last year, we successfully conducted a horizontal communication test of approximately 8 km between the Itoshima Peninsula and Shika Island in Fukuoka Prefecture. In addition to that

In the vertical direction, we succeeded in communicating from the ground to approximately 30 km, which is the highest point the balloon could reach.

v11. Long distance communication test (retest)

the purpose

After the rover is dropped, we believe that the rover and the ground station near the headquarters will be separated by a maximum of several kilometers. Therefore, we
It is necessary to confirm that the wireless communication module used is capable of communicating over several kilometers. Therefore, actually
The purpose is to verify whether communication is possible at intervals of approximately 5 km using the communication module used.

contents of the test

We will check whether communication is possible at a point on the Arakawa riverbed where the distance between two points is approximately 5.3 km. In this exam
For simplicity, we determined whether wireless communication is possible by sending and receiving dummy data. Also,
In parallel with the experiment, we also confirmed whether it was possible to change the radio channel.

Test results

<Communication module used in this test>

In this test, Green House Co., Ltd.'s RM-92A series was used as the communication module at the ground station and rover.
do.

1)Change channel

We used mbed to change the initial settings of the communication module and conducted a test to change the channel.

Video: https://youtu.be/mMWeGzN5krc

Also, by changing the communication channel and communicating, you can check whether the channel has actually been changed.
did.

	Sending side channel	Receiving side channel	Communication availability	movie
First time	twenty four	twenty four	ÿ	https://youtu.be/zvmHbDYyttU
Second time	twenty four	61	ÿ	https://youtu.be/11AEvkhDUy8

1) Long distance communication test

This time, in Yuriage, Natori City, Miyagi Prefecture, **we conducted a total of three communication tests between the communication modules while maintaining the distance between the two points.**

1st: August 28, 2022 **14:43-14:46**

Figures 6.11.6 and 6.11.7 are screenshots of Map, which comes standard on iPhones, on the sending and receiving sides, respectively. **The time is listed in** the upper left corner , and you can see that the two points were separated at almost the same time.

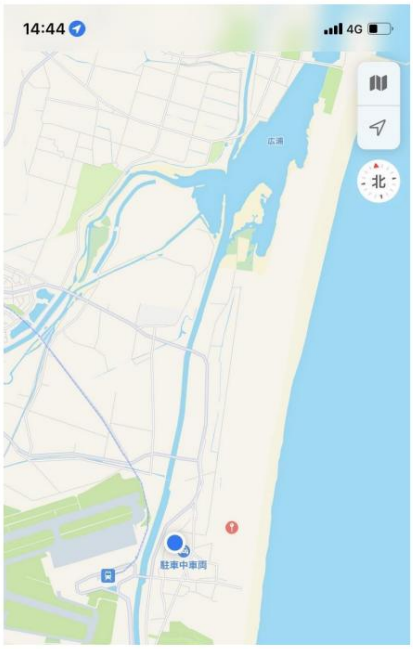


Figure 6.11.6 **Sending side position Figure** 6.11.7 **Receiving side position**

Figure 6.11.8 shows the results of measuring the distance between these two points using GoogleMap. This revealed that there is a sense of 5.25 km between the two points.

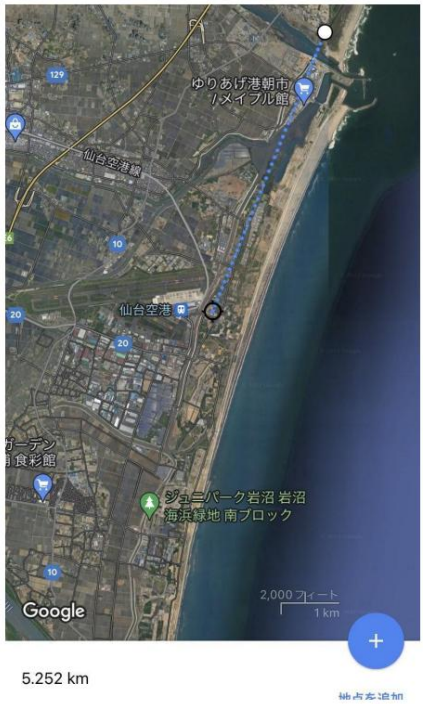


Figure 6.11.8 Results of distance between two points

2nd time: August 28, 2022 **14:53-14:56**

Figures 6.11.9 and 6.11.10 are screenshots of Map, which is standard on iPhones, on the sending and receiving sides, respectively. **The time is listed in** the upper left corner , and you can see that the two points were separated at almost the same time.

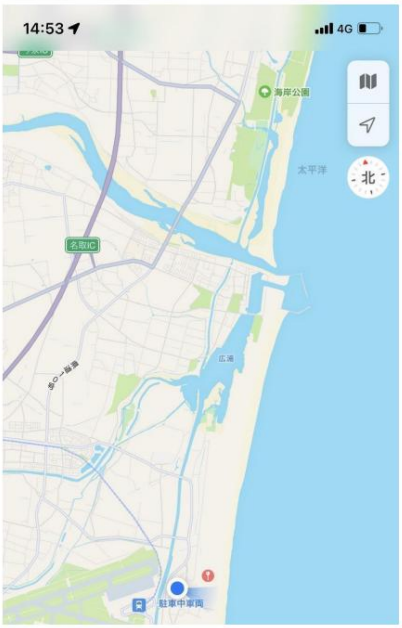


Figure 6.11.9 **Sending side position Figure 6.11.10 Receiving side position**

Therefore, the distance between the two points is 5.25km, the same as the first test.

3rd time: August 28, 2022 **14:57-14:59**

Figures 6.11.11 and 6.11.12 are screenshots of Map, which is standard on iPhones, on the sending and receiving sides, respectively. **The time is listed in the upper left corner , and you can see that the two points were separated at almost the same time.**

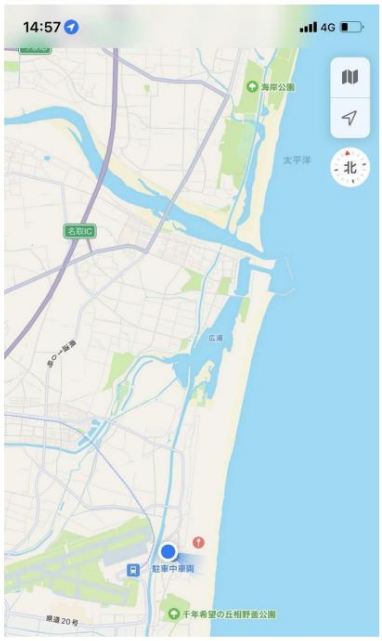


Figure 6.11.11 **Sending side position Figure 6.11.12 Receiving side position**

Therefore, the distance between the two points is 5.25km, the same as the first and second tests.

The results and videos of the first to third tests are summarized below.

	Sender video	**Receiver video**	**Distance between two points**	**Possibility of communication**
First time	https://youtu.be/P0lUM03EQpI	https://youtu.be/I9d3Q4aW5r4	5.25km	ÿ
Second time	https://youtu.be/1M30fl21fuU	https://youtu.be/B6-s7Nfj7RU	5.25km	ÿ
Third time	https://youtube.com/shorts/Y2jwTHWY9QY?feature=share	https://youtu.be/VeCZbDGIbQo	5.25km	ÿ

As a result, we proved that the currently used communication module can communicate up to 5.25km.

v12. End-to-End exam

Purpose:

Tests other than this test have been subdivided into individual systems, and it has not been demonstrated whether all functions will work as expected as a result of integrating these tests. Therefore, the purpose of this test was to integrate the experiments of each system that have already been confirmed, and to demonstrate whether the series of movements from falling to the goal can be performed normally. P.S.: Since this test is a test to achieve the 0m goal of minimum success, the mission, such as image acquisition, will not be performed, and only autonomous control will be performed.

Test details [End

to End (1)] **(Drop ÿ Landing judgment ÿ Nichrome wire conduction) A rover with a parachute tied to it is dropped from a bridge, and when it detects that there is no change in altitude using temperature and pressure sensors, the nichrome The wire is made conductive and the nylon wire that fixes the envelope is fused.The test location is Shin-Arakawa Ohashi Bridge. Since we were unable to secure a sufficient altitude for the drop and an open terrain modeled on the Black Rock Desert, we conducted the drop-landing phase as phase (1). The drop height was 11 meters, so the parachute was deployed and the envelope was deployed.**

[End to End(2)] (Landing judgment ÿ (Nichrome wire conduction) ÿ GPS driving ÿ Image processing guidance) **We prepared the FM that will actually be used in the competition, and when we placed it on the ground from a handheld state, there was no change in altitude. We will detect whether it is possible to reach** the 0m **goal using autonomous control (GPS guidance) ÿ autonomous control (image guidance) by applying current to the nichrome wire (resistance and LED that looks like it). The starting point and ending point were set up as shown in Figure 6.12.1, and the distance was about 15 m apart.**

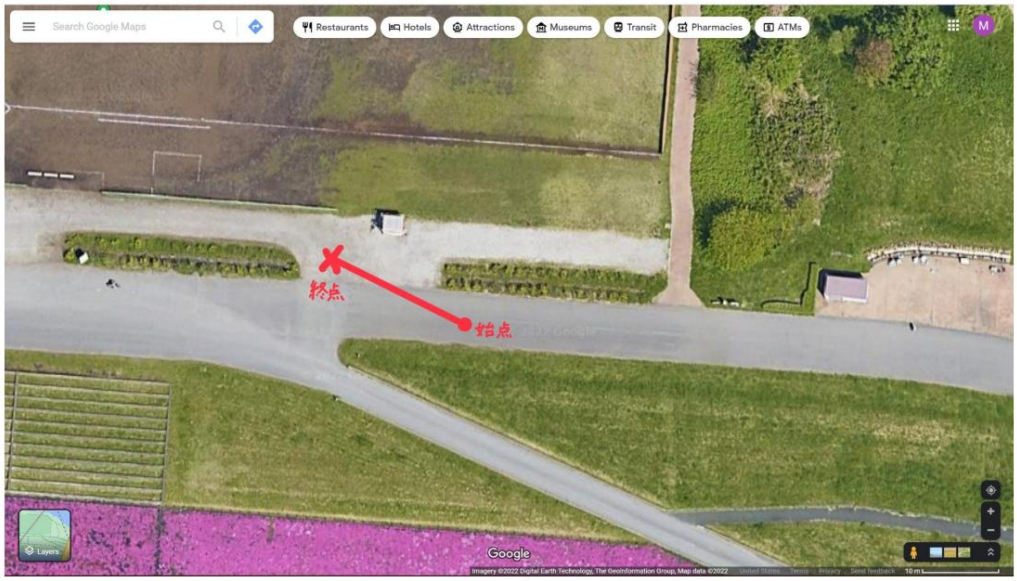


Figure 6.12.1 **Location of start and end points**

Figure 6.12.2 **Road surface condition**

The test location was the Shin-Arakawa Ohashi riverbed. The road surface is a gravel road as shown in Figure 6.12.2, making it a relatively competitive venue. We believe that the road surface conditions are similar to those in .

Test results

[End to End(1)] **(DropÿLanding judgmentÿNichrome wire conduction)**

Succeeded from falling to fall detection and envelope expansion. The video URL is shown below.

Exam (1): https://www.youtube.com/watch?v=_mY_FKB_tWk

[End to End(2)] (Landing judgment ÿ (Nichrome wire conduction) ÿ GPS driving ÿ Image processing driving)

Table 6.12.1 Test (2) results

First time	**Successfully approached the red cone (reacted to other cones around it and reached the 0m goal)**
Second time	**Successfully approached the red cone (reacted to other cones around it and reached the 0m goal)**
Removed the red cones that were around.	
Third time	**Image processing failed due to lighting conditions**
Moved the GPS target location closer to the light source.	
4th	**Successful approach to red cone**
5th time	**Successful approach to red cone**
Video (5th time) : https://www.youtube.com/watch?v=C0t2aFOfQ4Y	

12.4.Remarks **1.**

In the second image processing guidance, a phenomenon occurred that caused a reaction to the surrounding triangular cones . This is thought to be due to the fact that the experiment was in the evening and the sunlight was shining diagonally, so the surrounding triangular cones were captured more clearly by the camera than the target triangular cone. In fact, on the first and second runs, we drove towards a cone on the east side of the original target point . Therefore, from the 4th time onwards, I set the goal point 5m on the sun side (west side) of the triangular cone , and I was able to reach the goal stably. The third time, the cone was set at about 2m toward the sun from the goal point, but the cone could not move enough to receive sunlight, and detection failed.

P.S.: Because the unfolded part of the envelope came into contact with the ground, I supported it with my hand and photographed the unfolding process. Currently, as a countermeasure, a weight is placed on the envelope itself so that the unfolding part is at the top, making the envelope unfolding more likely to succeed. We have also confirmed that it can be expanded even if the expansion part is facing downwards.

Envelope expansion video: https://youtu.be/Qqghdg7fZ2U

v13. 3D model generation test

PurposeIn the actual mission, we will use images taken from the rover to generate a 3D model of the terrain using VisualSLAM on a PC at the ground station. In this test, we will confirm that it is actually possible to generate a 3D model from two or more images.

contents of the test

It automatically processes the images sent to the PC and runs a program that generates and displays a 3D model. After that, we will confirm **that it is possible to automatically generate a 3D model at the ground station using images taken during the v12 image capture test .**

Test Results

Images taken with an iPhone were compressed to 18kB (left) and 19kB (right) (Figure 6.13.1), and the images were processed inside the PC (Figures 6.13.2, 6.13.3, 6.13.4, 6.13) . **5, 6.13.6), executed the program that generates and displays the 3D model (Figure 6.13.7)**

Figure 6.13.1 Two compressed images

Figure 6.13.2 **Correcting lens distortion for two images**

Figure 6.13.3 **Combining two images**

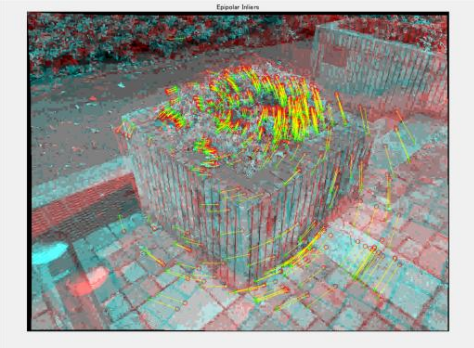


Figure 6.13.4 **Merit point combination 1**

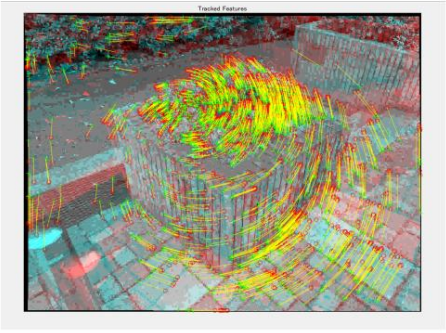


Figure 6.13.5 **Combining feature points 2**

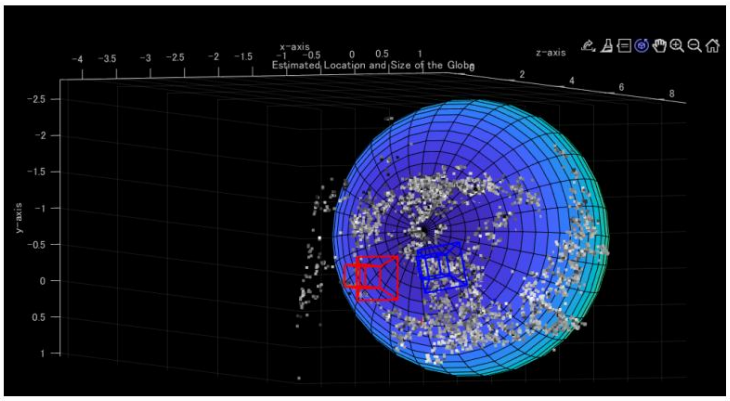


Figure 6.13.6 **Reconstruction of 3D position of feature points**

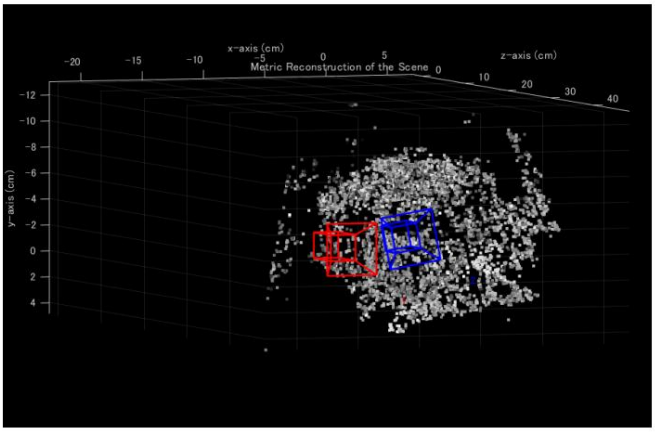


Figure 6.13.6 Generated 3D model

v14. 0m goal test using camera

When

moving to the target image processing driving phase, **we will demonstrate that the 0m goal can be achieved and that the goal can be determined and the motion can be stopped.**

contents of the test

Since GPS guidance allows guidance within a radius of approximately 2m from the goal point, the red component is determined from a position 2m from the goal cone to confirm that it is possible to approach.

The experiment was performed three times to confirm reproducibility.

Implementation results

Figure 6.14.1 **Recognizing the red cone and determining a goal**

Table 6.14.1 Image processing driving test results

First time	**0m goal success**	https://youtu.be/uD_2qJMGto0
Second time	**0m goal success**	https://youtu.be/QtawkN9dEoc
Third time	**0m goal success**	https://www.youtube.com/watch?v=jfm26a9AT_w&feature=youtu.b

Discussion We found that guidance using image processing was possible with sufficient accuracy when starting from a location 2 meters away. On the other hand, in order to ensure guidance accuracy, it was necessary to adjust the threshold according to the environment before starting the experiment, so it is desirable to make sufficient preparations before the competition.

(Additional note) This test **is a camera hardware test and threshold setting test to see if the goal cone can be recognized within 2 m, based on the fact that it has been confirmed that the goal cone can be approached within 2 m using GPS guidance. ÿÿ (This is clear from the fact that the "Purpose" section also states, "Determine the red component from a position 2m from the goal cone and confirm that it is possible to approach.") Regarding guidance control, etc., v12.End-to-** End The test has been confirmed.

v15. Control history report creation test

Purpose : Confirm that GPS and 9-axis sensor values are being recorded while the rover is moving.

Experiment details While running the GPS running program during the end-to-end run of the rover, we checked whether the program that records the GPS and 9-axis sensor values in a csv file is running.

Test results

Table 6.15.1 Some of the saved logs

	A	B	C	D	E
1	16:31.7	35.7886	139.7217	-0.9755	0.219994
2	16:32.3	35.7886	139.7217	-0.90365	0.42827
3	16:32.8	35.7886	139.7217	-0.94868	0.316228
4	16:33.4	35.7886	139.7217	-0.96385	0.266431
5	16:33.9	35.7886	139.7217	-0.82931	0.558787
6	16:34.6	35.7886	139.7217	-1	-1.84E-16
7	16:35.2	35.7886	139.7217	-0.99989	0.014597
8	16:35.7	35.7886	139.7217	-0.99982	0.018865
9	16:36.3	35.7886	139.7217	-0.99481	0.101714
10	16:36.8	35.7886	139.7216	-0.77122	0.636565
11	16:37.4	35.7886	139.7216	-0.62682	0.77916

Part of the record is shown above. From the left: (1) time, (2) latitude, (3) longitude, (4) x component and (5) y component of the unit vector of the aircraft's orientation. The entire data is shown in the link below. https://docs.google.com/spreadsheets/d/1vihCeRPJvIw5cEz1W8FSAzKz9BHGk cOf1Me7lH4ZPDM/edit#gid=1359184147

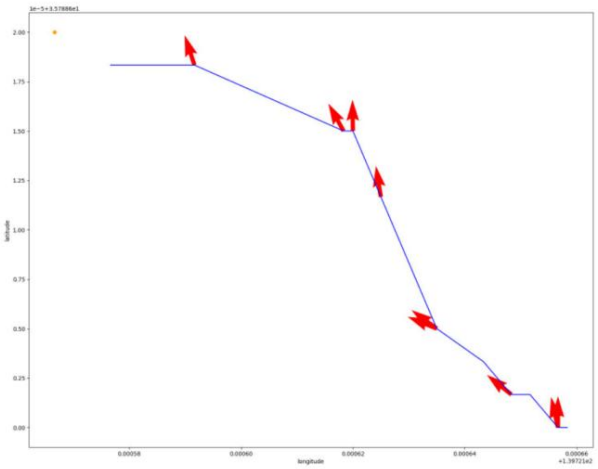


Figure 6.15.1 Rover azimuth and trajectory

From the data in the obtained CSV file, we drew the trajectory and vector from the start point to the end point of GPS guidance.By submitting the above GPS logs, you can prove that the mission is being carried out autonomously at the end of the mission. can be done.

v16. GPS driving test

Purpose: This is done to confirm whether the rover can use GPS and geomagnetic sensors to head toward the goal and come within 1.5 meters of the goal .

Experiment
details Start running from the drop point, find the angle with the goal from the GPS and geomagnetic sensor values, and drive until the rover is within 1.5m of the goal while making adjustments so that it is within ±15 degrees of the angle with the goal. Then, **conduct a test in which the motor stops when entering within 1.5m of the goal .**

Test results

I was able to confirm my goal to the goal cone using only GPS. The experiment is shown in the video URL below.

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

v17. Stack test

Objective During the competition, it is predicted that the rover will get stuck due to the presence of ruts on the unpaved desert. In such cases, it is necessary to get the rover out of the stuck state. The purpose of this test was to verify the running performance of the motor and the effectiveness of the escape method actually used.

Experiment

details [Physical
performance test] In order to confirm the physical running performance of the rover, we will understand its performance in stepping over steps and climbing hills. Perform each test using the following procedure.

- Use a **stack test**
  shovel to dig a hole, bury one or both wheels of the aircraft, and run a pattern trial program to see if you can escape.
- **Level crossing test**
  Tests of climbing over steps are performed using bricks, rocks, and natural terrain. During the test, we confirmed that it could climb over a 60mm step. • Slope

climbing test The slope is
measured on an outdoor slope to determine whether it is possible to climb the slope.

[Pattern trials]
When our rover becomes stuck, we judge it based on the smallness of the change in GPS and perform several pattern runs to escape from the stuck state. Below is a draft of the pattern.

1. **Rotate both wheels backwards for 5**
seconds. 2. **Rotate the right wheel backwards for 5 seconds, then both wheels backwards**
for 5 seconds. 3. **Rotate the left wheel backwards for 5 seconds, then rotate both wheels**
backwards for 5 seconds. 4. **Turn the right and left wheels backwards for 5 seconds each, then turn both**
wheels backwards for 5 seconds.5.
Turn both wheels forward for 5 seconds.6 . **Turn** the **left wheel forward for 5**
seconds, then turn both wheels forward for 5 seconds7 . .Turn the right wheel
forward for 5 seconds, then both wheels forward for 5 seconds.8.Turn the right **wheel and left wheel forward for 5 seconds each, then turn both wheels forward for 5 seconds.**

These patterns are run while stuck in a rut, and valid patterns are verified. After narrowing down the effective patterns, we will implement it so that if the patterns become stuck during actual running, the pattern can be run randomly.

V17. Stack test (additional)

Exam 1

We created a track to see if the rover could pass through.

Explanation video: https://youtu.be/kbsvqL5d9mY

Measurement video: https://youtu.be/w692xsMIAns

Exam 2

I buried one wheel in a hole to see if I could escape.

Explanation video: https://youtu.be/5RcJpJ5PR2E

Exam 3

Check whether the aircraft can be recovered from an inverted state.

Test results

The results of the stack test, hill-climb test, and step test are shown in the respective tables and figures. The reason why patterns 7 and later were not performed in the first one-wheel test was because the rover restarted during the stack test, so patterns 1 to 8 were performed in the second time. **P.S.: The two figures below show what it looks like when both wheels of the aircraft are buried in the hole, and the depth of the hole at this time is about half the depth of the tire, so the radius of the tire is 63 mm. It is estimated to be 63mm .**

Figure 6.18.1 **Both wheels buried 1**

Figure 6.18.2 **State when both wheels are buried 2**

Table 6.18.1 **Stack test results**

100	single wheel				both wheels	
	First time	**movie**	**2nd time**	**movie**	**First time**	**movie**
pattern 1 x		https://youtu.be/74JnrK_P1-E	×	https://youtu.be/veR8Vvk16ig	×	https://youtu.be/eimUYqssP8E
2×		https://youtu.be/9nNTa9cS0n8	×	https://youtu.be/W903v24Lo00	×	https://youtu.be/DAKapDpnpm8
3×		https://youtu.be/GVYMyQXqBSY	×	https://youtu.be/eVoMn_A0OHI	×	https://youtu.be/814GXLQ-Bt0
Four	×	https://youtu.be/01cPFz17pDg	ÿ	https://youtu.be/4RHE7OUUFm4	-	-
5	ÿ https://youtu.be/bQ1bbyMgE0g		ÿ	https://youtu.be/UF-ujqE4s50	×	https://youtu.be/TZmyic52IuY
6	ÿ https://youtu.be/YlwcL7qZwaw		ÿ	https://youtu.be/hoBQbmLt7r8	×	**https://youtu.be/HEHAu6xQkWw**

7	-	-	ÿ https://youtu.be/Xym3HrjeWjg	×	https://youtu.be/1d0_dmObkeY	
8	-	-	ÿ https://youtu.be/7Q2FI6b6cVg	×	https://youtu.be/dYNB1XF6hNI	

I was able to escape ÿÿ

I can't escape ÿÿ

Table 6.18.2 **step crossing test results**

Number of times 3cm			5cm		7cm	
	went up Kado mosquito	**movie**	**Did it go up?** mosquito	**movie**	**Did it go up?** mosquito	**movie**
1	ÿ https://youtu.be/foxe1rVHITQ		ÿ	https://youtu.be/mpqAh-h4QDU	ÿ https://youtu.be/SRtvuGTkHg8	

Can run ÿÿ

Unable to runÿÿ

Only one wheel ran overÿÿ

Table 6.18.3 **Climbing test results**

number of times	2°~7° (9°)		10°~18° (16°)		20°~30° (32°)	
	get over it Takado mosquito	**Video overcoming**	**Etaka please ~**	**movie**	**get over it Etaka please ~**	**movie**
1	ÿ https://youtu.be/eTlrPXA3tR.E.		ÿ https://youtu.be/013qxrQ2P3s		×	https://youtu.be/wQrJ_XpP90I

Possible to move forward ÿÿ

Unable to move forwardÿÿ

Proceeded in a direction with a gentle slopeÿÿ

Table 6.18.4 Additional test 1 results

number of times	Did you overcome it?	movie
First time	ÿ	https://youtu.be/3MXtLaxxmjo
Second time	×(One tire came off) https://youtu.be/AC9l8x76spQ	
Third time	ÿ	https://youtu.be/d8kbhxUNWVw
1st time in reverse direction	ÿ	https://youtu.be/wbIGNVb69UI
Second time in the opposite direction	ÿ	https://youtu.be/4JWo6g_ITlE
3rd time in reverse direction	×	https://youtu.be/volr8hnwIEQ

Can run ÿÿ

Unable to runÿÿ

Table 6.18.5 Additional test 2 results

number of times	Did you escape?	movie
1	×	https://youtu.be/3Mxza5PB4uk
2	×	https://youtu.be/fdguTE76wWU

I was able to escape ÿÿ

I can't escape ÿÿ

Table 6.18.6 **Additional test 3 results**

number of times	whether he returned or not	movie
1	×	https://youtu.be/M07gZntpgbw
2	ÿ	https://youtu.be/OYcMhK8xcF0

Returned ÿÿ
Did not return ÿ ×

V18. Image acquisition and storage test

Purpose We have defined a mission to acquire, store, and analyze images as a goal that goes beyond minimum success. In this test, we will confirm whether one of the steps, the phase of acquiring and saving images, can be executed.

Test details

Using the camera installed in the onboard computer, identify the position of the cone based on the red color. Once **the location is determined** and it gets close enough, it runs a program that captures images and saves them to the SD card. **This time, since the submission was imminent, we conducted a simulated test using a camera and a red man.**

As a result of
running **the test result program, we confirmed that two images were obtained. (Figure 6.18.1)**

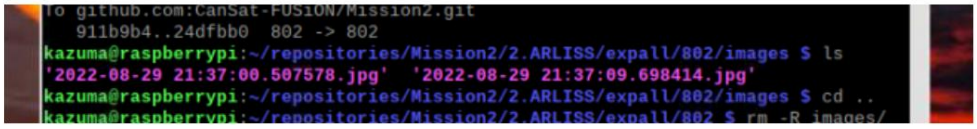


Figure 6.18.1 **Two acquired images (time is saved as file name)**

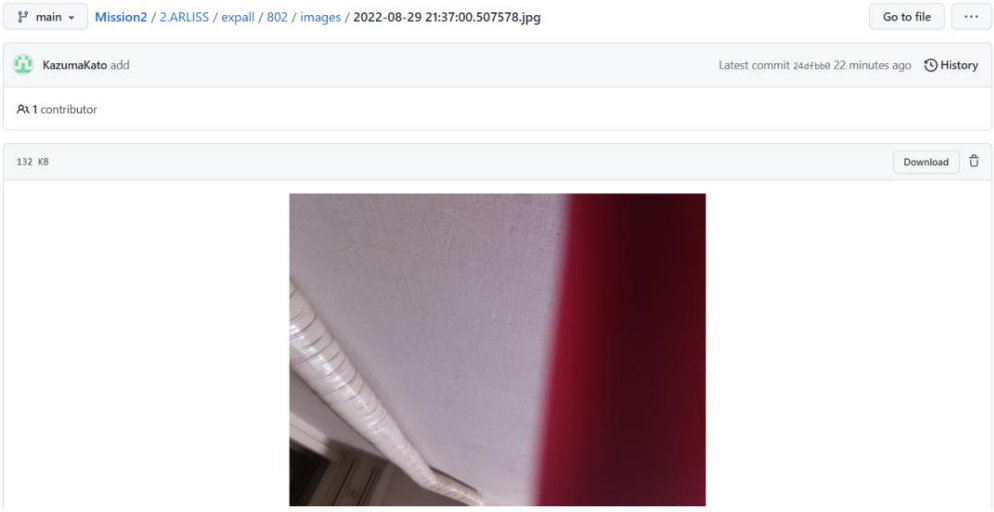


Figure 6.18.2 **Acquired image 1**

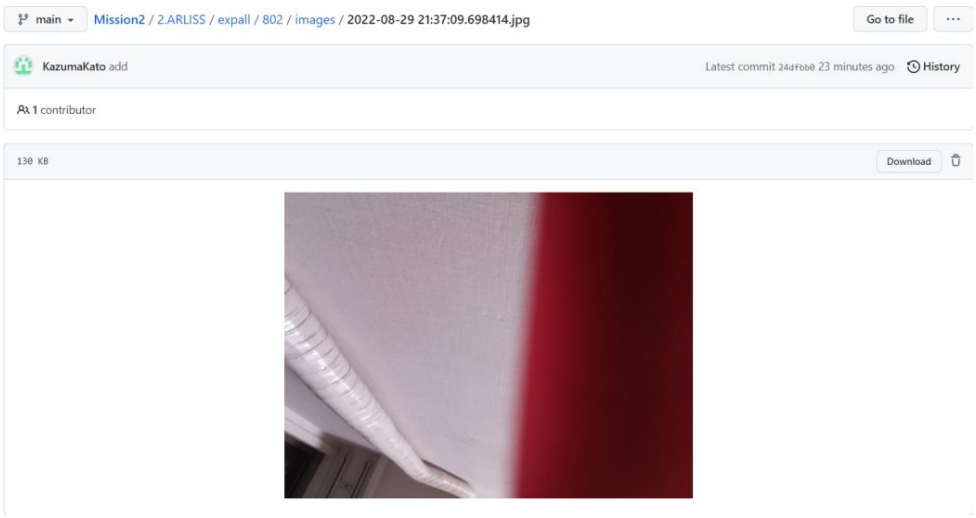


Figure 6.18.3 **Acquired image 2**

A video of the process until image acquisition is shown below.

Video: https://youtu.be/VdgT2ZOnU1o

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

I compiled the Gantt chart into a spreadsheet.

https://docs.google.com/spreadsheets/d/1UFTNGpzMs8RpDfL-R-xkkVM6Q0wubtPFjg0zKioRRiQ/edit#gid= 890752657

Chapter 8 **Summary of self-safety examination results by responsible teachers**

(This chapter must be filled out by the responsible instructor)

1.Safety standards review

要求番号	自己審査項目	自己審査結果	責任教員コメント（特筆すべき事項があれば）
	ARLISS2022安全基準		
	The mass of the aircraft dropping S1 **meets the standards**	ÿ	**There is still a lot of room left, so I am suggesting that you install a battery or something like that.**
	S2 **volume meets carrier standards**	ÿ	
	Tests have confirmed that the quasi-static loads during S3 **launch do not impair functionality to meet safety standards.**	ÿ	
	Tests have confirmed that the vibration loads during S4 **launch did not impair the functionality required to meet safety standards.**	ÿ	
	Tests have confirmed that the impact load during separation of the S5 **rocket (when the parachute is deployed) does not impair the functionality required to meet safety standards.**	ÿ	
	S6It **has a deceleration mechanism to prevent it from falling at dangerous speeds near the ground, and its performance has been confirmed through tests.**	ÿ	
	Measures are being taken to prevent S7 Lost, and their effectiveness has been tested. (Examples **of countermeasures: location information transmission, beacons, fluorescent color paint, etc.)**	ÿ	
	It has been confirmed that the regulations for turning off the power of radio devices at the time of S8 launch can be complied with **(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 turn off the power of radio equipment that is FCC certified and has a software** or hardware switch.) _	ÿ	
	There is a willingness to adjust the S9 **radio channel, and we have confirmed that adjustment can actually be made.**	ÿ	
	We have been able to conduct an end-to-end test that simulates **loading the** S10 rocket, starting the mission, and recovering it after launch, and there will be no major design changes in the future.	ÿ	**A full end-to-end exam is difficult, so a two-part exam can be used instead of the whole exam.**

			However, we judge that it has reached a sufficient level.
	If you wish to participate in the Comeback Competition, please be sure to meet the following requirements:		
	Achieves autonomous control without human intervention during M3 missions **We have confirmed that this will be carried out.**	**ÿ**	
	After the M4 **mission, it will be possible to submit the specified control history report to the management and examiners and explain the logs and acquired data.**	**ÿ**	

1.Responsible teacher's impressions

It is a multi-university team, and I am the responsible faculty member. We have been invited to the University of Tokyo and have already held several review meetings, PDR, and CDR to see the technology.
The design, manufacturing, and management are very well advanced, winning first place in the remote control category at the Tanegashima competition, and I commend them for making repeated modifications to the design to accurately reflect our comments. . I am commenting on the review report after having had the opportunity to conduct CDR again, and I can tell you that the required tests have been thoroughly carried out, and that the rover has been made with various innovations and can be expected to produce results. It is judged that the rover is of a level that has the possibility of reaching the go

Chapter 9 **Tournament Results Report**

Results <First time>

Posting date: September 13th

(Tuesday) Time schedule:

UTC		**hh:mm:ss**	**Event**
13th September	**8:22:22**	**-1:22:43**	**1st regulation review. Unable to release gas from carrier, readjust.**
	8:30:00	**-1:15:05**	**Changed the way to attach the envelope parachute string.**
	8:40:00	**-1:05:05**	**Start programming the aircraft.**

	8:44:00	-1:01:05	Passed regulation inspection.
	8:53:32	-0:51:33	Insert the rover into the rocket.
	9:15:00	-0:30:05	Start moving carrying the rocket.
	9:19:00	-0:26:05	Arrived at the launch site.
	9:39:15	-0:05:50	Tokyo Manji Union aircraft launch.
	9:45:05	0:00:00	Rocket launch.
	10:10:00	0:24:55	A vehicle search begins.
	16:00:00	6:14:55	Search ended for the day. Aircraft/envelope/parachute Both were not found.

record:

Since the program ended before launch, no records were left.

Consideration <first time>

Achievement of success criteria:

minimum success	ÿ
middle success	ÿ
full success	ÿ

phenomenon:

The program terminated before the rocket launched.

I accessed the Raspberry Pi and started the program using SSH, but the rocket
The program stopped several seconds before launch, making it impossible to run after the fall.
This was discovered when the Raspberry Pi was accessed after the aircraft was recovered.

Cause:

Program stop due to SSH connection disconnection

In addition to our team, there are other teams whose programs stopped before the rocket was launched.
Both were accessing the Raspberry Pi through SSH connection, so SSH
We considered that there may be a problem with remote control. In fact, under certain conditions
It has not been confirmed that the program stops when the SSH connection is disconnected.
Ru.
In addition, as a result of exchanging information with other teams regarding this issue, we found that
Opinions have also emerged that communication interference may have been one of the causes.
Ta. Although it has not been actually verified, some kind of communication problem occurred.
I concluded that this may be the case.

Possible solutions:

1. **In order to prevent interference with Wi-Fi communications, the number of teams that can prepare before launch will be limited.**
2. **Control the Raspberry Pi directly by using tmux in the SSH connection method.**

Result <second time>

Drop date: **Thursday,** September 15th

time schedule:

UTC		hh:mm:ss	Event
15th September	7:15:00	-0:47:14	Passed regulation inspection.
	7:30:50	-0:31:24	Insert rover into rocket.
	7:43:40	-0:18:34	Start moving carrying the rocket.
	7:48:10	-0:14:04	Arrived at the rocket launch site.
	8:02:14	0:00:00	Rocket launch.
	8:20:00	0:17:46	Vehicle search for the aircraft begins.
	8:22:30	0:20:16	Found the second stage of the rocket.
	8:24:10	0:21:56	Found the first stage of the rocket.
	8:33:00	0:30:46	Visually check that the aircraft is within the envelope. be discovered.
	8:37:27	0:35:13	Visually confirmed that the green LED lamp on the aircraft was blinking, and It was determined that the program was operating normally.
	9:42:32	1:41:18	Smoke was confirmed from the top of the aircraft, and the envelope was deployed. Confirm that you have entered the phase. But the envelope is not expanded.
	9:43:20	1:41:06	Start running within the envelope.
	9:55:00	1:52:46	I decided that the envelope would not expand and retired.

record:

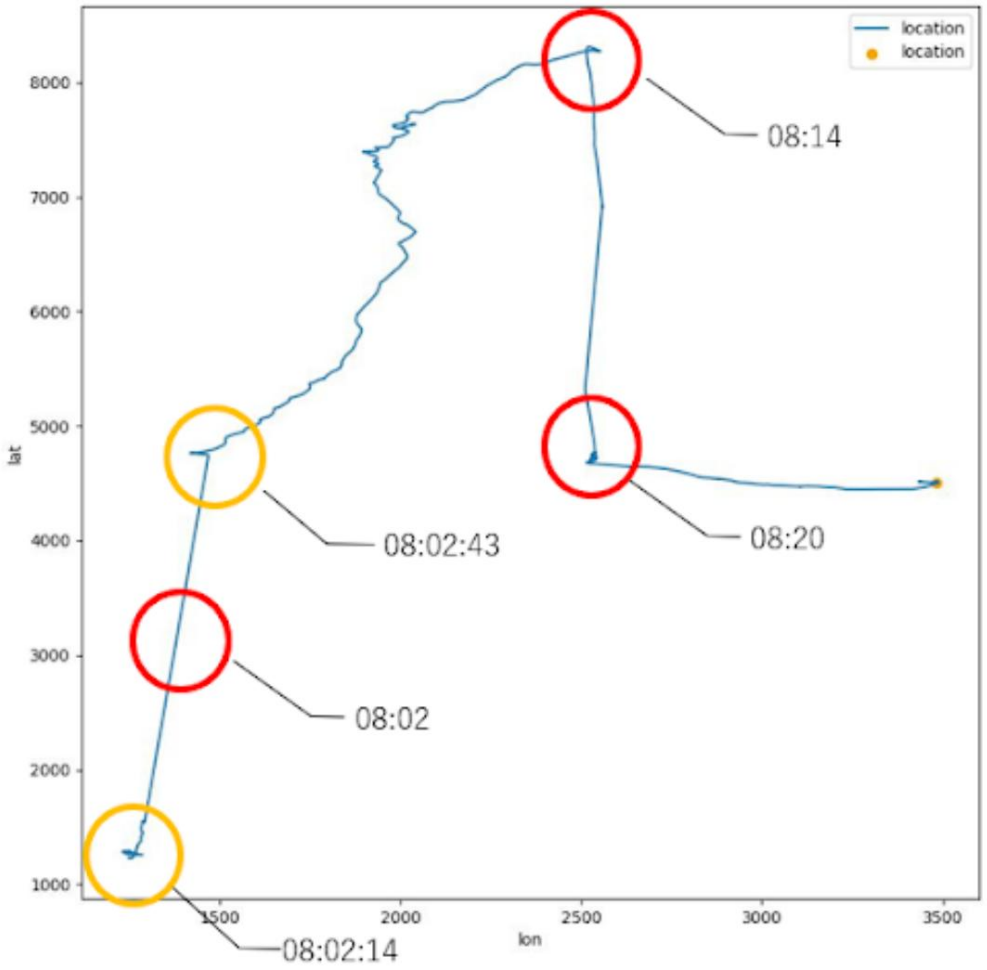


Figure 9.1.1 GPS log from launch

A rocket was launched at 8:02:14, and due to the acceleration due to gravity, GPS values were temporarily unavailable. After a few seconds of being ejected, the GPS readings returned and the object continued to fall toward the northeast. Then, at 8:14 a.m., the wind changed direction and headed south , **and we landed at 8:20 a.m. The subsequent movement history is from when the driving test was conducted after declaring retirement.**

Discussion <Second

time> Achievement level of success criteria:

minimum success	**ÿ**
middle success	**ÿ**

full success	ÿ

phenomenon:

1. The envelope did not unfold. Originally, the envelope was supposed to unfold after landing using an envelope unfolding mechanism that uses resistance. However, although the heating of the resistor expanding the envelope was visible through the smoke, sufficient heat was not transferred to the nichrome wire and it was not possible to fuse it.

Cause:

1. The resistor did not heat up completely due to the influence of the wind The likely cause was that the resistor was not heated sufficiently due to the influence of the temperature and air volume in the natural environment. In fact, after returning to Japan, we conducted a resistance combustion test and found cases where overheating was not sufficient due to the influence of the wind.

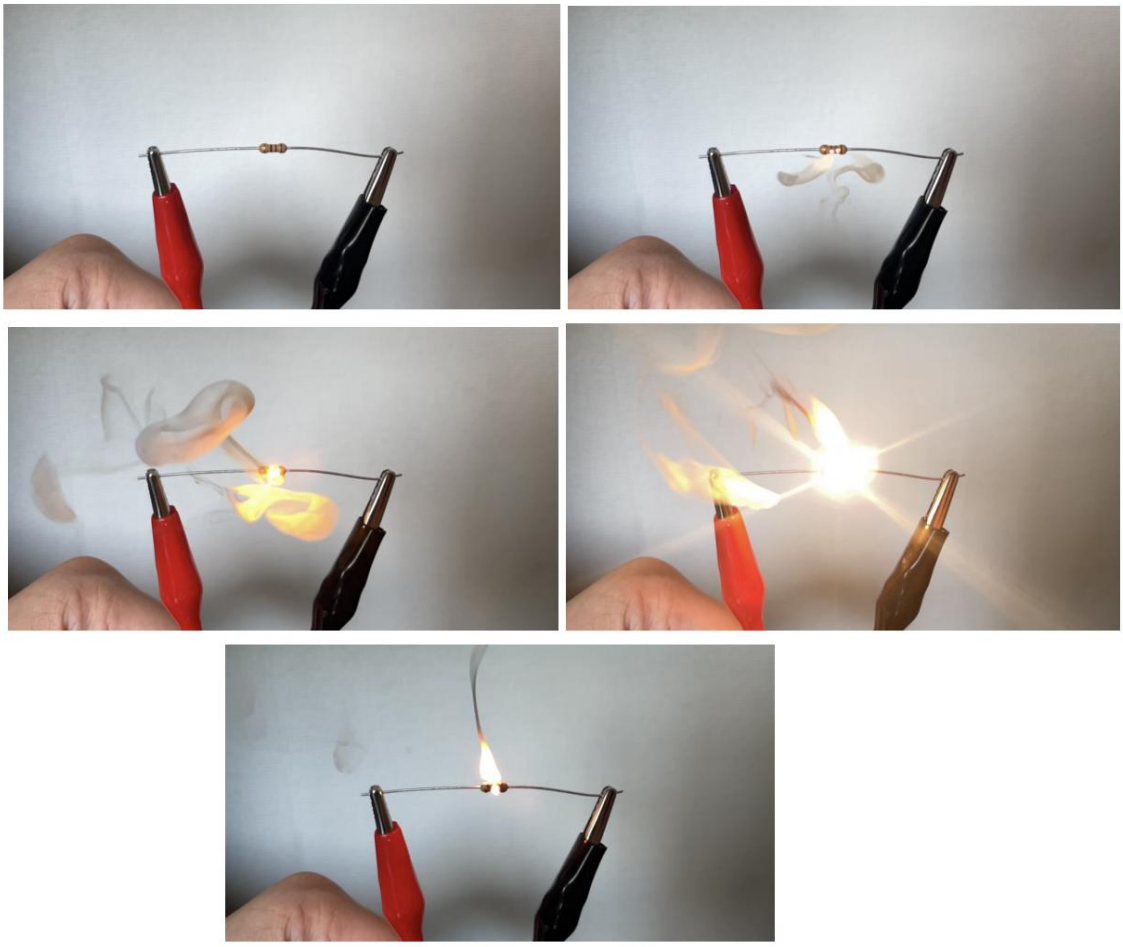


Figure 9.1.2 **How the resistance burns**

Possible solutions:

1. Increase redundancy by providing not just one but multiple contact points between the resistor and the envelope wire . 2.

By changing the mechanism to one that uses nichrome wire, which generates more heat than the resistance, it increases the possibility of melting down the nylon wire that connects the envelope.

Chapter 10 **Summary**

A. Engineering systems a.

Structural/drive

system i. **Points of innovation/**

effort Reducing the

number of parts Spacers were used to fix parts, but by printing a structure with integrated spacers, the number of parts was reduced. This led to improved maintainability and reduced spacer purchase costs.

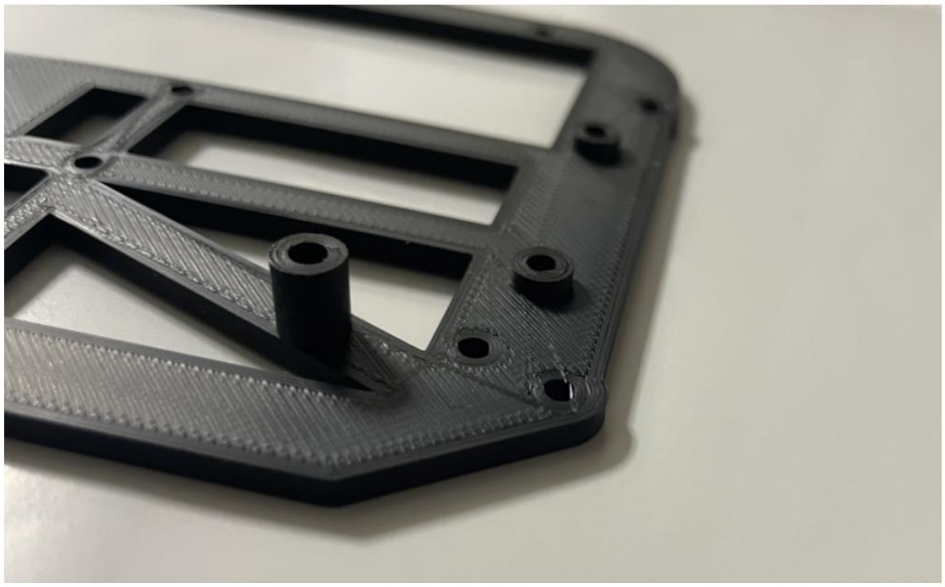


Figure 10.1.1 **Printed plate**

Motor protection

structure The motor protection structure, which uses couplings and bearings, prevented the motor from being damaged by drop impact from the experiment to the actual production. During a parachute opening experiment, the envelope opened immediately after falling , resulting in a free fall from a height of approximately 11 m. Two of the three layers of the plate **that fixed the sensor were cracked, and the bearing holder, which serves as a motor protection structure, was also cracked. Although the aircraft was severely damaged, the motor was not damage**

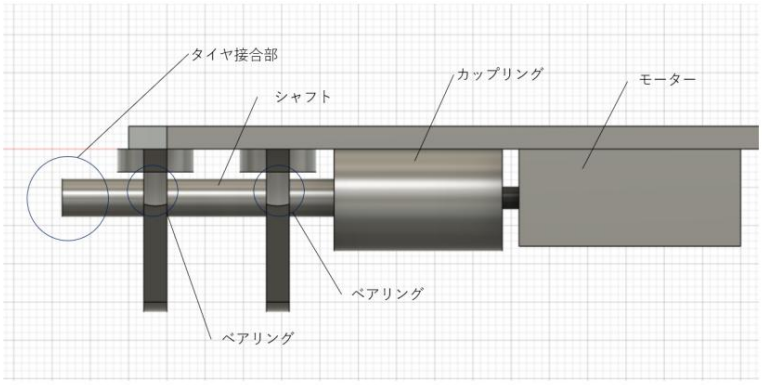


Figure 10.1.2 **Motor protection structure**

Inserting bearings into 3D printed products Through multiple drop experiments, there were cases where the bearing holder (circled in red) cracked or the bearing came off (Figure 10.1.3).The bearing holder is a 3D printed product that is a motor protection **mechanism . The printed product has a hole that perfectly fits the outer shape of the bearing, so press fit the bearing into that hole. However, the press-fitted bearings often came off due to the impact of falling. To counter this problem, we decided to insert it during the printing process instead of press-fitting it** (Figure 10.1.4) . **By changing the bearing holder from a press-fit to an insert, the bearing no longer comes off due to drop impact. As we changed from press-fitting to inserts, we made the bearing holder thicker, which prevented it**

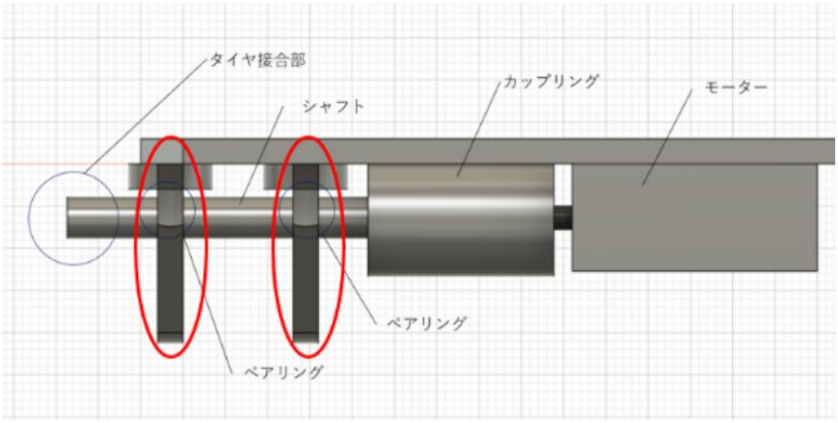


Figure 10.1.3 **Bearing holder**

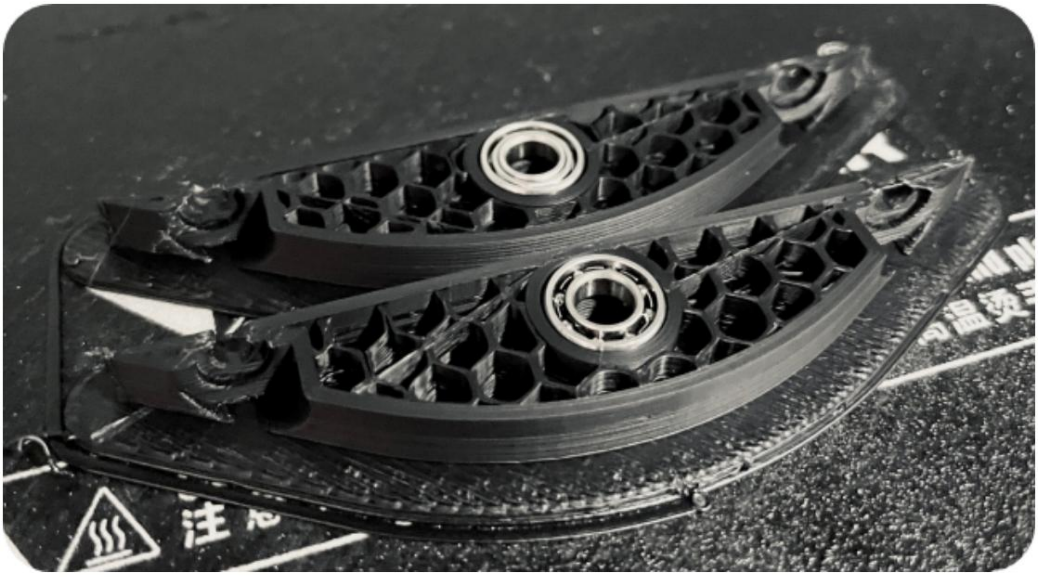


Figure 10.1.4 **Insert bearing**

Creating jigs using 3D printed

products 3D printers are an effective means for creating jigs in addition to creating prototypes and finished

products. The figure below shows the jig I made to find the appropriate width for attaching a resistor for burning out the Tegus. By creating the jig, we were able to speed up the trial-and-error cycle. (Figure 10.1.5)

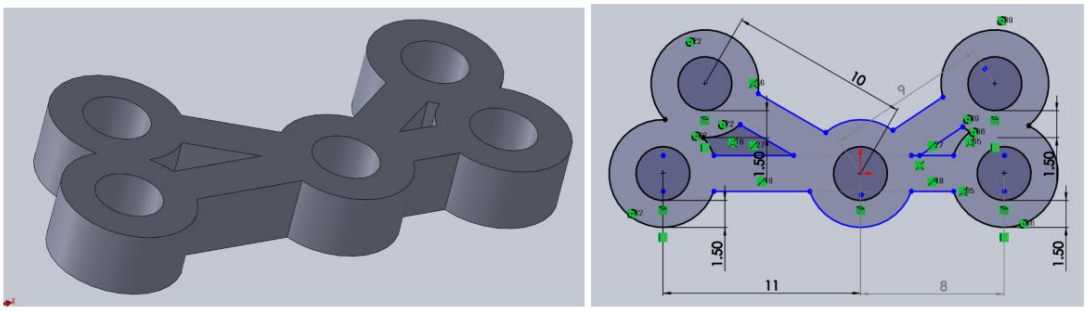


Figure 10.1.6 **Dimensioning jig**

Uses TPU printed products that are hard to damage

Parts made from TPU filament are stretchable, so there is no need to worry about them cracking in the stacking direction. It was used in a tire part where there is no problem even if it is stretchable, and where we do not want it to break. The elasticity of **TPU printed products can be controlled by setting the internal infill structure. Additionally, by making the wheels and tires removable, the efficiency of experiments to verify tire shapes and maintainability have been improved.**

Figure 10.1.7 **TPU wheels + tires**

ii. **Issues**

When we analyzed the recovered aircraft after the first ARLISS drop, we found that only one screw had come loose . There would be no problem even if the screws were not inserted, so there would be no problem even if the vehicle had been driven, but we should have been careful not to forget to tighten the screws or loosen the screws. In order to prevent the recurrence of forgetting to tighten or loosening screws, we thought that two people should use their fingers to check to see if the screws are insert

iii. **Future outlook**

Since forgetting to tighten a screw can directly lead to mission failure, we recommend creating a ``screw tightening confirmation list'' to prevent recurrence, especially when manufacturing non-repairable items. A screw tightening confirmation list is a list that clarifies how many screws of what mm and where to use ther

b. **Control**

system i. **Points of improvement/**

efforts Notes on using SSH

connection During the first launch of the competition, the distance between the PC used for control and the microcomputer became too large, resulting in the SSH connection being disconnected, and then

reconnected before launch. **An event occurred that caused the program to terminate.** The problem is that the control terminal is on the PC side, so the solution is to use tmux, which starts a **virtual terminal on the microcontroller side (server side) .**

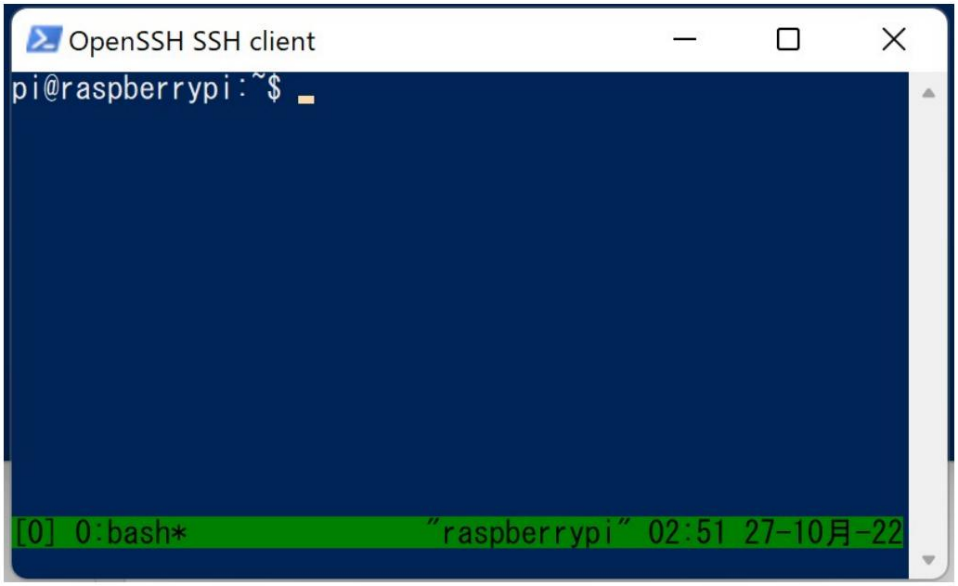


Figure 10.1.8 **Recommended terminal startup [tmux]**

Redundancy when an error

occurs Python has a try: grammar that performs processing within except: when an error occurs in the indented content . Here, by executing the entire program converted into a function in try: and setting it to return to the beginning of the program when an error occurs in except:, you can re-execute it when an unexpected error occurs. I can do it. Furthermore, if an

unexpected error occurs and the program terminates, you can rerun the system by combining the "Restart OS" and "Run program when OS starts" functions.

The ability to run a program when the OS starts up also provides redundancy against circuit current interruptions.

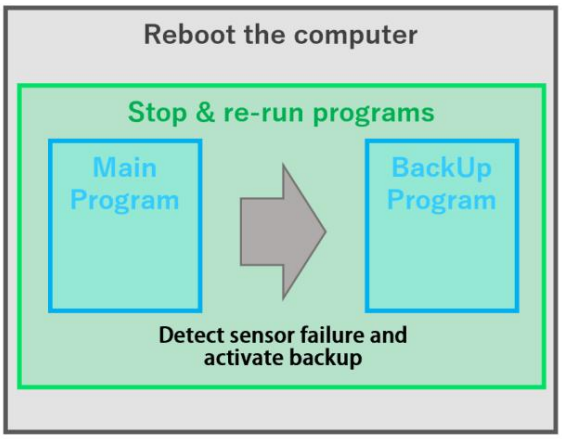


Figure 10.1.9 **System**

diagram Trigger considering series/

parallel When determining something and proceeding to the next flow, such as starting a landing determination or determining the end of GPS guidance, it is necessary to be aware of the serial/parallel nature of the determination conditions. . First, develop while being aware of whether you are currently considering "judgment"

If so, development should be conducted while considering whether series and parallel conditions are appropriate. The more series

conditions are added, the more accurate the determination becomes, but the more difficult it becomes. On the other hand, the more parallel conditions there are, the easier the decision will be, but there is a possibility that an unexpected decision will be made.

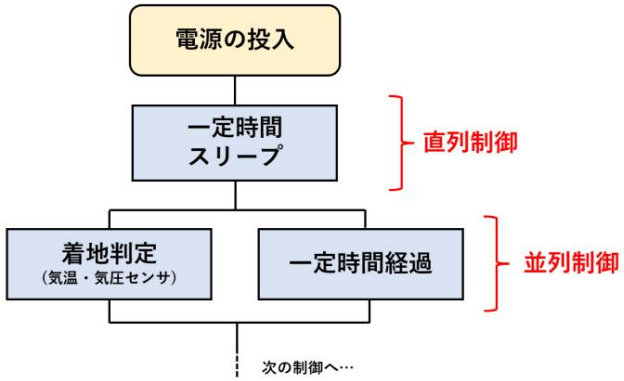


Figure 10.1.10 **Example of conditions for transitioning to the main program**

ii.Issue **Confusion**

of variables/Misuse of functions

[Issue]

During the development process, variables and functions could not be handled correctly, and even when checking the program, it was not possible to notice it, which repeatedly occurred. On the other hand, since the guidance logic written on the whiteboard was correct, it appears that confusion arose when writing it in the programming language.

[Solution]

Recently, services have been launched that allow AI to generate programming when the process is described in text, so one way is to use that service. Typos can be reduced by using AI to write the process for

variables after obtaining sensor values . On the other hand, when writing programming, a diagram is created once the induction theory has been established,

and programming is started by writing variables in the diagram. Another countermeasure is to set checkpoints, step by step, check the output values of variables, and proactively create opportunities to demonstrate to other members on a regular basis.

Improving the accuracy of stack detection

function [Issue]

The system we developed took several hundred seconds to detect a stuck rover. However, if the tire is spinning, this may not be a problem, but if the tire is fixed and current is applied for several tens of seconds, heat generation and gear damage may occur.

[Solution]
During the competition period, we were unable to come up with a solution to this problem immediately after the competition ended , but after interviewing multiple rover developers at a public open house at the JAXA Sagamihara campus, we found that It was found **that speed estimation (visual odometry) was possible . Consider future introduction.**

iii. **Future prospects**

Future efforts in control systems will be to acquire technology to solve the issues raised above.

c. **Circuit system** i. **Points of ingenuity and effort**

Using Raspberry Pi Pico for UARTÿI2C conversion of LoRa communication module

The LoRa communication module communicates using the UART standard, but it is not used for control. Raspberry Pi **Zero only has one UART communication port, and that port was already used for a GPS sensor . Therefore, it was necessary to convert the signal to I2C, but rather than using a new conversion module, the members** used Raspberry Pi Pico, which has the know-how of an external organization, to perform the conversion.
Creating a conversion board for Raspberry Pi Pico was an additional task, but it was not difficult and we had free space in the structure, so we were able to do it right away.

The battery is a large, high-capacity 4-cell LiPo battery (14.8V) In order to solve the problems of insufficient motor output and insufficient safety factor for the battery capacity, the battery was made larger. Performance has been improved **by increasing the voltage from 11.1V for 3 cells to 14.8V for 4 cells, and increasing the capacity from 1350mAh to 2600mAh . On the other hand, the dimensions had become excessively large and did not fit with the previous structure design, so a redesign of the structure was required. At the same time, the weight increased significantly, but the total weight of the structure and parachute at that point was approximately 700g, so it did not have a major impact . We evaluate that the decision to increase the size since there was excess weight worked effectively. Although we applied a voltage that exceeded the rating of the motor used, the running speed and terrain traversal performance improved significantly, and many concerns about running performance were alleviated simply by increasing the voltage. On the other hand, it is not preferable to change the structure by changing dimensions. When developing in the future, the process of ``checking the weight of the prototype once and increasing the size if there is room'' is likely to remain the same , so it would be a good idea to accept that the design was designed twice, but It became a b**

ii. **Issues: Poor wiring/forgotten solder [Issue]**

There were many errors related to forgetting solder and poor wiring. Since the people who create the board and then program it using it are not necessarily the same person, investigating defects after delivery is extremely inefficient and leads to worker stress. [Solution] When soldering, print out design drawings for the number of boards to be created, and solder while adding check marks. At the same time, print out the circuit diagram and check that the wiring is conductive after soldering. Mistakes in designing circuit diagram symbols and footprints [Issue] Sometimes it is necessary to create circuit diagram symbols and footprints (wiring print patterns on printed circuit boards) by yourself. **At this time, we sometimes have to apologize for the pin placement and dimensions, and the error is sometimes discovered after the product has been shipped from China, which takes about two weeks ,** which is extremely inefficient.

[Solution] If possible, it is preferable to have someone else check the dimensions, but it is difficult for someone else to check the dimensions every time. An effective approach would be to save data used within the organization in the past in a database to reduce the cost and effort of creating new data each time.

iii. **Future outlook**

Purchase one microcontroller per person When participating in a seed contest, each member purchased a microcomputer, and everyone was required to run the basic program at hand as a shared understanding. On the other hand, as microcomputers have become relatively expensive, although we did not adopt the same approach, problems such as shortages caused by burning out microcomputers and members lacking basic sense arose. In the future, I would like to incorporate it without omitting it, in order to equalize the abilities of the members and to develop the basic skills necessary to assist during experiments. This problem should be resolved in light of the fact that development is conducted online and mutual understanding becomes a barrier to communication. If you design the step-down circuit properly when creating the board, it will be able to withstand battery changes. This time, all parts except analog parts that require high voltage (motors, resistors, etc.) were supplied with power from a line from a converter that steps down to 5V. This approach of providing one mains voltage at a higher voltage eliminates the need to rework the board, as the circuit operates in the same way even if the mains voltage on the converter is changed.

d. **Flight**

system i. **Points of ingenuity**

and effort Regarding the flight mechanism (parachute and envelope)

The parachute was shaped as shown in Figure 10.1.11. About the parachute 1 side 70cm It was a regular hexagon, but by making a circular hole with a radius of 10 cm in the center, we **decided to adopt this shape because it made it more stable to fall. Red was chosen as the color to increase visibility . In addition, as shown in Figure 10.1.12, the joint between the eyelet and the line at the end of the parachute is made with a snap rather than a direct connection to prevent damage due to thread fraying and to make it easier to replace the parachute. A piece of sandpaper was attached to the envelope to prevent it from idling. Convex tape was attached inside the envelope to ensure that the envelope opened when opened (Figure 10.1.13). Also, at the site ,** we thought that some kind of electromagnetic waves were generated in the wireless communication between the ignition switch and the launch pad, causing an interference, so we wrapped aluminum foil tape around the envelope to provide electromagnetic shielding (Figure 10.1.14).

Figure 10.1.11 **Parachute shape**

Figure 10.1.12 **Parachute attachment part**

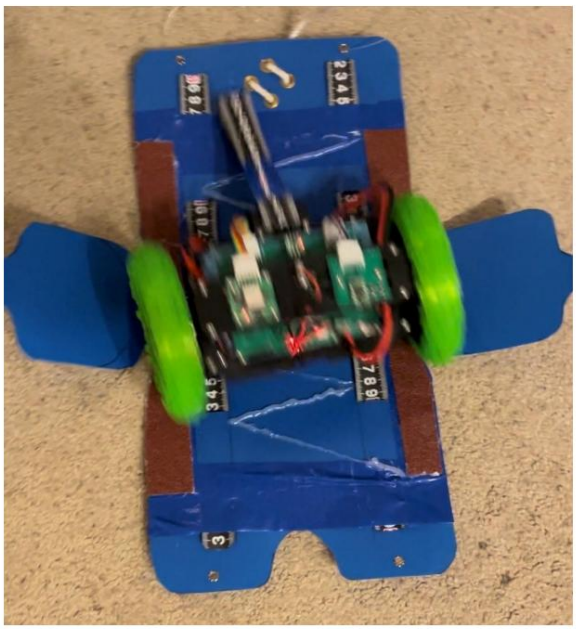


Figure 10.1.13 **Inside the envelope**

Figure 10.1.14 **Outside the envelope**

Regarding the opening

mechanism: To prevent fire and melting, the wire **was burnt off using a 10ÿ resistor instead of a nichrome wire** (Figure 10.1.15). **Since there was a large variation in landing judgment and it was difficult to deal with it by adjusting the threshold value, we introduced a timer. The start of landing judgment was controlled in series after a certain period of time had elapsed, and the end of landing judgment was also forced to open after a certain period of time by opening the envelope under parallel conditions.**

Figure 10.1.15 **Envelope expansion mechanism**

ii. **Issues**

Regarding the opening

mechanism During the actual tournament, I was unable to burn out the tegus and failed to open the opening. After declaring retirement, I checked the resistor and found that it was scorched only on one side that did not touch

It turns out that the heat of resistance is not being transmitted to Tegusu. A resistor was used to fuse the nylon wire, but unlike nichrome wire, which itself generates heat, the resistor generates heat locally, which causes the coating to burn, leading to the wire breaking. Therefore, in strong winds or low temperatures, the combustion of resistance may be stopped midway, and resistance was found to be unsuitable. In addition, I reflected on the fact that the failure of opening could have been prevented if resistors (or nichrome wires) were placed in parallel, as shown in Figure 10.1.16, energizing when determining landing and energizing multiple times using a timer.

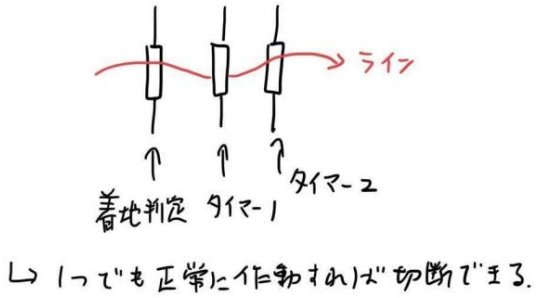


Figure 10.1.16 **Improvement proposal for envelope expansion mechanism**

e. **Image**

system i. **Points of**

improvement/efforts On-site

parameter adjustment In image processing driving, the accuracy greatly depends on how the acquired images are processed. Experiments using image processing had been conducted in Japan, but because the way the goal was seen and the strength of sunlight were different in the field, it was believed that the guidance accuracy obtained in the experiments in Japan could not be achieved. . Therefore, by acquiring cone images on-site and analyzing them while changing parameters, we made adjustments to get closer to highly accurate guidance.

ii. **Challenges**

Red cannot be recognized correctly due to too strong

sunlight

[Challenge] In experiments conducted in Japan, when images were acquired, red could be detected without any problems. However, when images were acquired on-site, the images were blown out due to the effects of sunlight and the reflection of the ground, making it difficult to recognize the cones, especially in images taken from the front-light direction.

Figure 10.1.17 **Goal image from backlight**

[Solution]

It is also possible to adjust the exposure time of the Raspberry Pi camera. Therefore, we believe that shortening the exposure time will be a solution to preventing white spots in the image.

Simplification of parameter

adjustment [Issue] We were not sufficiently prepared to change camera parameters according to the surrounding environment during the actual tournament. For this reason, we believe that we were unable to resolve the issue of image overexposure on-site and were unable to resolve the issue with image

processing. [Solution] The solution is to build a system that changes parameters while actually monitoring images. Since the Raspberry Pi can actually monitor videos from connected cameras, we would like to utilize these functions to make it easier to adjust parameters.

f. **Communication**

system i. **Points of improvement and**

effort Acquisition of long communication

distance By using LoRa communication, we have developed a system that allows wireless communication even in environments where the distance between the ground station and the aircraft is several kilometers. In fact, a communication range of 5 km was confirmed in domestic experiments, and the system was able to play a part in countermeasures against lost communications.

ii. **Issues Decrease**

in communication distance

[Issue]

In experiments in Japan, wireless communication was possible at intervals of several kilometers, but when we actually checked the communication distance on site, communication was interrupted after about 600

meters. A decline occurred. [solution]

We suspected that the reason for the significant decrease in communication range was the negative effect of reflection from the sandy ground. Therefore, the solution was to raise the receiver side as high as possible to minimize reflection from the ground. In fact, other teams reported that ``we
were able to communicate while the aircraft was falling, but it was difficult to connect after the fall,'' so we believe that the sandy soil had a large effect.

B. **Management** a.

Development management

Schedule Figure 10.2.1 is a

Gantt chart created at the beginning of development, and Figure 10.2.2 **is a diagram summarizing the actual progress period.**

Figure 10.2.1 **Gantt chart created at the beginning of development**

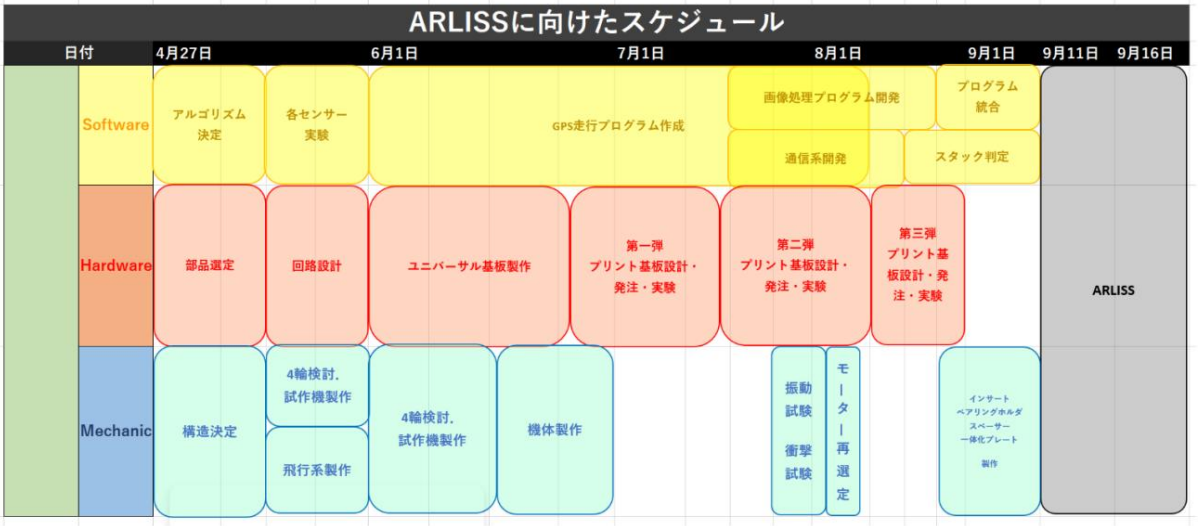


Figure 10.2.2 **Actual schedule**

There was a delay in development compared to the initial Gantt chart created.
The initial Gantt chart says that final adjustments will be made from mid-July to mid-August, but in reality, the flight model was not completed at that time, and final adjustments before the competition were made from early
September to the final day of the competition. ÿÿ **The reason we were not able to proceed according to the Gantt chart was that the initial Gantt chart we created lacked specificity and did not contain enough information to understand the flow leading up to the tournament. For example, if final adjustments were scheduled to be made from mid-July to mid-August, the programs would have to be integrated in two weeks from late June to early July. They should have done such backward calculations and updated the Ga**

About to-do lists
I managed my personal tasks using a to-do list. Progress management was carried out with the individual's obligation to meet the deadline.

About online development
FUSiON has members scattered all over the country, and its theme is online development. Managing things such as electronic parts, tools, and rovers is a bottleneck in online development. Basically, the main base is the area where many members live and parts and rovers are collected, but if there are sensors and printed circuit boards at other bases, the burden of experiments and programming can be checked.

b.Human **management**

The majority of the members participating in ARLISS this time were members who were brought up from seed competitions, so we were able to proceed with development with a real sense of accumulating

technical skills and experience. On the other hand, I have a strong impression that the members who participated in this tournament took more time than expected to get used to the speed of the already established team. Our team is limited to a small number of members and develops on a project basis, so even new members and those with no work experience are required to be actively involved in development, but we are unable to catch up sufficiently. This is thought to be the cause. The three abilities required for the sport are summarized below. (i) Ability to refer to past documents and catch up on the current state of development as appropriate (ii) Ability to understand the flow and control of the CanSat competition and understand what is required in the area in charge (iii) Perform experiments. Hypothesis verification ability to examine the causes of failures and make improvements when performing them.In addition to development, we have summarized the skills required in project-based learning into the fo

• Ability to get things done
• Ability to meet
deadlines • Ability to manage and adjust
one's own schedule •
Communication ability • Active speaking ability

c. **Budget Management**

Cost Usage The

total development costs used this time were 352,348 yen. The breakdown **of monthly expenditures and total expenditures is as shown in the figure below. The classification includes structure, electrical equipment, daily necessities for delivery, etc., and the specific contents are as follows. (In addition, the final item**

"Nakai" consists of the types that Nakai, the main member, had replaced : parachute cloth, strings, motors, filaments (for 3D printers),

fastening parts such as screw nuts, lipo batteries, etc. Electrical equipment: Raspberry Pi, Electronic parts

such as circuit boards, camera modules, resistance sensors, LTE modules , etc. Shipping Daily necessities: radio pliers, drill blades, ARLISS souvenirs, shipping fees for manufactured parts, **cigarette** socket converters, etc.

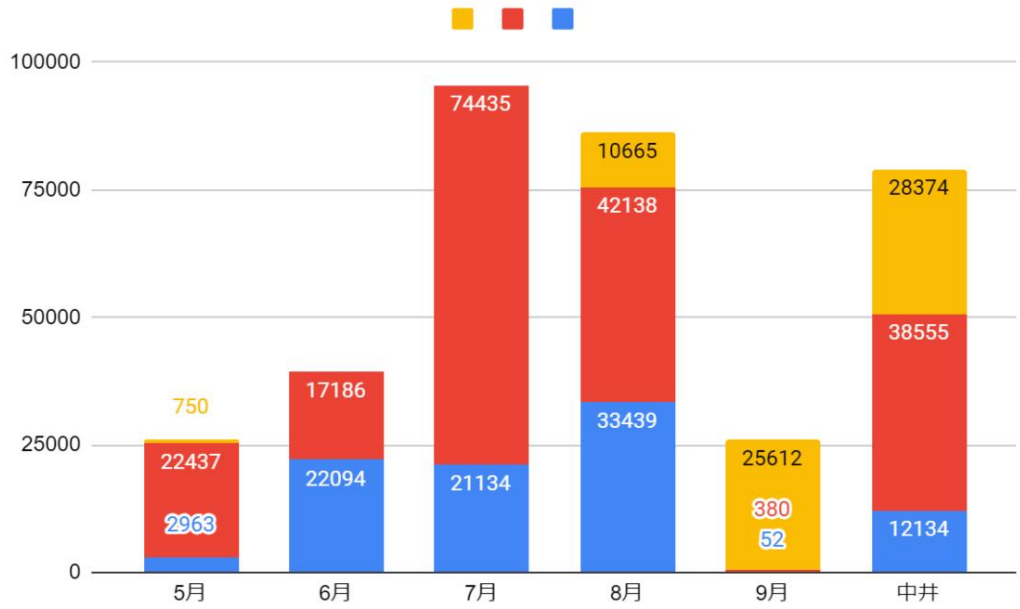


Figure 10.2.3 **Expenses by period**

Items that can be expected to

be reduced a. **Parts damaged due to human error such as reverse connections, etc.**

• Raspberry Pi (damaged 8 times): Approximately
30,000 yen • GPS sensor: 2,200 yen

b. **What could be reduced by buying cheaper items**

• Nylon thread, cloth, etc.: about 2,000 yen (items that cost about 800 yen cost about 2,000 yen)

etc.)

c. **Regarding the expenses incurred during the experiment**

(reference) There are many cases where you forget something in the last half of August, or you are not able to make use of what you learned from the previous experiment, and you end up having to go again because you are not able to carry out sufficient experiments at the site, which results in wasted round trips. There were several experiments. This was not reflected in the budget this time, but I lost about 10,000 yen in rental car fees, transportation expenses, etc.

system	cost
structure	2000
Electrical equipment	32200

About the budget management method This time, it was difficult to predict the scale of the project in detail, so instead of setting a budget in advance, we refinanced the costs each time. The management method was to distribute the funds after the end of the project. It was not possible to develop the product while keeping track of the current expenses, so this is an area for improvement.

C. Overall future outlook

Through this development, we learned that in addition to moving forward with the necessary items for development, we also need to improve the development environment such as jig production. From now on, I plan to utilize what I learned at this conference in my own future activities, as well as preserve these experiences and knowledge in a tangible form and pass them on to younger generations. There is.