ARLISS2022 development review report

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• Team information

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CanSat class	Open class

• Members

role	name
PM, team leader, structure team	Yasuhiro Ishii
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*Structural team: A team that develops mechanical parts and mechanisms.

*Mission group: A group that develops reflective films, etc. necessary for missions.

*Electrical equipment team: A team that develops electrical circuits and controls.

• CanSat production purpose/reason for participation in the competition

Through CanSat manufacturing, which involves thinking from scratch, we are able to develop satellites in a short period of less than half a year.

By participating in ARLISS, you can experience the process from start to finish, and you can learn about CanSat at other universities.

Being able to interact with people who are developing space technology and students studying space technology from around the world, etc.

Through these activities, students acquire the knowledge and skills needed as engineers.

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Chapter 1 Mission Statement

Towards expanding the usable range of solar cells in outer space
Demonstration of light/heat collection technology using membrane expanded structure

In space exploration to date, various energy sources have been used depending on the purpose and scale of the spacecraft. It's here. While chemical energy is effective for short-term space activities such as one hour or one day, However, over long periods of time ranging from one month to several years, solar power generation becomes more effective than chemical energy. Ru. Most modern spacecraft are equipped with solar panels. However, in exoplanet exploration, The current situation is that countries have been using nuclear energy since the early stages of space development.

Therefore, Table 1.1 provides a comparison between nuclear cells and solar cells, which are currently being considered for deep space exploration. It is shown in Looking at this, it can be seen that although nuclear batteries have several advantages, they do not harm the human body during development or launch. It is not used in deep space exploration in Japan due to safety issues such as the great danger it poses. Sunlight is a common energy source on the ground and in space, and solar power generation is not practical on the ground. Because it is easy to experiment with, it is easy to obtain confirmation that it can be used, and it is widely used in spacecraft as a power source. Ru. Against this background, the use of solar cells is also being considered for deep space exploration. but, As shown in Table 1.1, one of the current major challenges for solar cells in deep space exploration is power generation. One example is that the amount depends on the distance from the sun. As the distance from the sun increases, the unit area Not only does the amount of light energy per solar cell decrease, but the light intensity and temperature on the surface of the cell also decreases. This has the characteristic of significantly reducing power generation efficiency. In deep space exploration, LILT (Low Intensity Low Temperature) environment, where the light intensity is low and the temperature is low, which increases the negative effects on the solar cell characteristics. As a result, the amount of power generation decreases significantly. In this way, there are lower limits to power generation depending on light intensity and temperature. Therefore, the area in which solar cells can be used is limited in space.

Table 1.1 Comparison of power generation methods in deep space exploration

比較項目	原子力電池	太陽電池
姿勢によって出力が変動しない	○	△
発電量が太陽からの距離に依存しない	○	×
単位質量当たりの発電量	△	○
開発時・発射時に人体に危険を及ぼす恐れ	×	○

Therefore, in this mission, we aim to cover a large area as a solution to the power problem in deep space exploration.

By concentrating incoming sunlight within a certain range, solar cells can be used even in deep space in the LILT environment.

We will propose and demonstrate a technology that ensures usable temperature and light intensity. Assumed deep space mission

The position of the CanSat mission in the current situation is shown in Fig.1.1. In this CanSat mission

focuses on light focusing technology, which is a key point in the envisioned deep space mission, and focuses on light focusing technology.

Verify the effects of light intensity and temperature. The technical demonstration of this CanSat mission will enable us to solve problems that are currently difficult to use.

In addition to demonstrating the possibility of using solar cells in deep space, solar cell power generation by adjusting light intensity

We also explore the possibility of application to quantity optimization.

Fig.1.1 Positioning of this CanSat mission in the envisioned deep space mission flow

mission sequence

The mission image and mission flow are shown in Fig.1.2 and Fig.1.3 below.

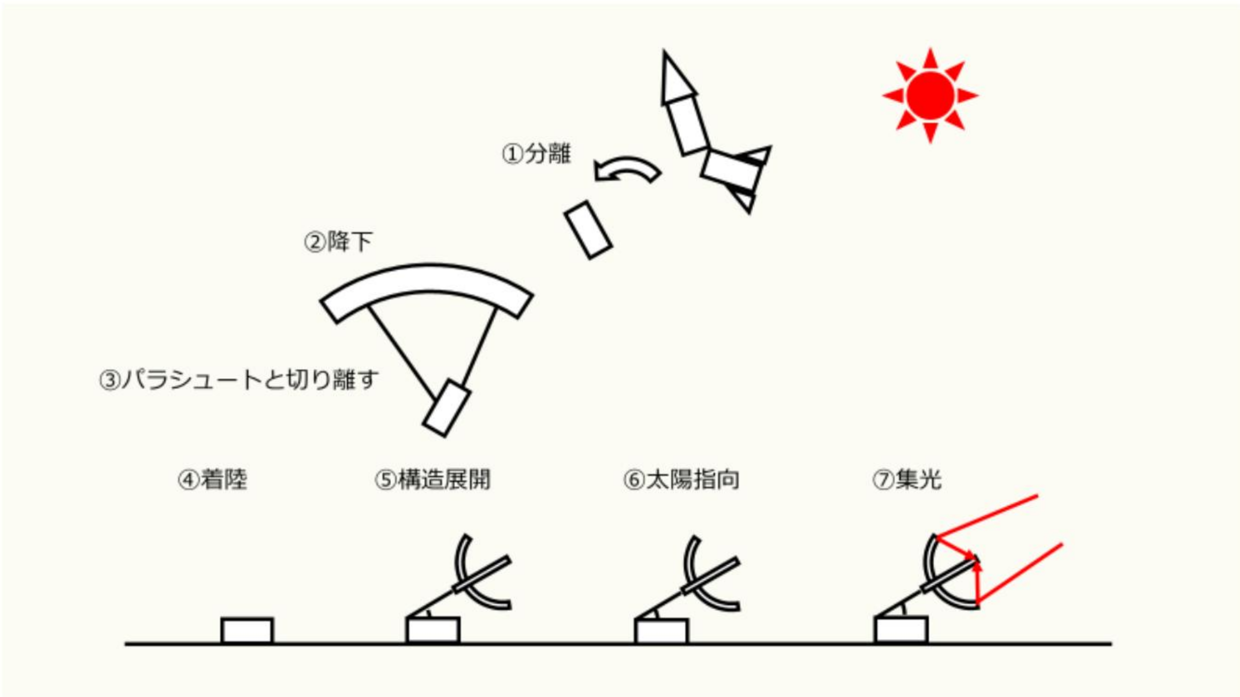


Fig.1.2 Mission image

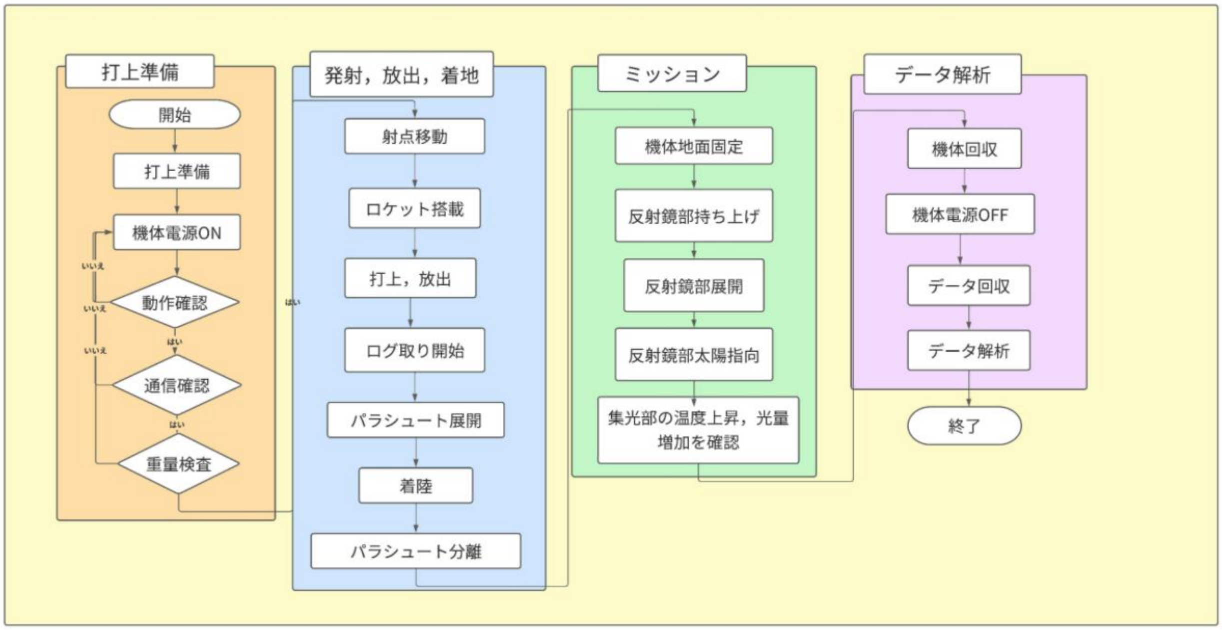


Fig.1.3 Mission flow

The mission sequence of this mission is as follows. First, turn on the power to the aircraft and check its operation. verification, communication confirmation, and weight inspection. If each item is satisfactory, move to the launch site and load it onto the rocket. and launch it. After that, when released in the sky, it starts recording logs, deploys a parachute and decelerates. Descend while doing so. After landing and separating the parachute, lift the reflector and deploy it toward the sun. Ru. After that, we measure the temperature change and light concentration on the center rod of the reflector. When the measurement is complete, turn off the power to the aircraft. Collect and analyze the data. This is all the work.

Chapter 2 Success Criteria

minimum success	• Deploy the parachute • Separate CanSat from the parachute • Deploy the cover and point the reflector up • Lift the reflector • Deploy the reflector
full success	• The reflector is rotated by a turntable to face the sun • The reflector collects light • The reflector continues to be maintained at 45 degrees from the ground
advanced success	• The reflector is rotated by a turntable to rotate toward the sun. follow • The reflective mirror section collects heat. • Make the focusing accuracy the same as the theoretical value.

Regarding the above success criteria, the classification for each function is shown in Table 2.1. Each evaluation method are written in [ ].

Table 2.1 Classification and evaluation method of success criteria

function	minimum success	full success	advanced success
Parachute	Parachute deployment [Visually check]		
	Parachute separation [Visually check]		
Cover part	The cover part expands and The mirror section faces upwards. [Turntable section and Visually check that there is no interference]		
Reflector part	Expand the reflector to focus light		Make the focusing accuracy the same as the theoretical value

	[The role of a stopper] There is a screw head that That's how far the wheel is moving. Check visually]	[Tip and center of reflector section] Photo installed in the light section The illuminance is measured using a transistor and the values are compared. 1x that's allÿ	[With a structure that has been completely developed in advance.] Focus the light and compare it with the value at that time. The values to be compared are based on the magnification of the light intensity of the condensing part and the normal part. Error 15% or more let it be inside Ru.]
			Reflector part collects heat [Measure the tip of the reflector and the condensing part from outside with a radiation thermometer, and check the values. Compare]
Lifting part	Lift the reflector section [Visually check]	Keep the reflector section at 45 degrees from the ground [Measure with a protractor]	
Turntable section		The reflector part is turned Rotate by the bull and face the sun [Illuminance meter from outside] Confirmation of use, measuring stick The angle between the shadow of and the center bar by measuring confirmation. Angle within ±15°ÿ	The reflector part is turned rotate by bull Follow the direction of the sun by do [Angle within 15°]

•Reflector section

It is generally said that sand reduces the power generation efficiency of solar power generation systems installed in deserts by 10 to 15%. In this mission as well, there is a concern about the impact of sand, so it is thought that the light-gathering magnification will similarly drop by 10-15%. Therefore, the expected error in the light collection magnification for this mission is the maximum It was set at 15%.

Chapter 3 Setting requirements

3.1 System requirements (requirements for ensuring safety and regulation)

request number issue	System requirements (ARLISS launch safety standards)
S1	The mass of the aircraft to be dropped meets the criteria.
S2	volume meets carrier standards
S3	Quasi-static loads during launch impair functionality to meet safety standards. Tests have confirmed that there are no
S4	Is the function required to meet safety standards impaired due to vibration loads during launch? Tests have confirmed that there is no
S5	Due to the impact load when the rocket separates (when the parachute is deployed), safety standards are met. It has been confirmed through testing that the functions required to
S6	It has a deceleration mechanism to prevent it from falling at dangerous speeds near the ground, and its performance has been tested. It has been confirmed
	Measures against S7 loss have been implemented, and their effectiveness has been confirmed through testing. (Examples of measures: location information transmission, beacons, fluorescent color paint, etc.)
S8	It has been confirmed that the regulations for turning off radio equipment during launch can be complied with (FCC Devices that are certified and have a power output of 100mW or less do not need to be turned off. Also, if you use a smartphone, it must be FCC certified and can be turned off with a software or hardware switch. and)
S9	Verify that you are willing and able to adjust the radio channel. coming
The End-	We have successfully conducted to-end testing, and there will be no major design changes in the future.

3.2 Mission requirements

number	Mission requirements
M1	parachute can be deployed
M2	Tests have confirmed that the impact load upon landing does not impair the functionality needed to accomplish the mission.
	Tests have confirmed that it can supply sufficient power to perform the M3 sequence.
M4	OBC starts successfully
M5	parachute can be separated
M6	fuselage cover is expanded and the reflector is facing upwards.
M7	reflector part can be lifted and maintained by 45°
M8	reflector part can be expanded
M9	Change the direction of the reflector to face the sun
M10	The reflector can withstand heat while concentrating light.
M11	The reflector part can withstand wind while concentrating light.

Chapter 4 System specifications

4.1 Aircraft appearance

After the aircraft touches down, the outer part of the aircraft and the reflector section are deployed. Therefore, the exhibition

This will be explained separately before and after opening. The internal parts will be explained in more detail in Section 4.2.

• Before deployment

External views of CanSat before deployment are shown in Fig.4.1.1, Fig.4.1.2, Fig.4.1.3, Fig.4.1.4, and Fig.4.1.5.

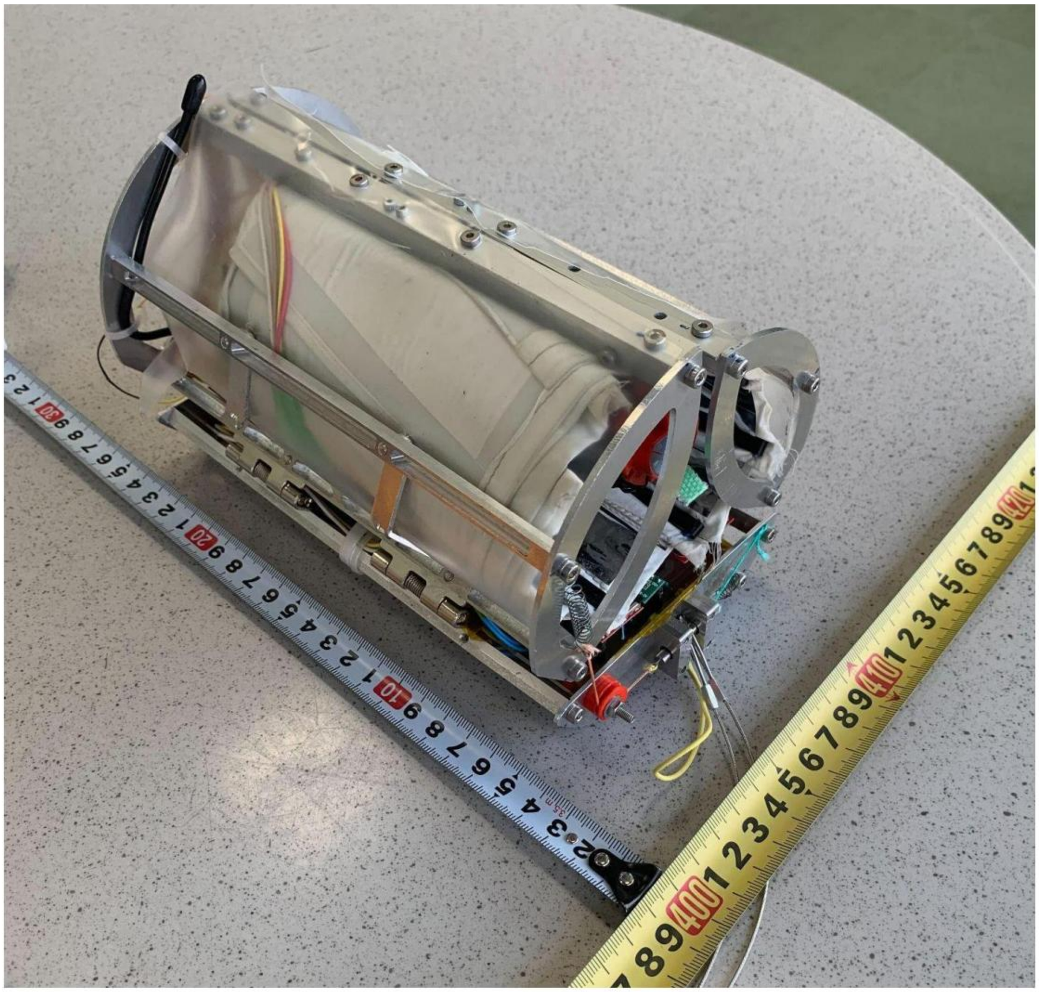


Fig.4.1.1 Bird's eye view of the aircraft exterior before deployment

Fig.4.1.2 External front view of the aircraft before deployment

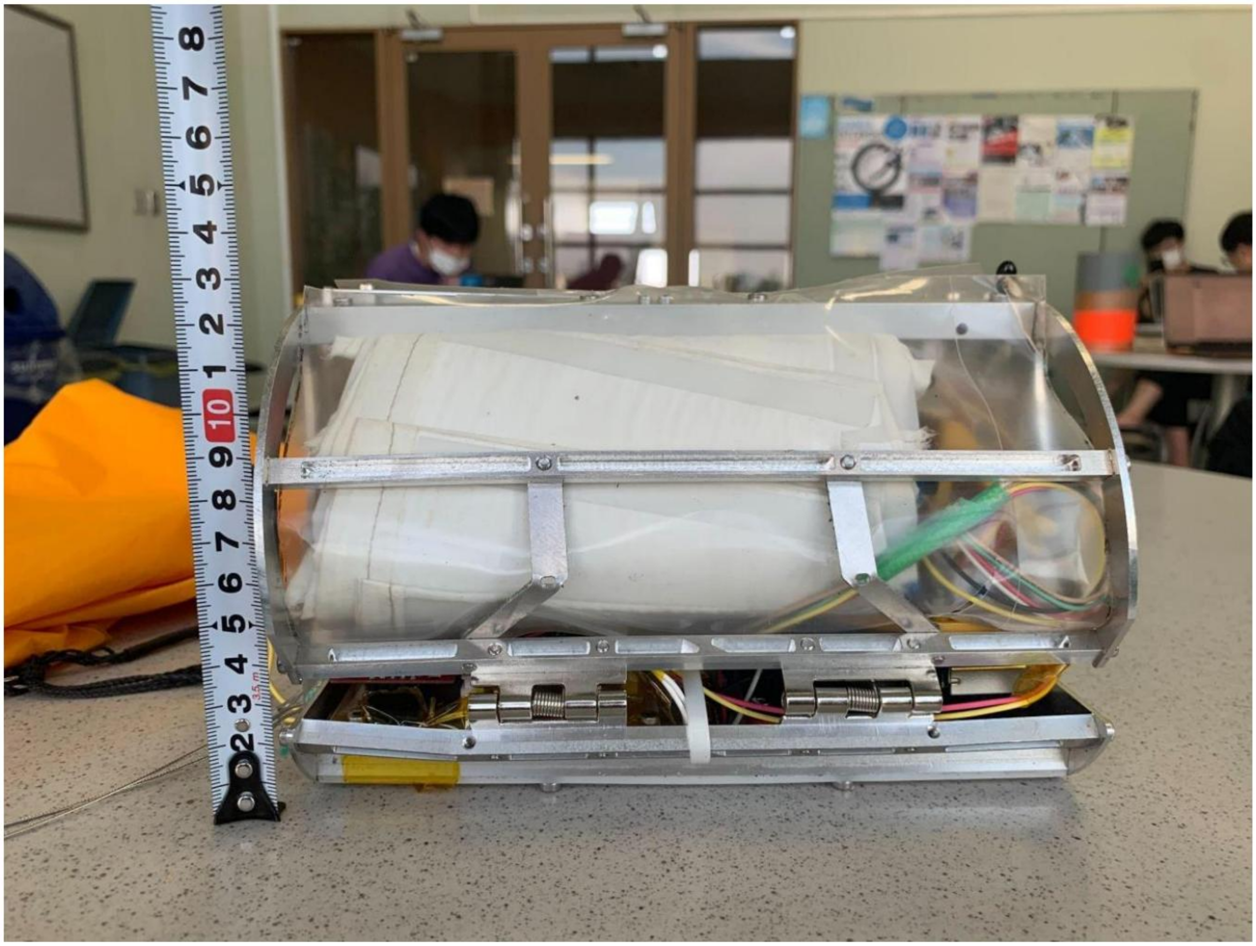


Fig.4.1.3 External left side view of the aircraft before deployment

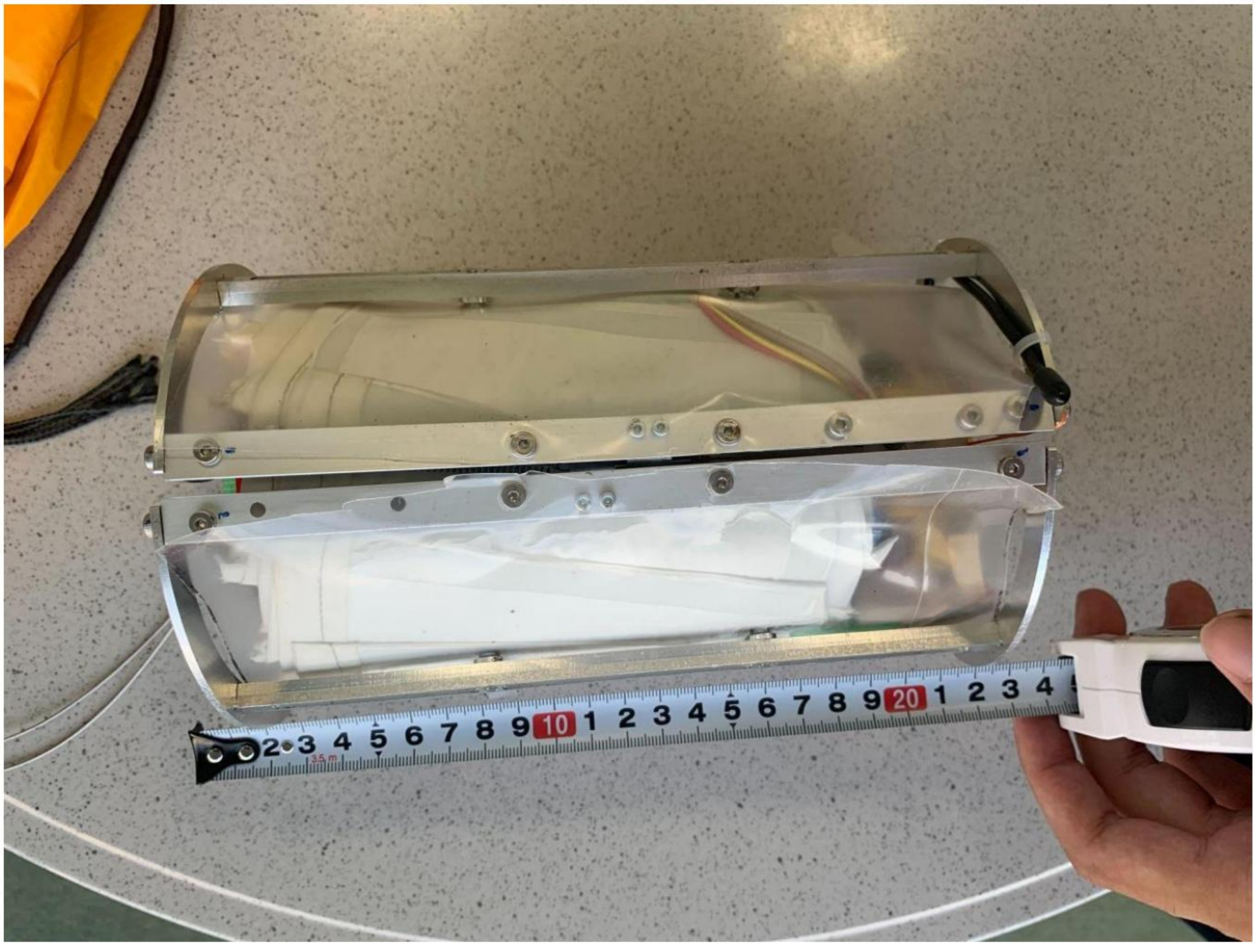


Fig.4.1.4 External plan view of the aircraft before deployment

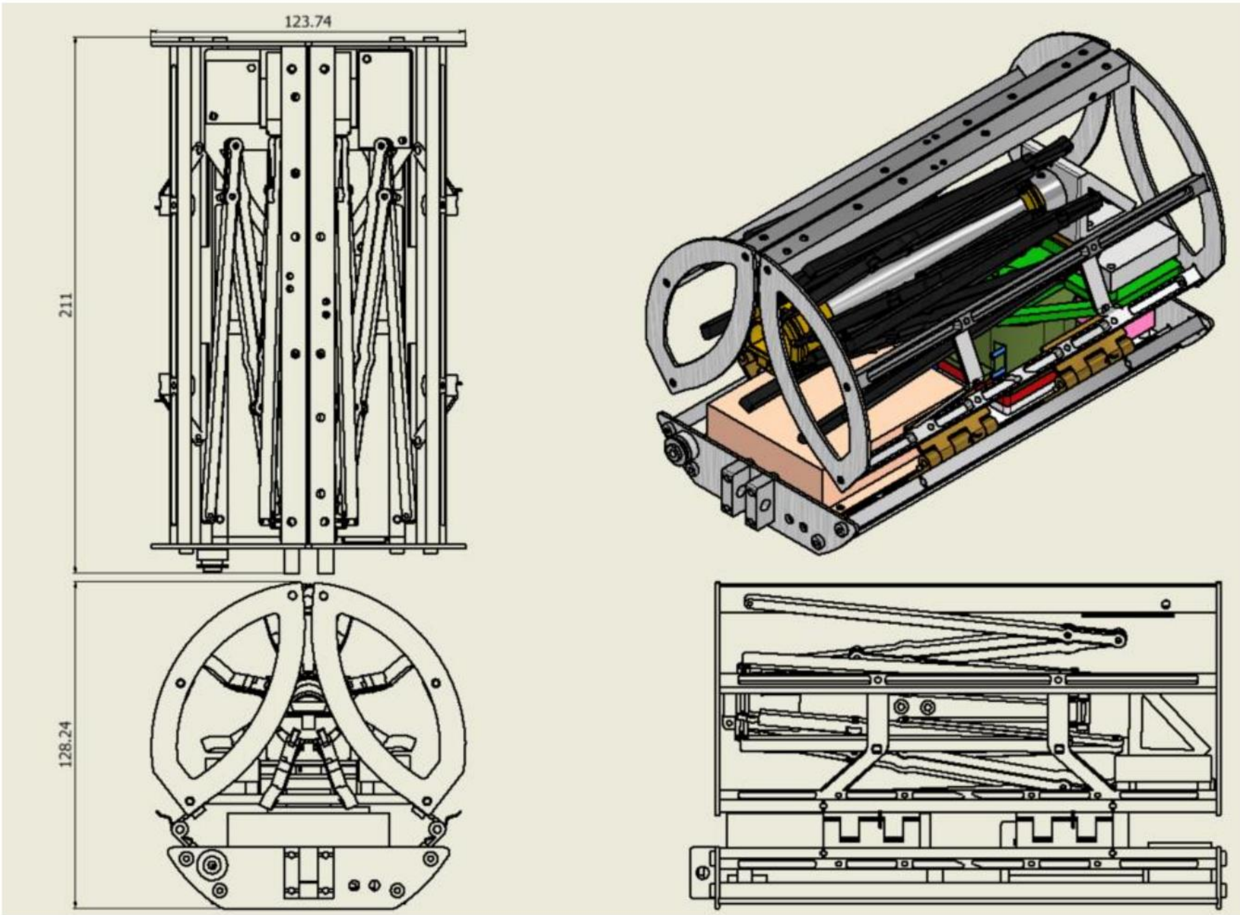


Fig.4.1.5 Three-view external view of the aircraft before deployment

• After opening the cover

Figures 4.1.6 and 4.1.7 show the appearance of CanSat after its cover is expanded. This CanSat uses a single fusing mechanism to deploy the cover part and the reflector part, and by creating a mechanical time difference, we have devised a way to prevent interference with interior parts when the reflector part is deployed. Therefore, the cover

The appearance after the part is expanded is the same as the appearance after the reflector part is expanded.

(a)

(b)

(c)

Fig.4.1.6 After cover is unfolded

(a) Front (b) Side (c) Back

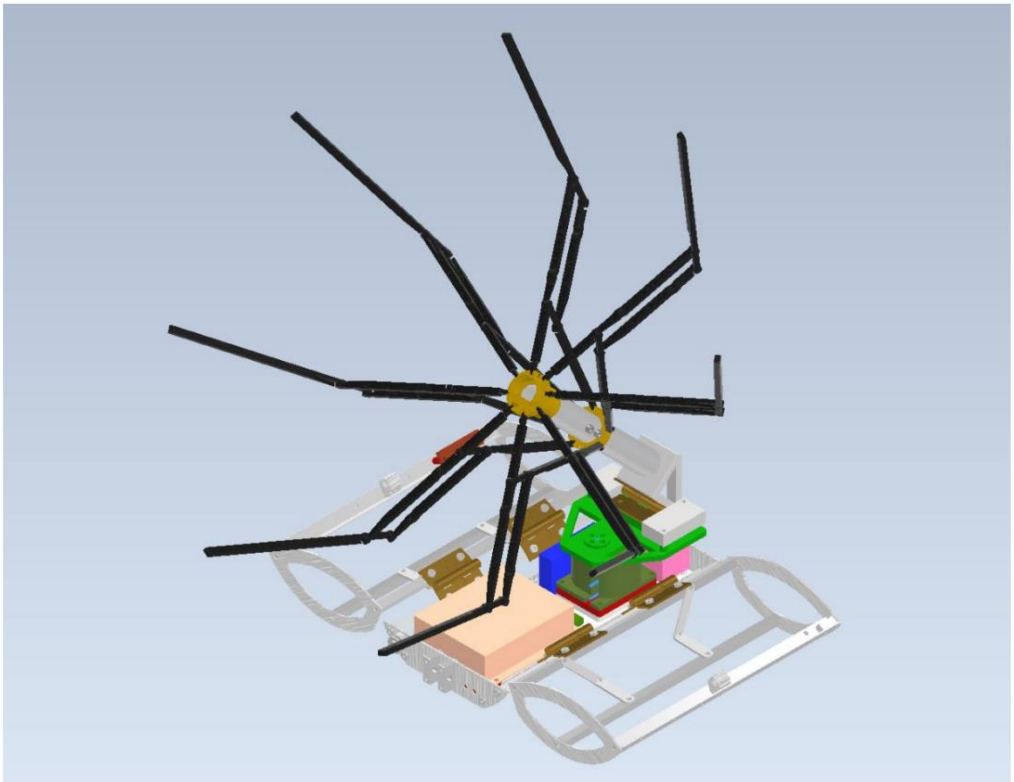


Fig.4.1.7 Bird's eye view of the aircraft after the reflector is deployed (CAD)

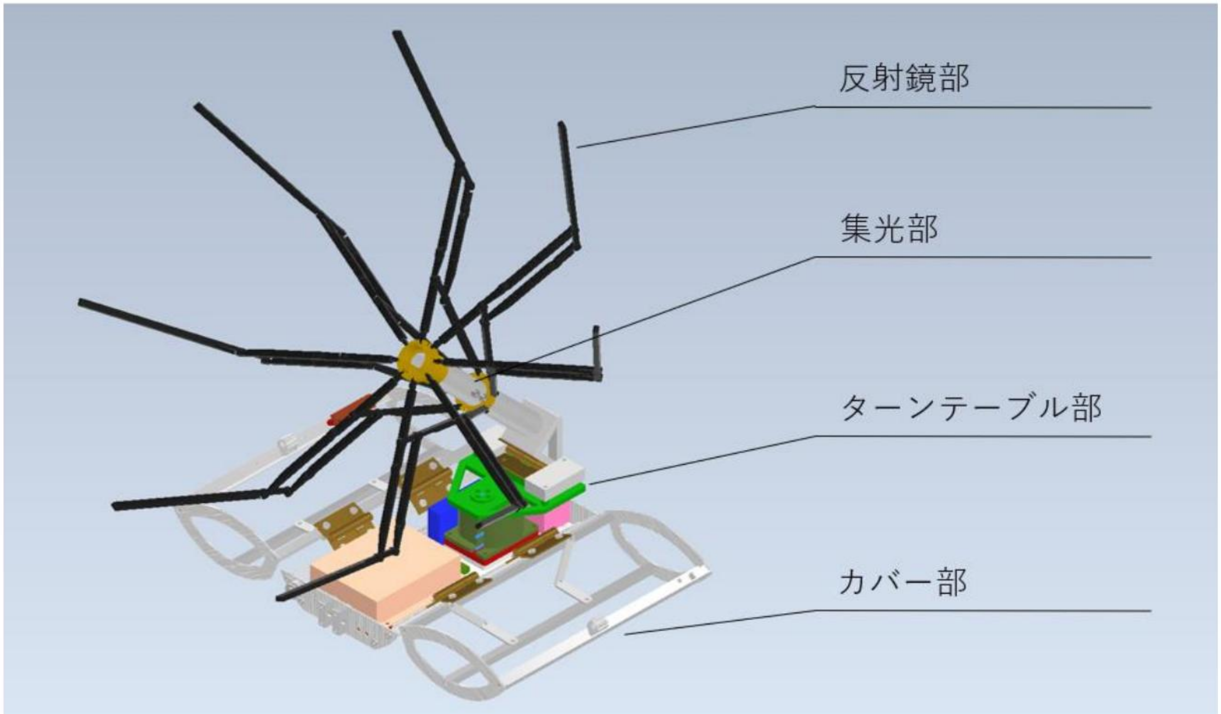


Fig.4.1.8 Names of each part of the aircraft

Finally, summarize the size and mass of the aircraft. The height takes into consideration the parachute section in addition to the fuselage shown in Fig. 4.1.1. Although the parachute part is not shown in the drawing, it is equipped with a parachute that can be stowed to a height of 40 mm and a diameter of 146 mm. In addition, the [V2] aircraft stowage/release test, which will be described later, shows that the actually produced flight model fits in the carrier.
It has been confirmed that.

The weight of the aircraft, including the parachute, was determined to be 930g by the [V1] mass test described later.
It has been confirmed that the weight is below the regulation of 1050g.

Table 4.1.1 Aircraft weight and size table

Diameter [mm]	128.24
Height [mm]	211
Mass [g]	930

4.2 Aircraft interior/mechanism

The mechanisms installed on the aircraft can be roughly divided into the cover section, reflector section, and turntable section.

• Cover part The

appearance of the cover part is shown in Fig. 4.2.1. The circular surface is made of aluminum alloy (A5052), the longitudinal direction is made of aluminum alloy (A5052) bar material and aluminum alloy (A6063S-T5) angle material, and the bottom surface is made of polyacetal resin. As mentioned in Section 4.1, this aircraft deploys the cover after touching down. The fusing mechanism releases the fixed shaft attached to the top of the cover, and the torque of the spring hinge causes the cover to expand. By deploying this cover, the reflector is designed to withstand wind and other external disturbances, that is, to support the reflector so that it does not capsize. The specifications required for the cover part in this mission are as follows.

• Must be able to withstand the impact of landing and opening,

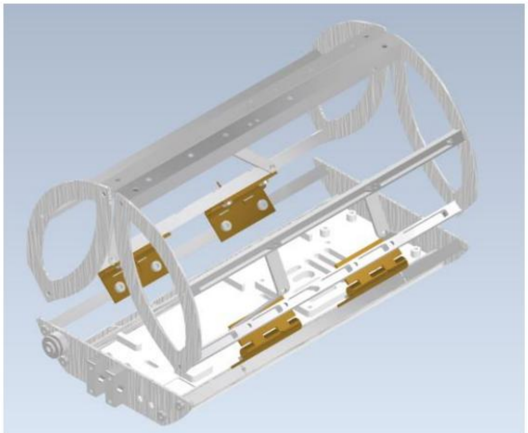
and be able to deploy. • Must be in the state shown in Fig. 4.2.1(b) after

being deployed. • Must not capsize due to the effects of wind, etc.

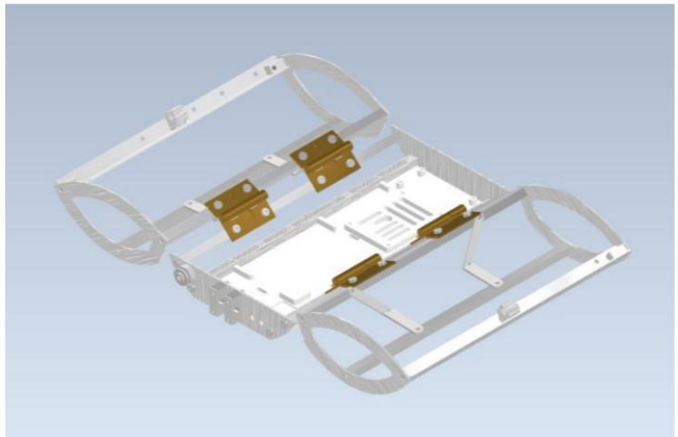
The ability to withstand various types of impact and the ability to deploy has been confirmed through the [V3] static load test, [V5] umbrella opening impact test, and [V11] landing impact test described below.

It has been confirmed by the [V15] cover deployment test that the state shown in Fig. 4.2.1(b) will always occur after deployment. By installing the electrical components, which mainly account for the weight, on the bottom during the design stage of the internal layout, We have devised a way to prevent the inside of the aircraft from pointing toward the ground after rolling.

(a)



(b)



(c)

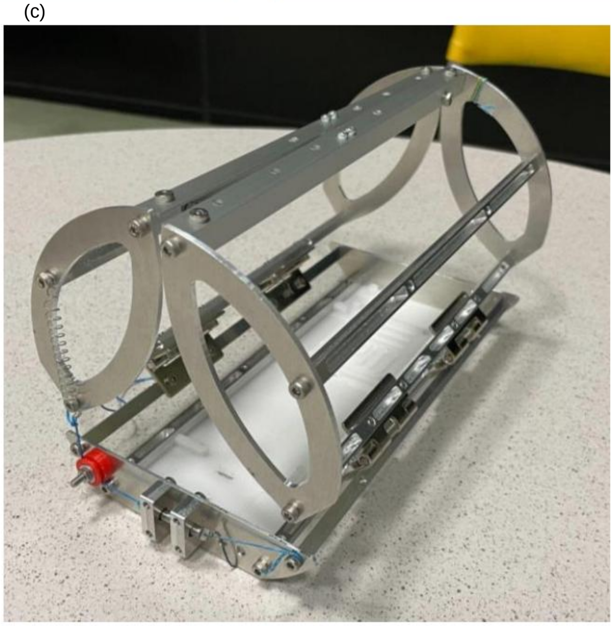
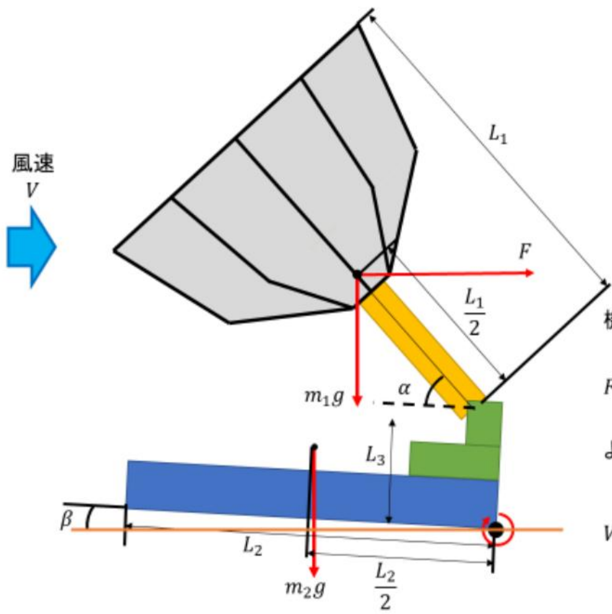


Fig.4.2.1 Cover part (a) Before deployment (CAD), (b) After deployment (CAD), (c) Actual machine

• Wind speed that CanSat can withstand

In this CanSat, there is a possibility that the aircraft may fall if the reflector section is exposed to wind. The wind speeds that CanSat can withstand are shown in Fig. 4.2.2, Fig. 4.2.3, Fig. 4.2.4, and Fig. 4.2.5. Assume that the reflector is a rigid body that does not close due to the influence of wind, and that the centers of gravity of the reflector and the rest of the aircraft are at their respective centers. The wind speed that can be withstood in this case is 8.2 m/s from Fig. 4.2.2 and 13.5 m/s from Fig. 4.2.3 in each case, assuming that ÿ in Fig. 4.2.2~Fig. 4.2.5 is 0°. s, 15.7m/s from Fig.4.2.4 and 9.14m/s from Fig.4.2.5. When the wind speed is lower than case 1, which is the minimum value among these, 8.20 m/s, CanSat does not fall over. In addition, the average wind speed on dates when ARLISS was held in the past was 4.4 m/s, which is smaller than 8.20 m/s. CanSat will no longer fall over.

stomach.



$L_1 = 0.262\mathrm{m}$: 反射鏡部の長さ
$L_2 = 0.200\mathrm{m}$: CanSat底面の長さ
$L_3 = 0.0730\mathrm{m}$: 底面から反射鏡部中心までの長さ
$m_1 = 0.14\mathrm{kg}$: 反射鏡部の質量
$m_2 = 0.71\mathrm{kg}$: 反射鏡部以外の質量
$g = 9.81\mathrm{m/s}^2$: 重力加速度
$\alpha = 45°$: 反射鏡部と機体の間の角度
$F = \frac{1}{2} C \rho V^2 S \cos(\alpha + \beta)$ [N]: 風による力
$C = 1.33$: 抗力係数(半球凹面)
$\rho = 1.29\mathrm{kg/m}^3$: 空気密度
$S = 0.122\mathrm{m}^2$: 反射鏡部の投影面積

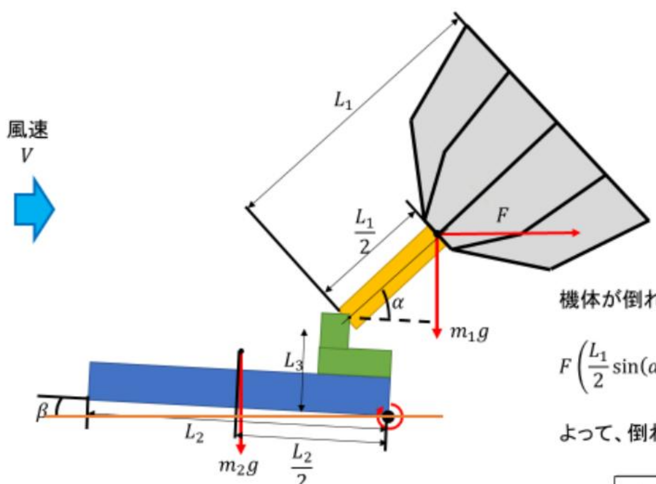
機体が倒れる条件は

$$F\left(\frac{L_1}{2}\sin(\alpha+\beta) + L_3\right) > m_1 g \frac{L_1}{2}\cos(\alpha+\beta) + m_2 g \frac{L_2}{2}\cos\beta$$

よって、倒れるために必要な風速Vは

$$V > \sqrt{\frac{\{m_1 L_1 \cos(\alpha+\beta) + m_2 L_2 \cos\beta\}}{\left\{\frac{L_1}{2}\sin(\alpha+\beta) + L_3\right\} C\rho S \cos(\alpha+\beta)}} = 8.20\mathrm{m/s}$$

Fig.4.2.2 Calculation of wind speed when falling down due to wind (case 1)



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機体が倒れる条件は

$$F\left(\frac{L_1}{2}\sin(\alpha+\beta) + L_3\right) > -m_1 g \frac{L_1}{2}\cos(\alpha+\beta) + m_2 g \frac{L_2}{2}\cos\beta$$

よって、倒れるために必要な風速Vは

$$V > \sqrt{\frac{g\{-m_1 L_1 \cos(\alpha+\beta) + m_2 L_2 \cos\beta\}}{\left\{\frac{L_1}{2}\sin(\alpha+\beta) + L_3\right\} C\rho S \cos(\alpha+\beta)}} = 13.5\mathrm{m/s}$$

Fig.4.2.3 Calculation of wind speed when falling down due to wind (case 2)

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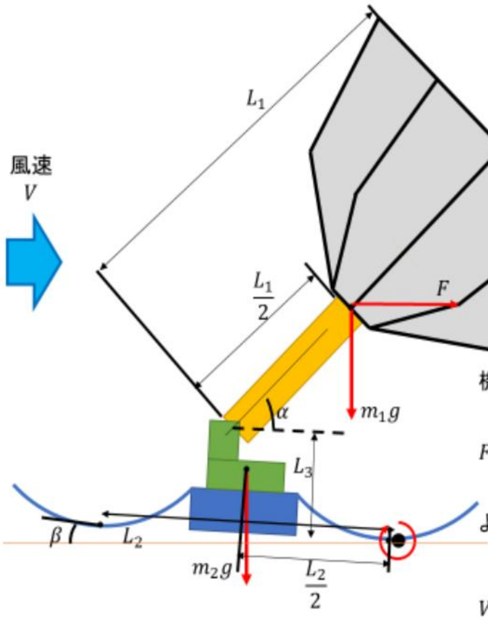

$L_1 = 0.262\mathrm{m}$: 反射鏡部の長さ
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$\rho = 1.29\mathrm{kg/m}^3$: 空気密度
$S = 0.122\mathrm{m}^2$: 反射鏡部の投影面積

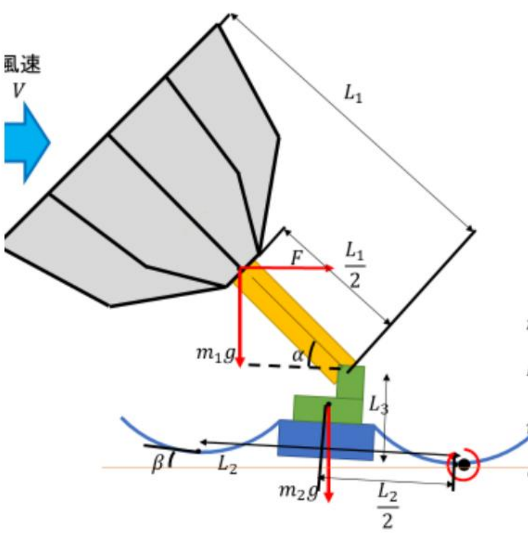
機体が倒れる条件は

$$F\left(\frac{L_1}{2}\sin(\alpha+\beta)+L_3\right) > m_1 g\left\{\frac{L_2}{2}\cos\beta - \frac{L_1}{2}\cos(\alpha+\beta)\right\} + m_2 g\frac{L_2}{2}\cos\beta$$

よって、倒れるために必要な風速Vは

$$V > \sqrt{\frac{g\{m_1\{L_2\cos\beta - L_1\cos(\alpha+\beta)\} + m_2 L_2\cos\beta\}}{\left\{\frac{L_1}{2}\sin(\alpha+\beta)+L_3\right\} C\rho S\cos(\alpha+\beta)}} = 15.7\mathrm{m/s}$$

Fig.4.2.4 Calculation of wind speed when falling down due to wind (case 3)



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$\rho = 1.29\mathrm{kg/m}^3$: 空気密度
$S = 0.122\mathrm{m}^2$: 反射鏡部の投影面積

機体が倒れる条件は

$$F\left(\frac{L_1}{2}\sin(\alpha+\beta)+L_3\right) >$$
$$m_1 g\left\{\frac{L_2}{2}\cos\beta + \frac{L_1}{2}\cos(\alpha+\beta)\right\} + m_2 g\frac{L_2}{2}\cos\beta$$

よって、倒れるために必要な風速Vは

$$V > \sqrt{\frac{g\{m_1\{L_2\cos\beta + L_1\cos(\alpha+\beta)\} + m_2 L_2\cos\beta\}}{\left\{\frac{L_1}{2}\sin(\alpha+\beta)+L_3\right\} C\rho S\cos(\alpha+\beta)}} = 9.14\mathrm{m/s}$$

Fig.4.2.5 Calculation of wind speed when falling down due to wind (case 4)

•Reflector section

As shown in Fig. 1.2, after the folded reflector section is stood up, the reflector section is unfolded. The reflection mirror before and after deployment is shown in Fig.4.2.6 and Fig.4.2.7, respectively. The names of the detailed parts of the reflector part in Fig. 4.2.7 are based on the name of the umbrella, which is the origin of this structure.

There is. The reflector has eight sets of frames, each of which has a reflective film sewn onto it.

Concentrates light. The upper wheel is fixed to the middle rod, and the reflector is expanded by sliding and pushing the lower wheel up using the spring inside the center rod. When unfolded, it has a structure that collects sunlight on the middle rod between the upper and lower wheels. In the envisioned deep space mission, solar panels will be attached to this part, but in this CanSat mission, the solar panels will be installed in this area.

As mentioned above, we will place more emphasis on light collection than power generation, and we will attach a light sensor and a temperature sensor to the hollow center rod to check the degree of light collection.

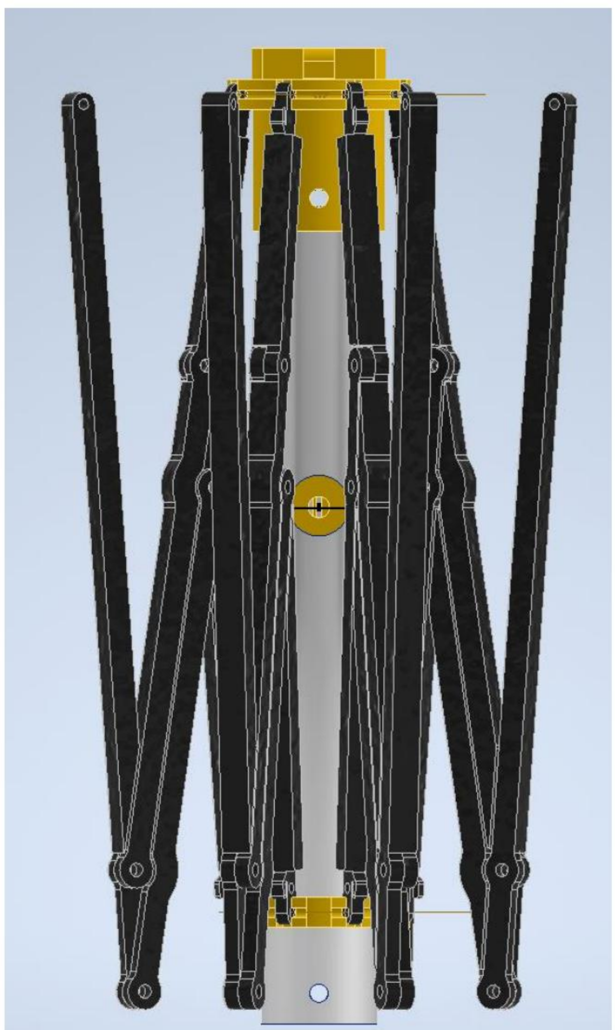

Fig.4.2.6 Reflector section before deployment

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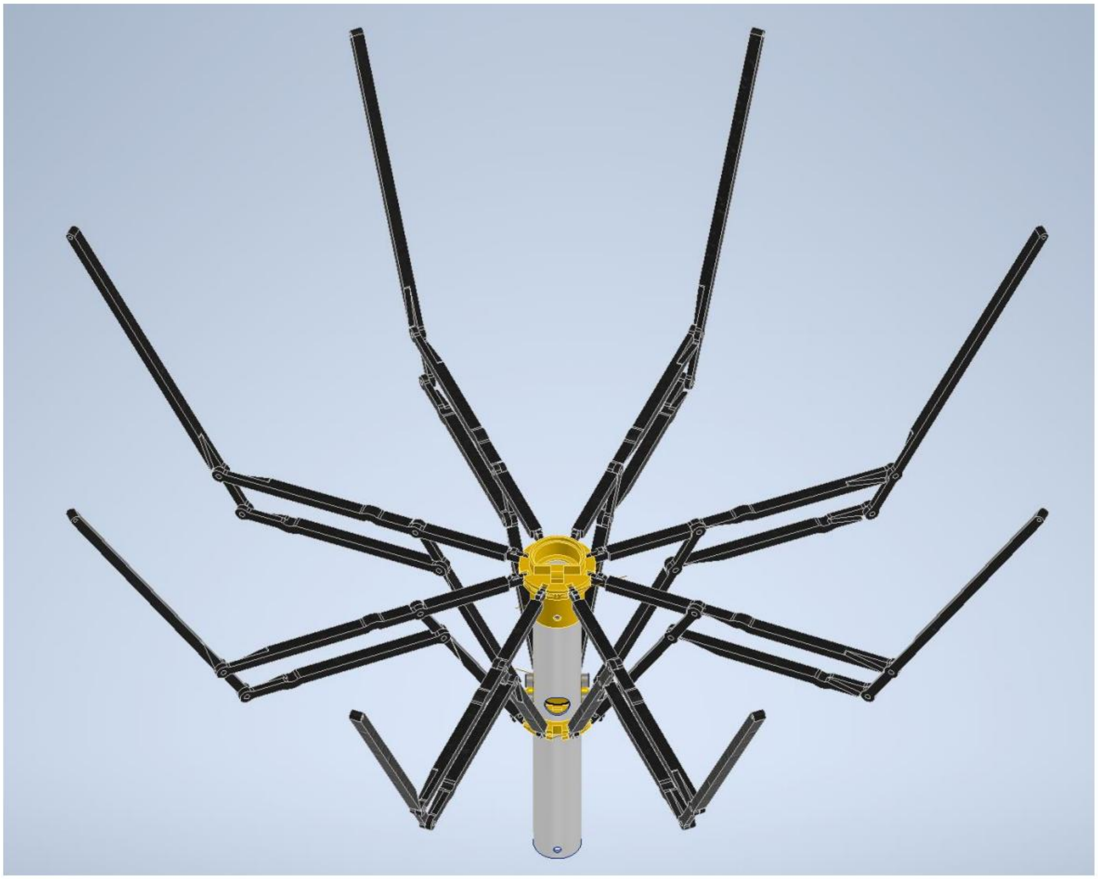
(a)



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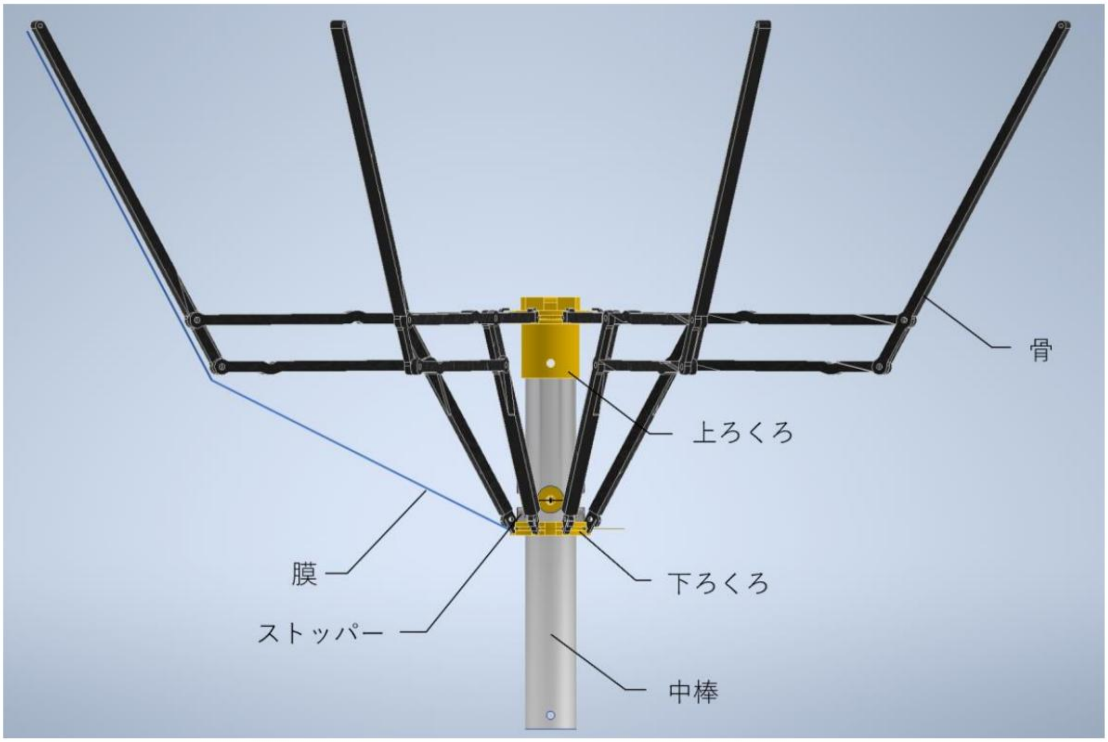


(c)

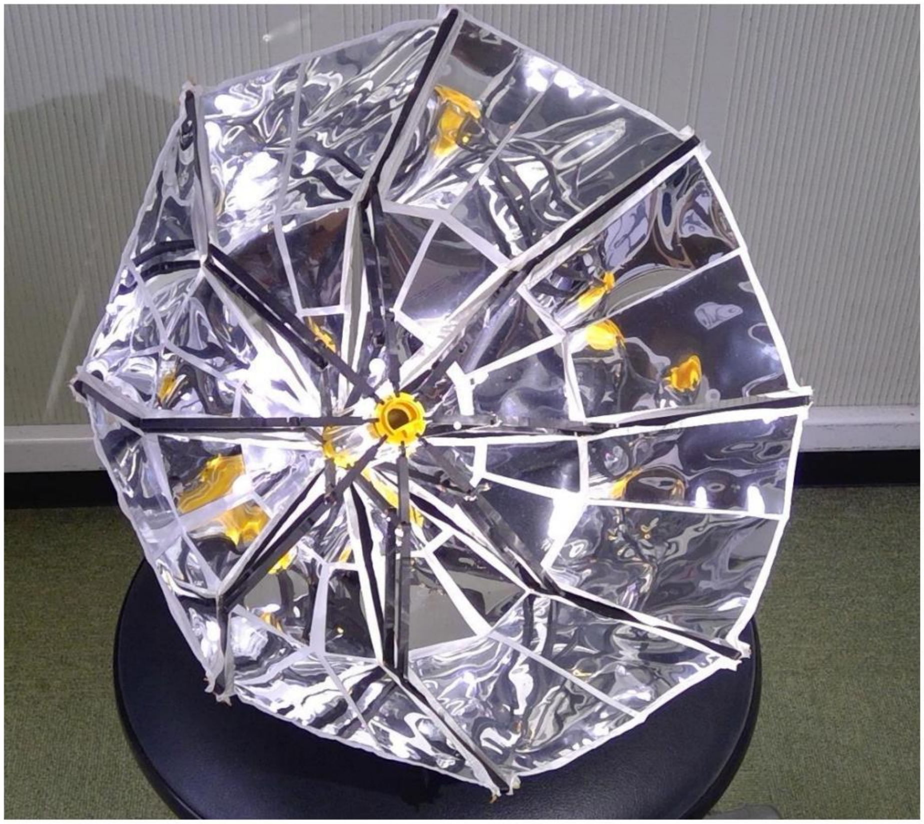


Fig.4.2.7 Reflector section after deployment

(a) Overview (b) Detailed name (c) State with reflective film attached

• Reflective film

This is the part of the reflector that has the function of reflecting sunlight. Fig.4.2.8 is reflected this time

This is the shape used when manufacturing the membrane.

The outermost shapes and lines in the diagram are the shapes of the cloth itself. When condensing light, the reflective film must be firmly

stretched with tension in order to approximate the ideal shape. This results in

The membrane is designed with a minimum distance between each bone, and it is

There is.

Also, in the figure, there is a part divided into five small areas apart from the outer shape of the reflective film, but this

This is a reflective material that is attached to the reflective film cloth. These reflective materials are placed to avoid the creases in order to be

attached to the cloth. This arrangement and shape maintains the surface accuracy of the reflective material.

It has an origami-like structure that allows for membrane expansion.

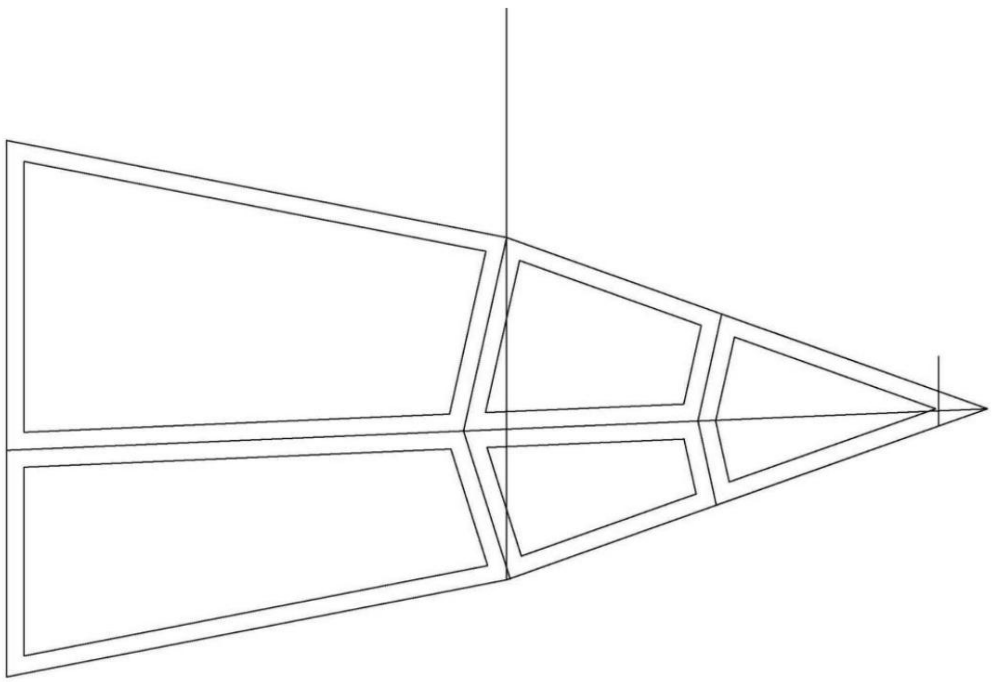


Fig.4.2.8 Shape of reflective film

• Bones

This structure requires the function of supporting the reflective film mentioned earlier, as well as the function of guiding movement during deployment and storage. This component is also a place where heat is collected due to condensing light, so it needed to be heat resistant and strong, and since it had a complex shape, it needed to be easy to process. Therefore, we used a 3D printer to process a resin containing micro-nano carbon fibers, which weighs about the same as ABS but has six times the strength.

The shape should have sufficient strength and a rubber band should be attached to store the reflector. The requirements were that there was a need for a place to store it, and that it could be folded into a small size. These Therefore, the structure shown in Fig. 4.2.9 was adopted for this mission. It is composed of four types of parts in total, and the locations for the rubber bands, which was one of the requirements, are located on bones 1 and 3. Also, Eyelets are used as the material to connect each part to ensure strength.

The reflector part is created by tying the reflective film from earlier to this bone part with thread. The reasons why we chose to join with thread are that free rotation occurs at the joint and that tension is applied. Also, the fabric does not elongate at the joint, and the fabric does not degenerate at the joint.

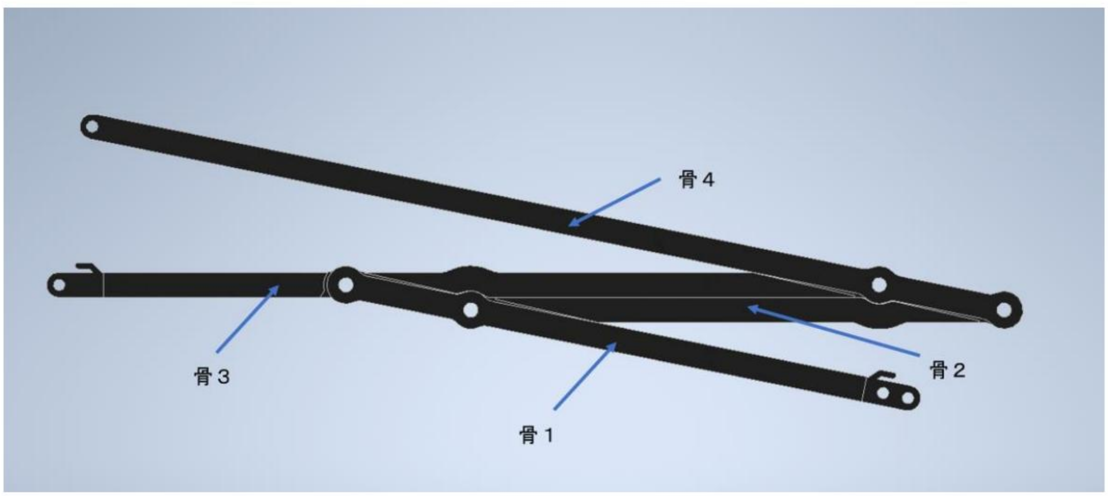


Fig.4.2.9 One skeleton

• Turntable section

This mechanism performs the ``lifting of the reflector'' and ``solar pointing'' as shown in Fig. 1.2. Fig.4.2.9 shows a bird's eye view and a view from the opposite side. In this part, the motor is fixed to the bottom of the cover part, and the cylinder of the rising part is fixed to the center rod of the reflector part, so that the turntable and the reflector part can be connected. can be rotated around the yaw axis. First,

to lift the reflector part, the reflector part is released by unfolding the cover part, and then lifted by the spring hinge and tension spring installed between the joint parts. The lifting angle at this time is 45 degrees. This is because the solar altitude during the day in the Black Rock Desert on the day of launch was 30 degrees to 60 degrees, and if the lift angle was 45 degrees, the error would be 15 degrees. The double cone structure that we adopted for the reflector section could collect light with 50% efficiency even at a deviation of 15 degrees from the sun's direction, so we determined that it would be sufficient to collect light even if the elevation angle was fixed at 45 degrees. be.

Next, the sun pointing is done by rotating the turntable section with a motor. Reflector part The light intensity is measured by the optical sensor attached to the tip of the center rod, and the motor (mini motor low speed gear box (4 speed)) shown in the dark green part of Fig. 4.2.9 is used to direct the light to the sun. I do. Optical sensor to confirm solar orientation and sunlight concentration, and temperature sensor to correct it.

The harness of the sensor passes through the center rod of the reflector section, is assembled on the circuit board on the turntable, and then connected to the main circuit board with a unified harness. The purpose of this is to prevent the 14 harnesses from tangling or twisting when the turntable is rotated. The acceleration sensor board is attached to the opposite side of the stand-up section, and from the top of the turntable, only two bundles of harnesses are connected to the main board.

The Rukoto.

(a) (b)

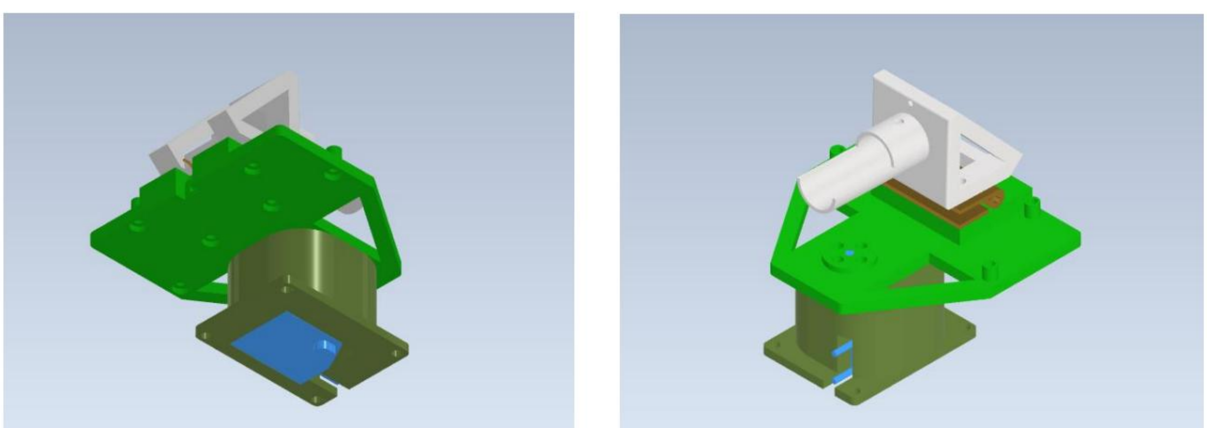


Fig.4.2.10 Schematic diagram of turntable section

(a) Bird's eye view, (b) View from the opposite side

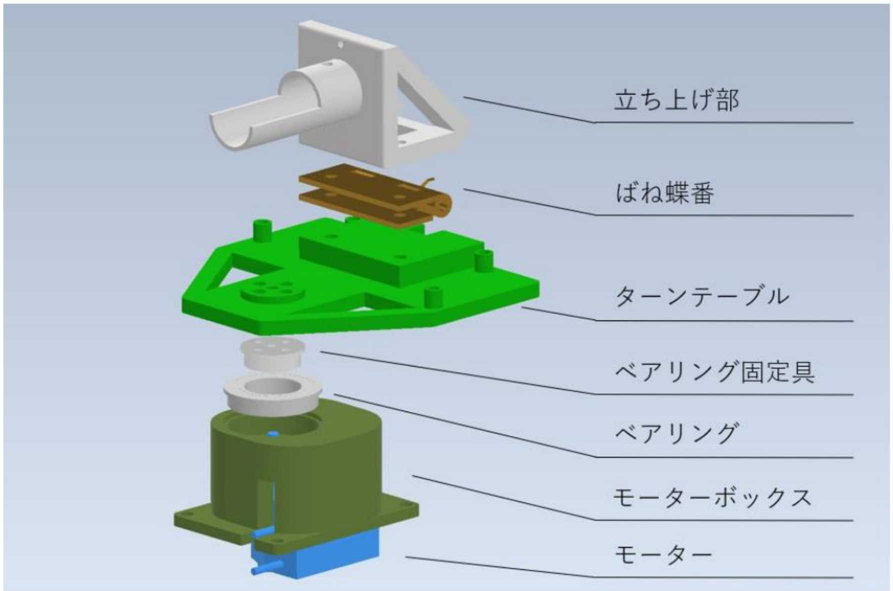
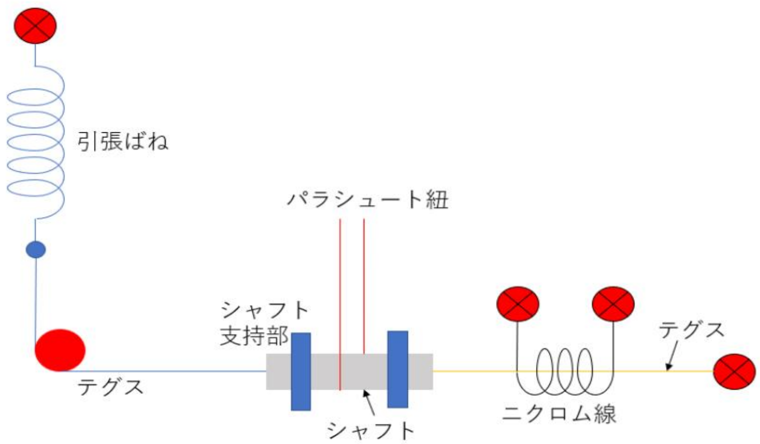


Fig.4.2.11 Detailed name diagram of turntable part

• Fusing mechanism

The fusing mechanism is used to separate the parachute and deploy the cover. Mainly tension springs, It consists of a foot, nichrome wire, and wire. When separating the parachute, electricity is applied to the nichrome wire. The tension spring attached to the opposite end of the shaft allows the shaft to be moved The shaft is designed to be removed from the support part. A photo of the actual mechanism is shown in Fig.4.2.12 (c). be.

(a)



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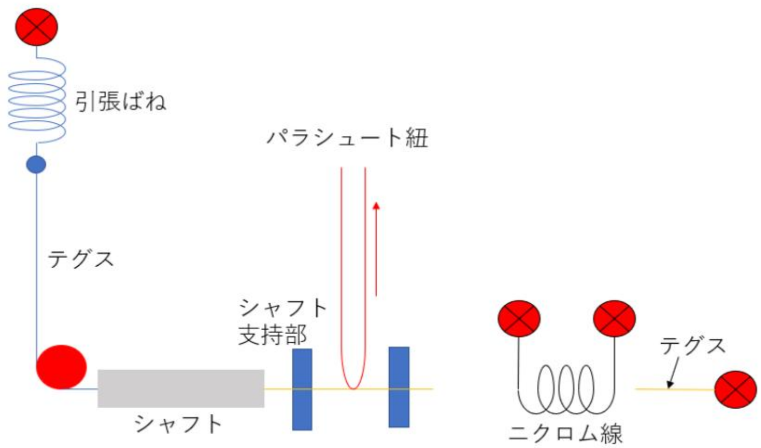


(c)

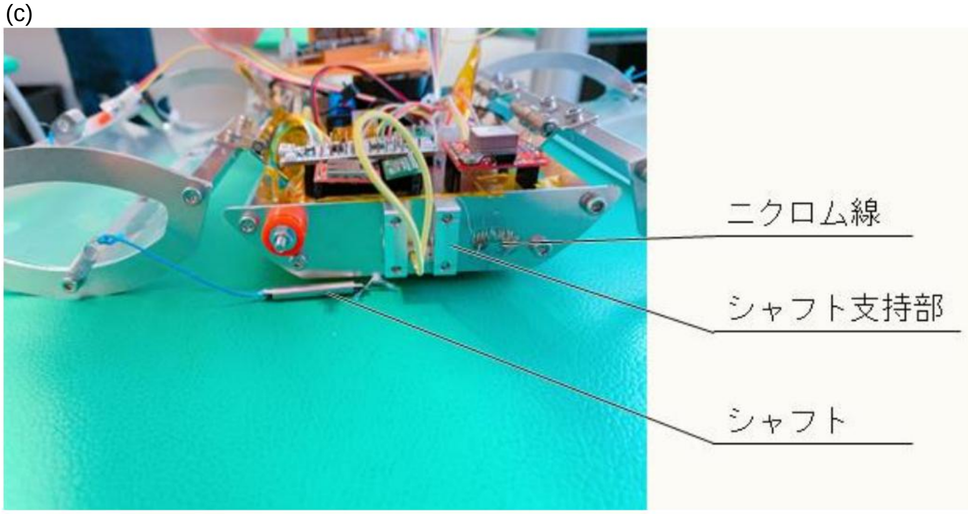
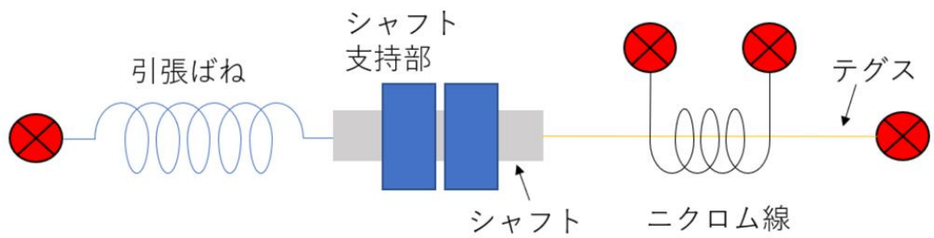


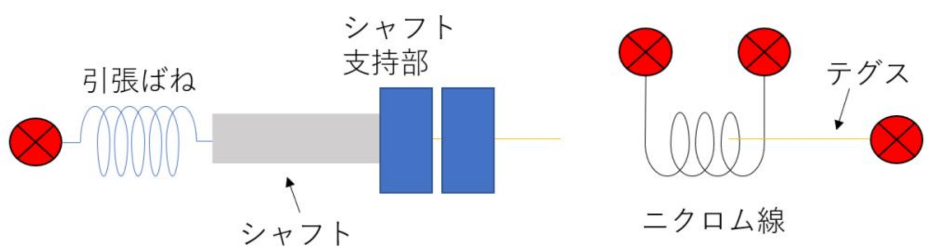
Fig.4.2.12 (a) Schematic diagram of the mechanism before fusing (b) Schematic diagram of the mechanism after fusing (c) Fusing mechanism for parachute separation

Furthermore, the mechanism for deploying the cover is similar to that of separating a parachute, except that the shaft is used like a bolt. A photograph of the actual mechanism is shown in Fig.4.2.13 (c).

(a)



(b)



(c)

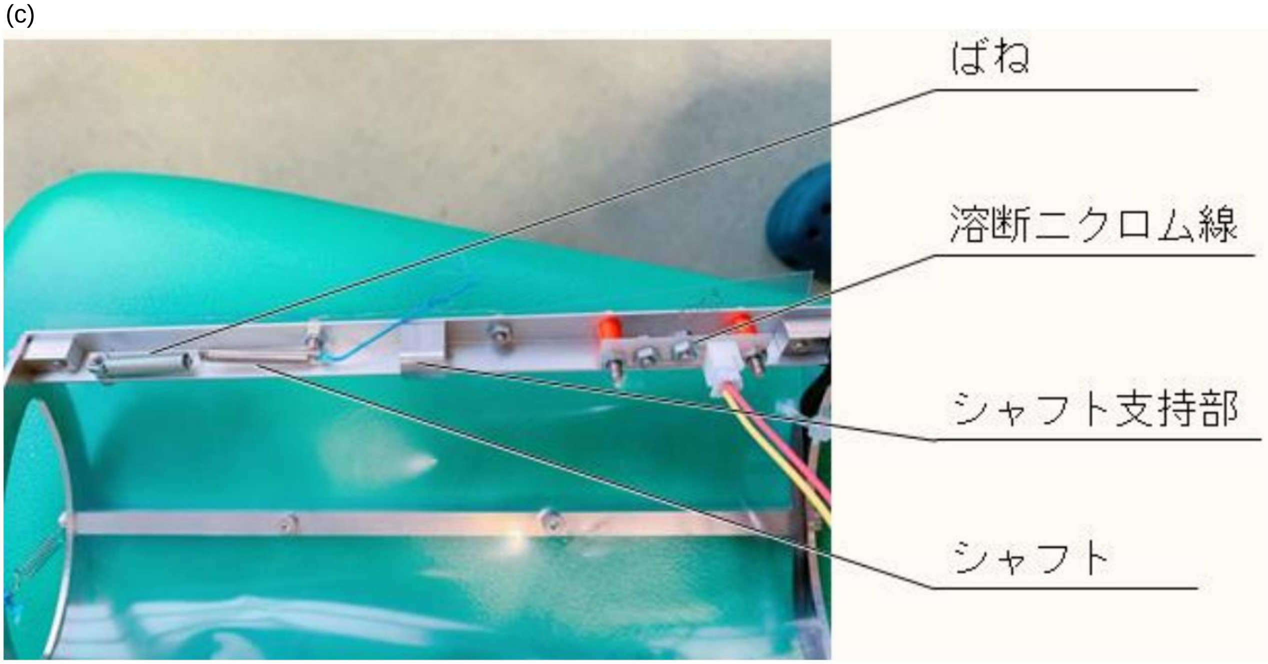


Fig.4.2.13 (a) Schematic diagram of the mechanism before fusing (b) Schematic diagram of the mechanism after fusing (c) Fusing mechanism for expanding the cover part

• Parachute

Considering the ease of manufacturing, we decided to make the parachute a regular hexagon. Ma

In addition, the base angle of the parachute is assumed to be 0° as it does not have a large effect on the dimensions.

Design it as a flat parachute. One side of a regular hexagon divided into six regular triangles

If the length is set to , then the area of the hexagon, ignoring the spill hole, is

$$_0 = \frac{3ÿ\overline{3}}{2} \; ^2$$

It is given by . This area is based on the "Parachute Recovery System Design Manual, TWKnacke".

Corresponds to the nominal area in the materials.

Next, the parachute mounted on this aircraft must have a spill hole to ensure its stability.

Suppose that Regarding the size of the spill hole, according to Utah State University's document "Recovery System: Parachutes 101" (Reference URL: http://

mae-nas.eng.usu.edu/MAE_6530_Web/New_Course/launch_design/Section3.5.pdf) Ba, pa

When the nominal area of the lachute is 0 and the area of the spill hole is ,

$$\frac{}{_0} \sim 0.01(= 1\%)$$

There was a statement that it is common to do so. Here, the parachute made of hexagons is deployed.

In this case, the cross-sectional shape is likely to be close to circular. Therefore, the spill hole

We will use a circular model as the design model. Therefore, the radius of the parachute

Let , and the radius of the spill hole be .

In order to make the design calculations easier to understand, a parameter called spill hole ratio is used.

$$= \frac{}{}$$

Let's define it as Then,

$$\sim 0.1$$

It can be calculated as Here is a parachute obtained from the empirical rules of past parachute drop tests.

Considering that the spill hole ratio is a little large for stabilization, it is assumed to be around $0.1 < < 0.2$.

Based on the results of the drop test, the more stable spill hole ratio was determined to be $= 0.2$.

Next, system requirement [S6] ``Deceleration mechanism to prevent falling at dangerous speed near the ground surface"

The target terminal velocity is set to 5 m/s, and its performance has been confirmed in tests.

Determine the design value from the equation of motion when the parachute is deployed. The equation of motion is

is written as follows, where is the descending speed of the aircraft.

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$$= ÿ \frac{1}{2} 2 [(\quad _0) + (\quad _0)]$$

However, (ÿ $_0$) is a parachute, (ÿ $_0$) is the product of the drag coefficient and the nominal area for the aircraft.

It shows. However, the nominal area of the aircraft should be defined in terms of cross-sectional area, not surface area.

Ru.

Regarding the drag coefficient of a parachute, a circular model according to "Parachute Recovery System Design Manual, TWKnacke" (reference URL: https://apps.dtic.mil/sti/citations/ADA247666) is used.

drag coefficient

$$0.75 < < 0.80$$

From this, we estimate a lower design value. $_,$ = 0.75.

Analytically, the aircraft will be modeled as a cylinder. Aircraft mass is large

Estimate, = 1.05, fuselage diameter is assumed = 0.14, fuselage length is also assumed

= 0.20. Then, ÿ 1.42, and since it falls sideways, the resistance is

The following values can be used for the force coefficient.

$$= \{0.63, (= 1) \; 0.68, (= 2)$$

By linear interpolation from this value, the drag coefficient of the aircraft is

$$_, = 0.63 + \frac{0.68 ÿ 0.63}{2-1} ÿ (1.42 ÿ 1) ÿ 0.65$$

We will use Also,

$$_{0,} = = 0.028 \quad ^2$$

Than

$$(\quad _0) = 0.0182 \quad ^2$$

is obtained.

The atmospheric density used to solve the equation of motion is based on the US Standard Atmosphere 1976 (https://www.ngdc.noaa.gov/stp/space-weather/online-publications/miscellaneous/us-standard-atmosphere-1976/us-standard-atmosphere_st76-1562_noaa.pdf)

= 1.0900 / 3 was adopted based on the altitude of the desert (approximately 1,200 m) .

Target terminal speed determined from system requirement [S6] (= 5 / $_ÿ$ = 0 / ^{2}) and substitute

Solving the equation of motion using

$$0 = ÿ \frac{1}{2} 2 [(\quad _0) + (\quad _0)]$$

from

$$, = \frac{\frac{2}{2} ÿ (\quad ' \quad _0)}{,} = 0.9833 \quad 2$$

The required nominal area of the parachute can be obtained as . By calculating backwards from this, we get

When you ask for it

$$=ÿ2 \frac{0}{3ÿ3} ÿ 0.62$$

Therefore, we decided to use these dimensions for this parachute.

The dimensions of the parachute are shown in Fig.4.2.14.

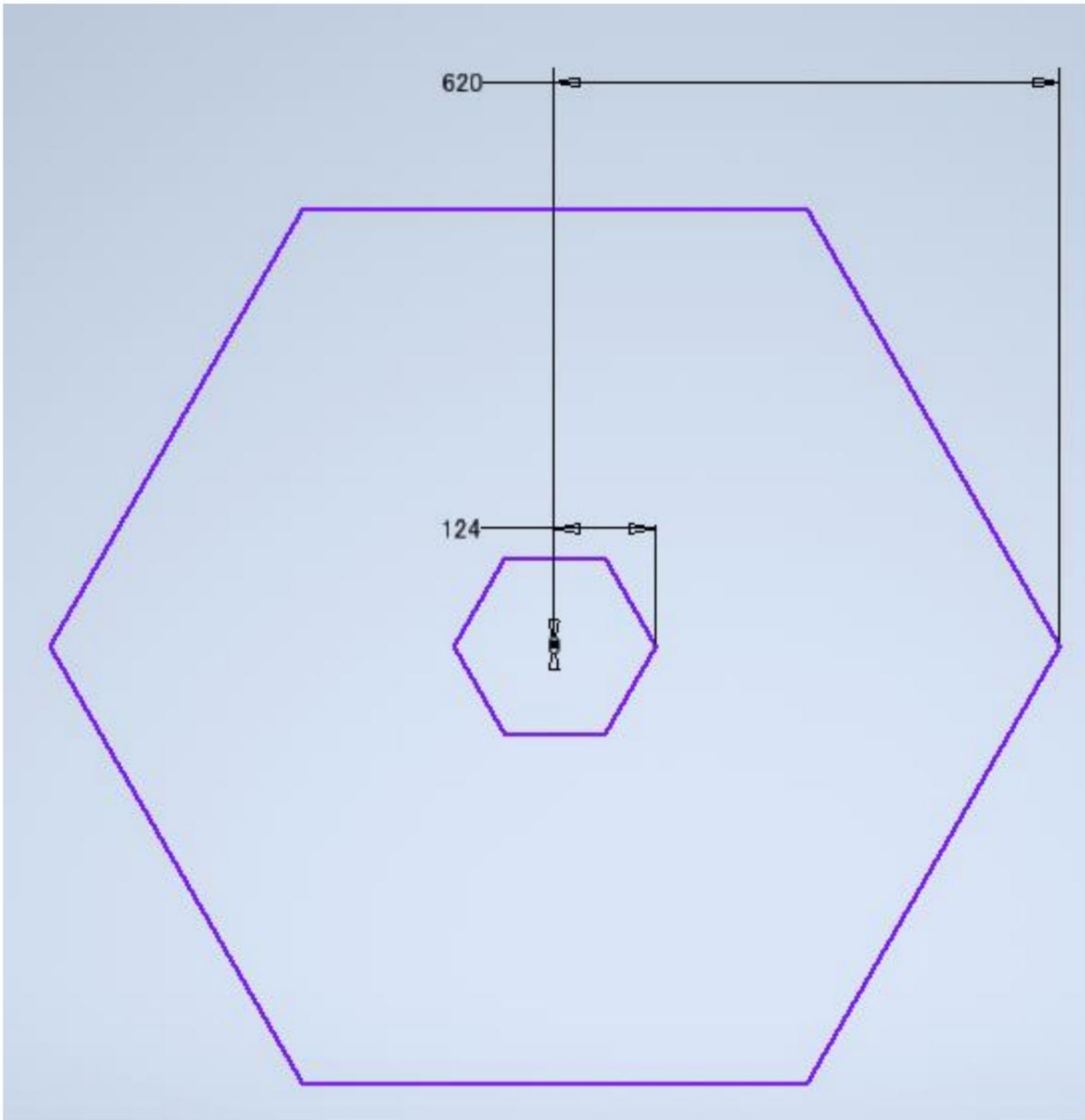

Fig.4.2.14 Parachute dimensions

The material of the parachute is ripstop, and the cut part is folded back and wrapped with nylon 66 thread.

I sewed it using A total of six eyelets with an inner diameter of 5 mm were attached to each vertex. actually made

The created parachute is shown in Fig4.2.15.

Fig.4.2.15 Manufactured parachute

The shroud line was created using Kevlar line. length is parachute

Nominal diameter of

0 =ÿ4 0 ÿ 1.119

Using Utah State University's document "Recovery System: Parachutes 101" (Reference URL: http://mae-nas.eng.usu.edu/MAE_6530_Web/New_Course/launch_design/Section3.5.pdf) to

Therefore, the shroud line is 1 < 0 Since it is often set to < 2, it is not possible to fall within this range.

The shroud line was created by determining = 1.5 using the given value.

In addition, in order to separate it from the fuselage without getting caught, both ends of the connection part with the fusing mechanism are machined with eyes.

It uses engineered wire. In addition, after landing, the parachute does not cover the top of the aircraft.

Place a distance of 1 m from the point where the shroud lines are bundled to the wire part, and use shrink tube to

It is hardened.

4.3 Electrical

equipment 4.3.1 Circuit

The electrical system is shown in the system diagram in Fig. 4.3.1.

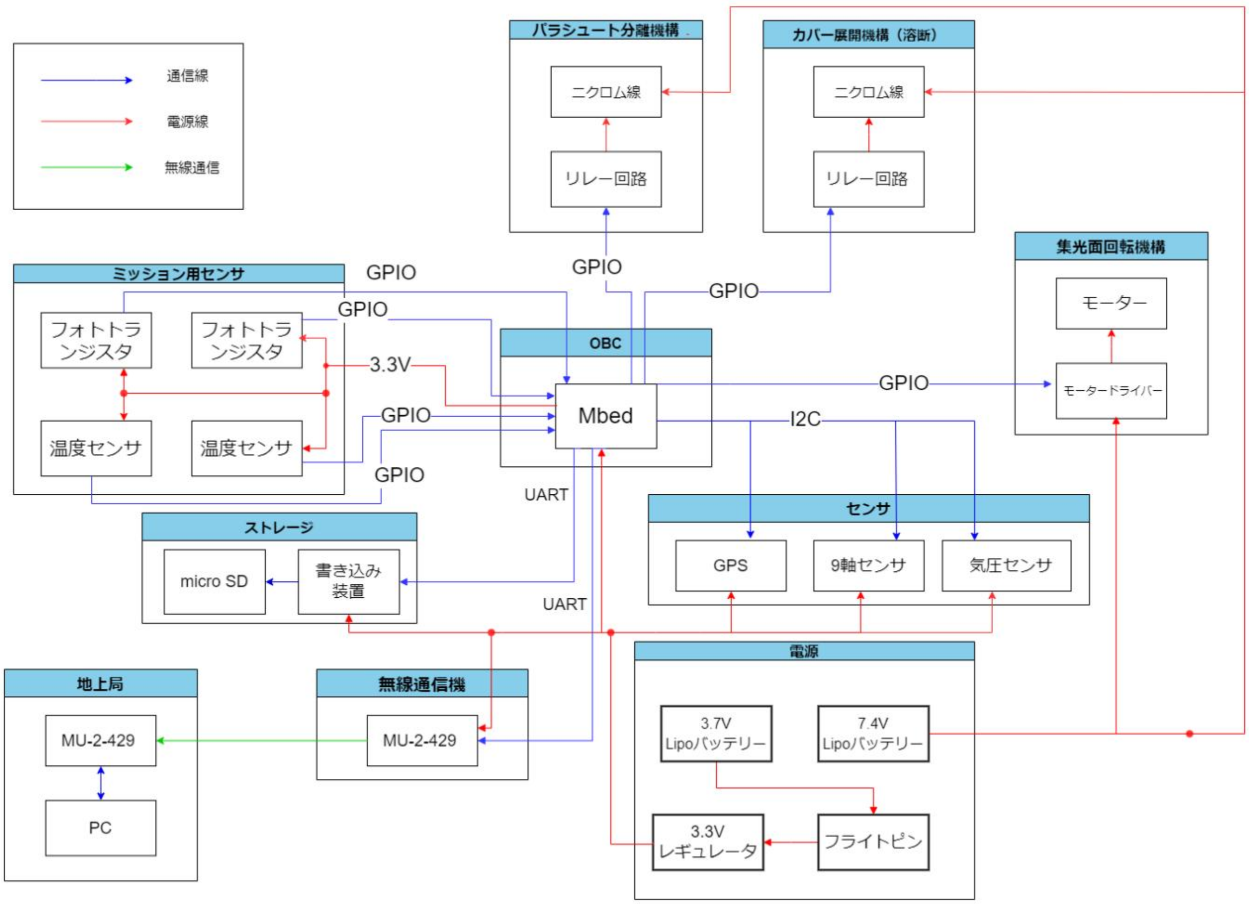

Fig.4.3.1 System diagram

The board consists of a main board on which the OBC and GPS modules are mounted, and a base on which the communication device MU-2 is mounted.

It is divided into a board, a board equipped with a 9-axis sensor, and a board for connecting to each sensor.

Power is provided by 3.7V and 7.4V Lipo batteries. By removing the flight pin, power is supplied to the microcontroller from the 3.7V battery. The 7.4V battery is used to blow the wire and supply power to the motor.

ÿ 4.3.1.1 Main board

mbed, various sensors, SD slot, motor driver, nichrome for cutting wires

It is equipped with a circuit that controls the current flowing to the line.

The microcomputer, sensor, SD, and radio are powered by a 3.3V regulator from a 3.7V battery.

Power is supplied via a The mission sensor is powered by 3.3V from the microcontroller.

There is.

In addition, a 7.4V battery is used to cut the wire and drive the motor.

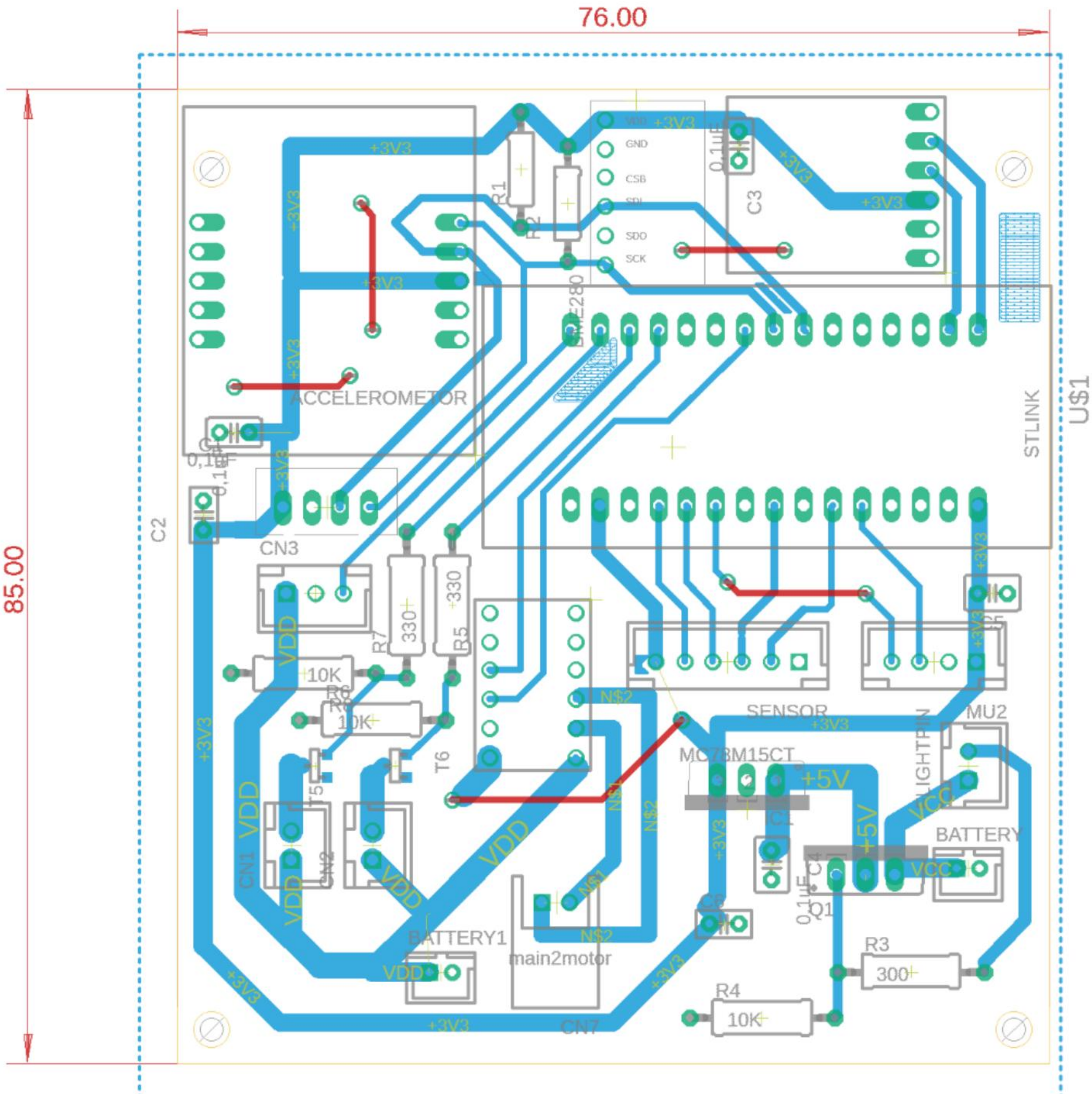

Fig.4.3.2 Main board board diagram

ÿ 4.3.1.2 MU-2 board This

board is equipped with the MU-2-429 (radio device).

It is connected to the mbed on the main board via a connector.

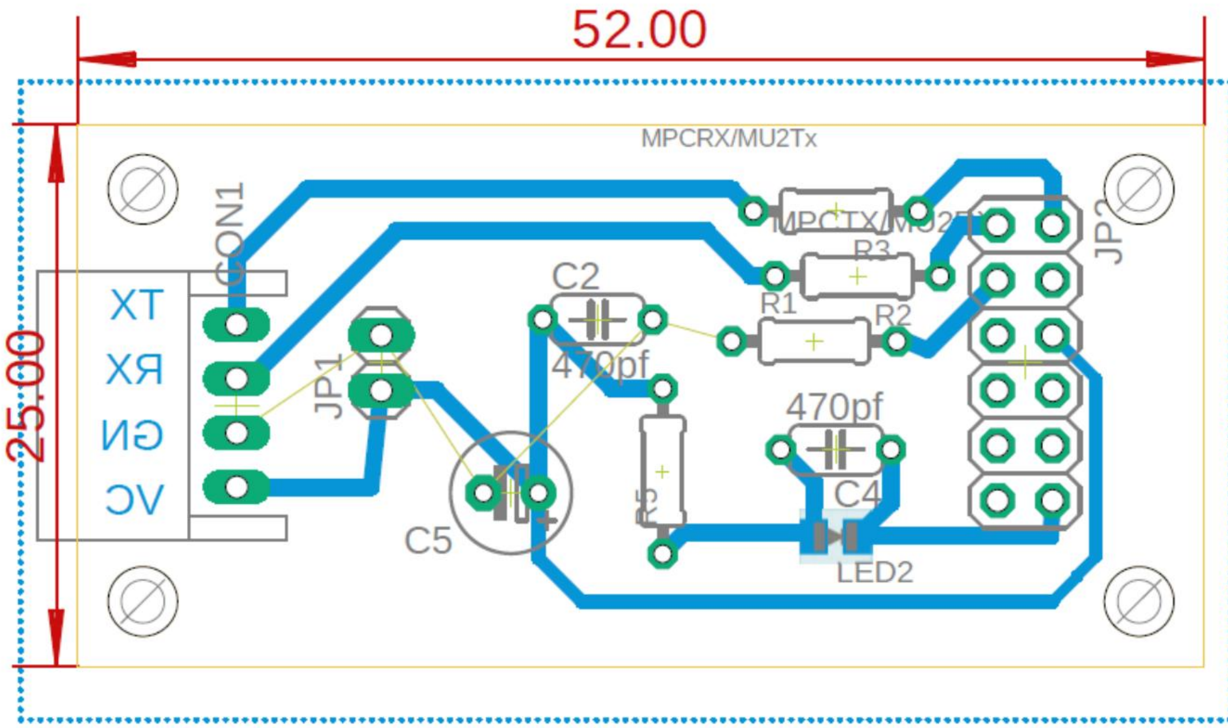

Fig.4.3.3 MU-2 board board diagram

ÿ 4.3.1.3 Light/temperature sensor board

This board includes a light sensor and a temperature sensor placed inside and at the tip of the center rod of the reflector, and the mbed.

This is the board that relays the information.

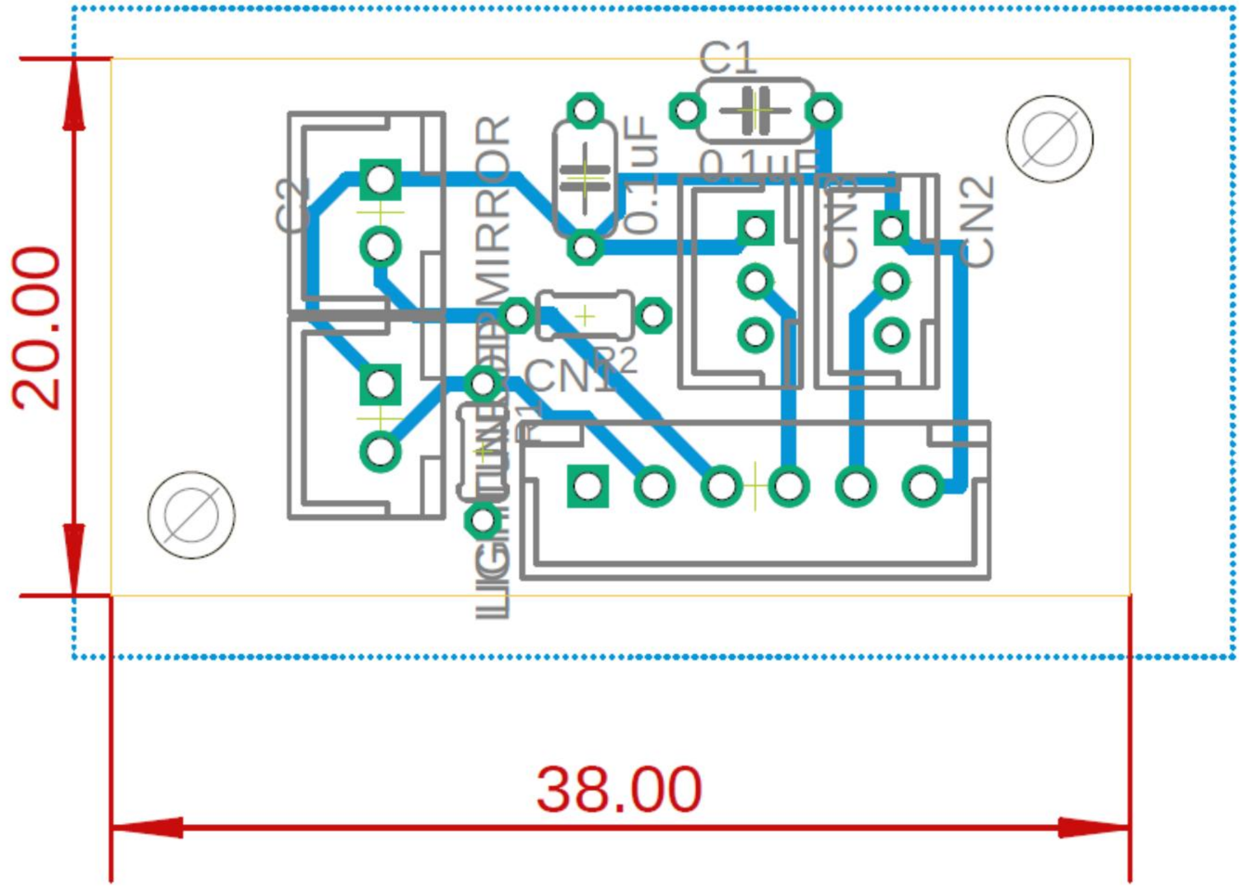

Fig.4.3.4 Light/temperature sensor board Board diagram

ÿ 4.3.1.4 9-axis sensor board

A 9-axis sensor is mounted on this board and is installed on the turntable.

It is connected to mbed through a connector.

The 9-axis sensor is used to detect the rotation angle of the reflector, and it is used in conjunction with the information from the optical sensor.

This directs the reflector toward the sun.

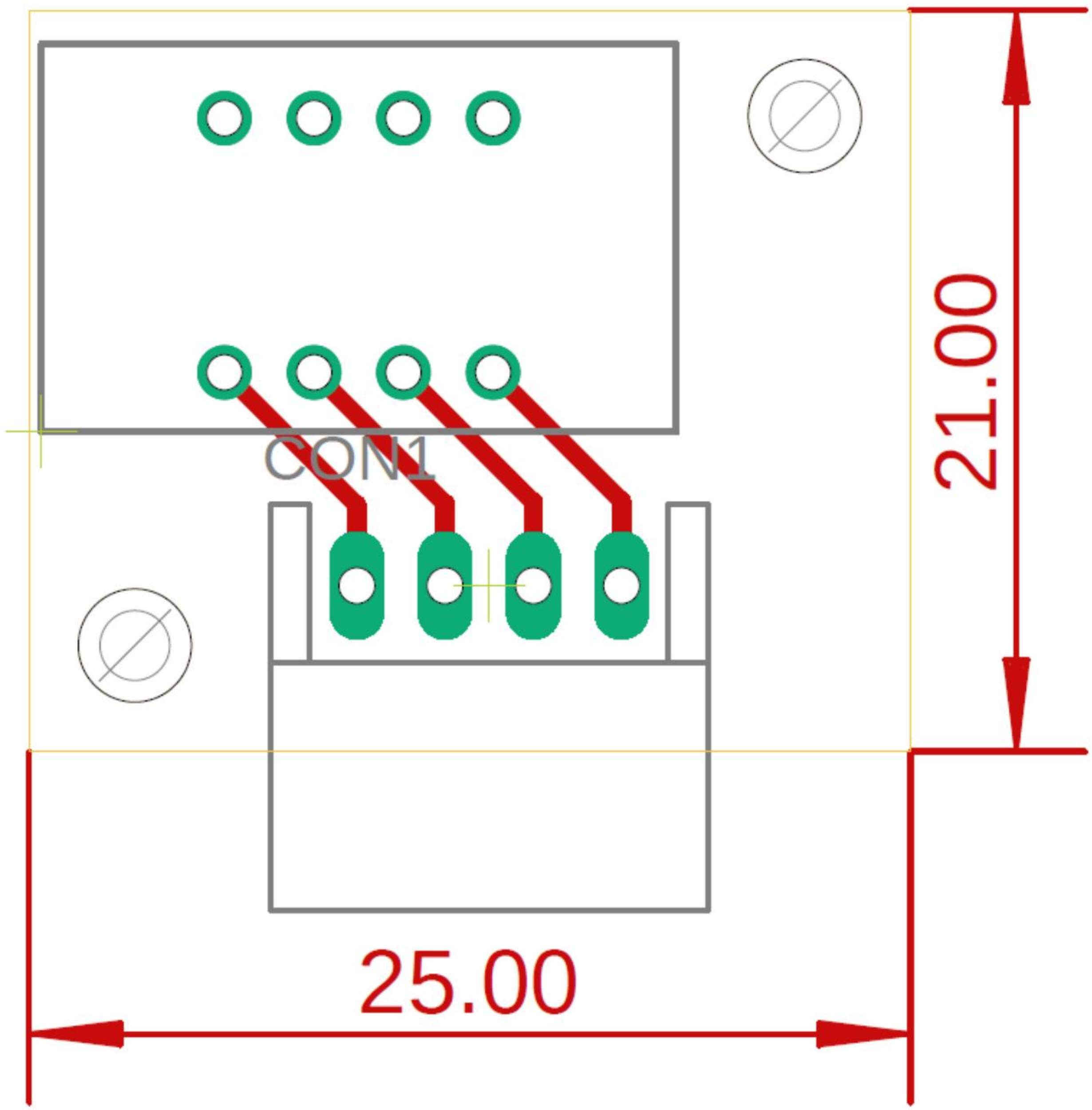

Fig.4.3.5 9-axis acceleration sensor board Board diagram

Table 4.3.1 shows the electrical components installed in this machine.

Table 4.3.1 Electrical equipment list

Microcomputer	mbed STM32 NUCLEO L432KC
communication device	MU-2-429
GPS sensor	GPS module XA1110
9 axis sensor	9 axis sensor module BNO055
writing device	SD card slot OpenLog
atmospheric pressure sensor	Barometric pressure sensor module BME280
Motor driver DRV8835	
Phototransistor ST-1CL3H	
temperature sensor	Temperature sensor IC MCP9700A

4.3.2 Algorithm

After starting up the microcomputer, this device connects the GPS thread and mission to send satellite status and GPS information.

A multi-threaded method is used in which control is divided into main threads, which control the main thread.

The main thread selects each mission sequence as a satellite status.

The GPS thread acquires position information and satellite status, and transmits the contents using a communication device. Mamoru

If the star status is other than 5, write the contents to SD. Repeat this loop every 2 seconds.

The flowchart is shown below.

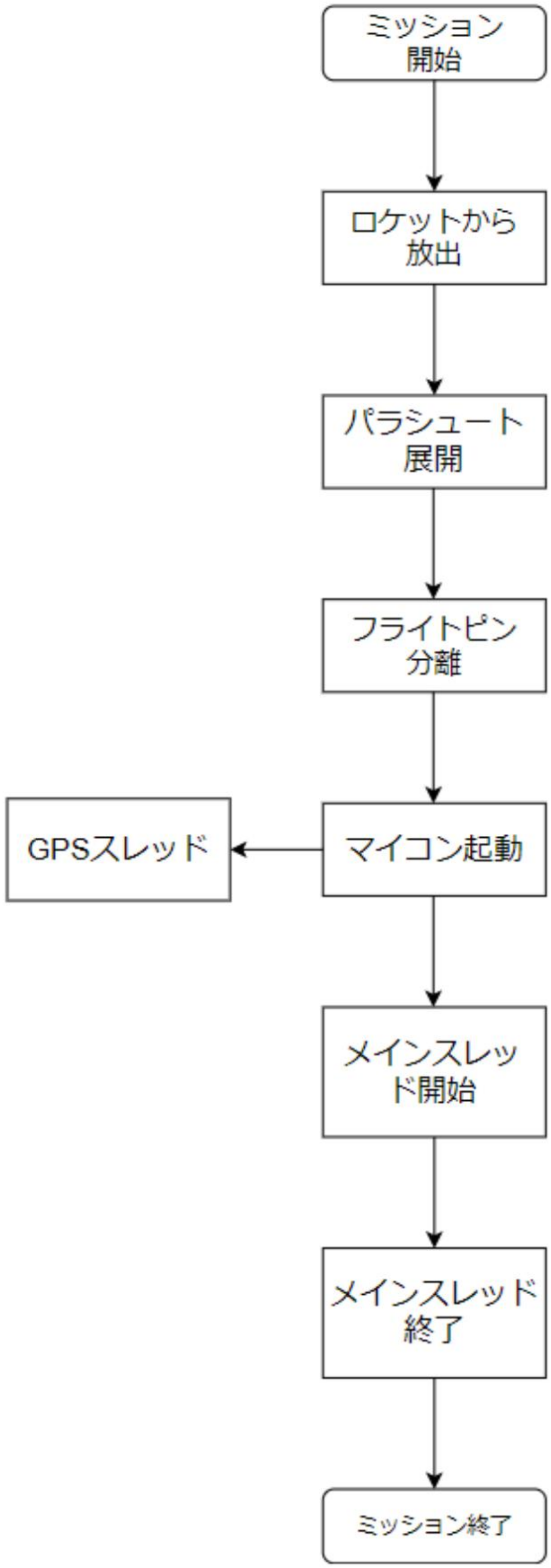

Fig.4.3.2.1 Overall flowchart

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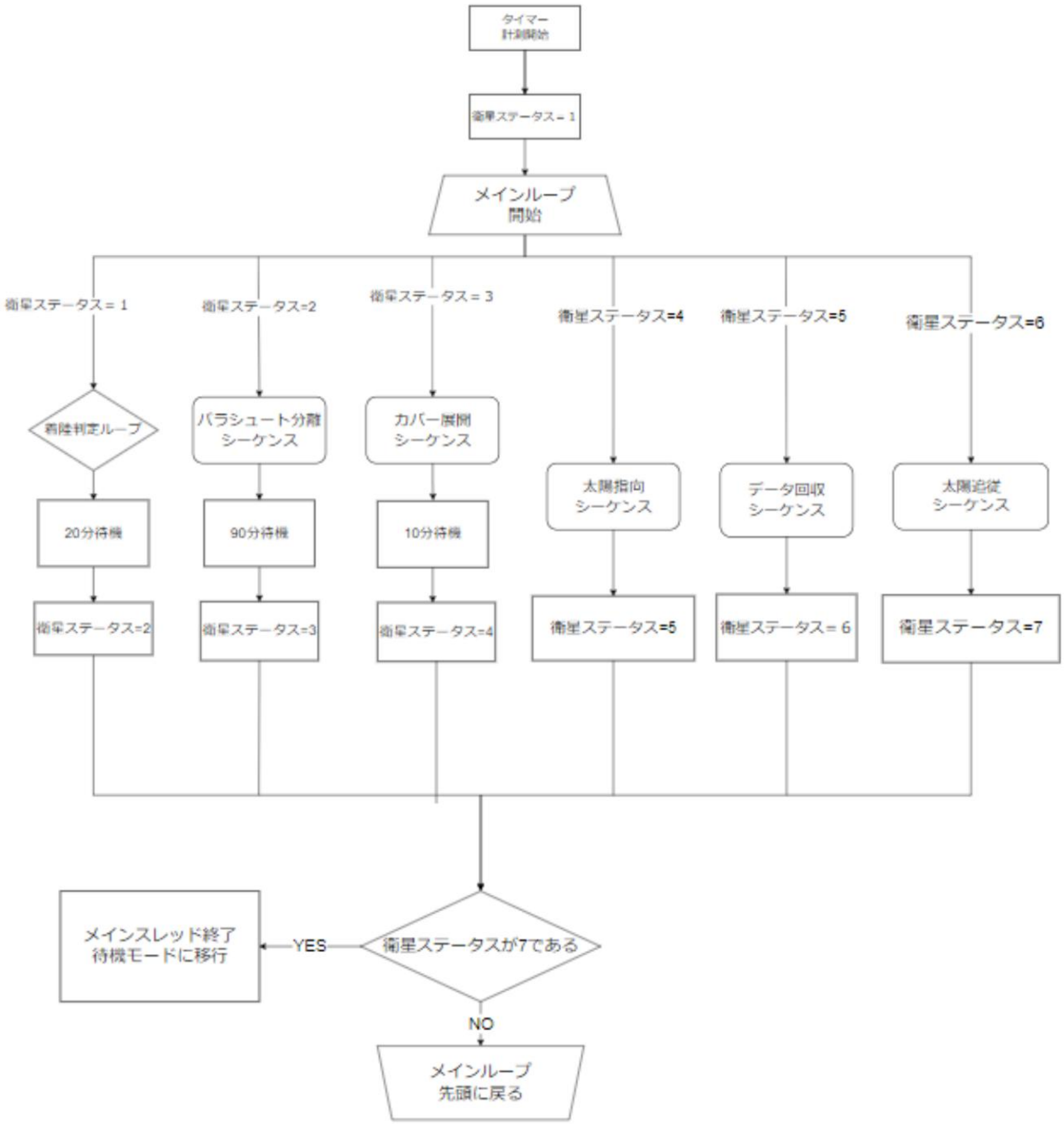

Fig.4.3.2.2 Main thread flowchart

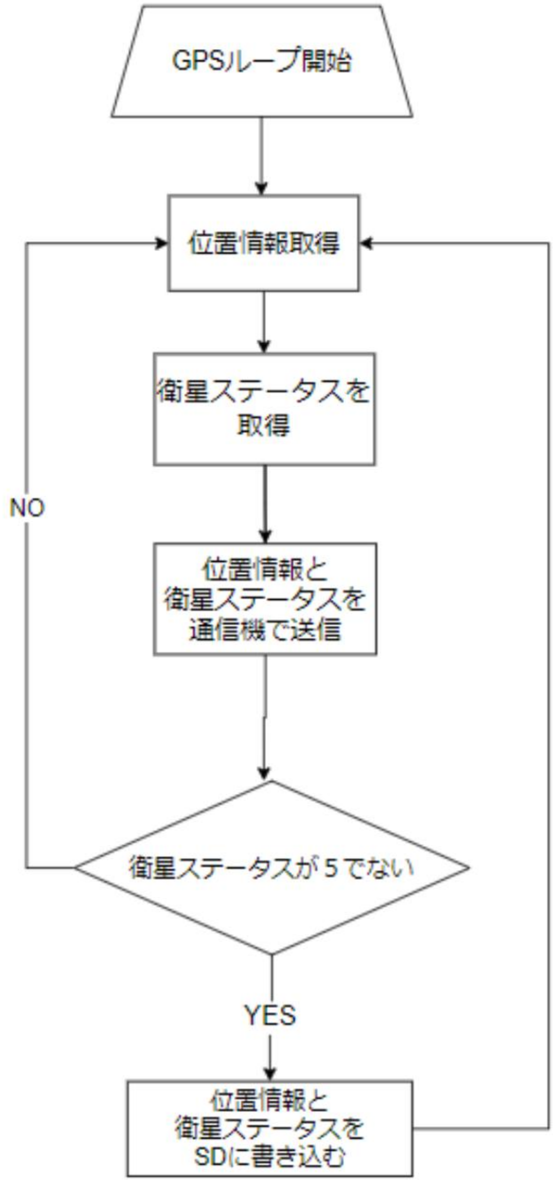

Fig.4.3.2.3 GPS thread

Table 4.3.2 shows the sequence contents for each status.

Table 4.3.2 Status number and sequence content correspondence table

Status number	Sequence content
1	Landing detection
2	Parachute separation (tegus cutting)
3	Cover development (tegs fusing)
Four	Sun-oriented (motor rotation)
Five	Data collection (SD writing)
6	Sun tracking (motor rotation)
7	Standby mode

Status 1: Landing detection sequence

Obtain the atmospheric pressure value and compare the difference with the previously obtained value. If the difference is greater than 0.1hPa, the Return to atmospheric pressure value acquisition without changing the land count. When the difference is less than 0.1hPa, the landing count is increased by 1 and the landing is completed. If the count is less than 10, return to atmospheric pressure value acquisition. The landing count exceeded 10 and the timer If the measured value exceeds 15 minutes, the landing will be determined.

Furthermore, even if the landing count does not reach 10, the process will proceed to the parachute separation sequence after 20 minutes. The number of 20 minutes was determined from the fall time of a parachute drop from 4 km above the ground with a terminal velocity of 5 m/s.

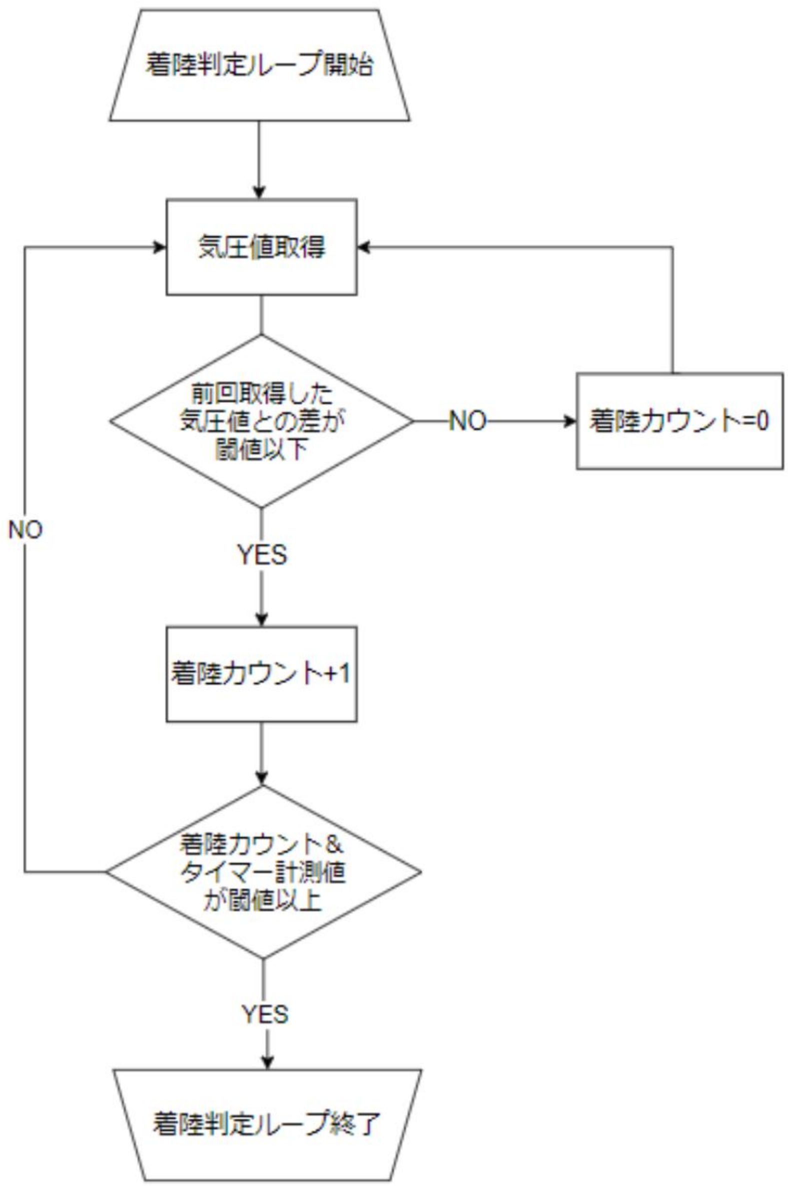

Fig.4.3.2.4 Landing detection flowchart

Status 2: Parachute separation sequence

Heat the nichrome wire by inputting 1 from the pin. When heating starts, record the heating start in SD do. After 5 seconds, input 0 to the pin to finish heating the nichrome wire. The completion of heating is recorded in the SD, and after a 90-minute waiting period, the process moves to the cover deployment sequence.

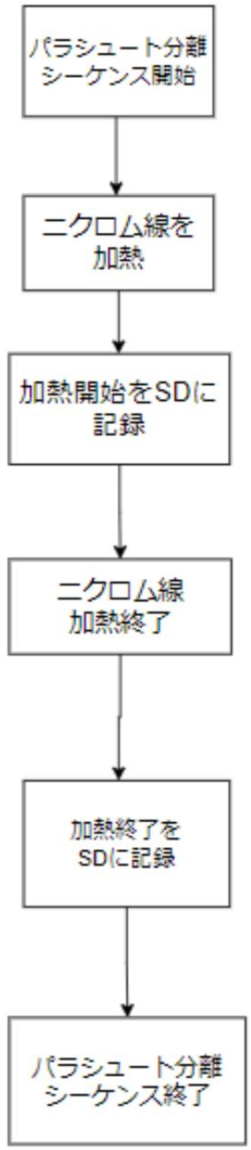

Fig.4.3.2.5 Parachute separation flowchart

Machine Translated by Google

Status 3: Cover deployment sequence

Heat the nichrome wire by inputting 1 to the pin. When heating starts, record the heating start in SD.

Ru. After 5 seconds, input 0 to the pin to finish heating the nichrome wire. Record the completion of heating in the SD and unfold the cover.

Move to sequence.

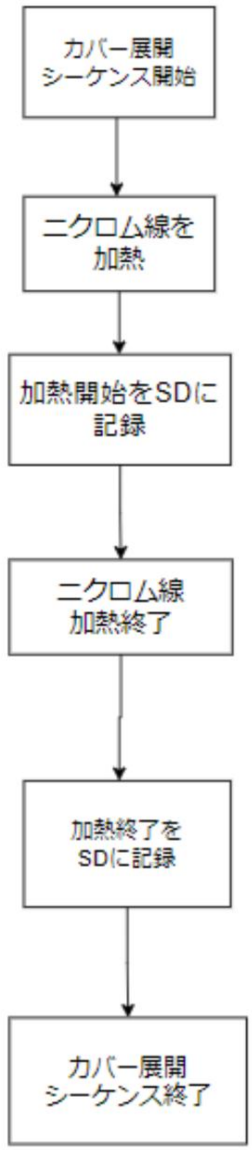

Fig.4.3.2.6 Cover expansion flowchart

Status 4: Sun pointing sequence

Obtain the value of the 9-axis sensor, and if it cannot be obtained, reset the 9-axis sensor and start the sequence. Return to. If the data can be obtained, rotate the motor by -180° from the initial position, and start the sun detection loop from here. This is the start. Rotate the motor counterclockwise for 0.1 seconds and obtain the phototransistor value. If the obtained value is larger than the previous value, the angle around the yaw axis of the current turntable is changed to the sun direction. Suppose that If the rotation angle of the motor has not reached 360°, the process returns to the beginning of the sun detection loop. When it reaches 360°, the sun detection loop ends and the motor rotates to the determined sun direction. Have this After completing the solar orientation, move on to the data collection sequence.

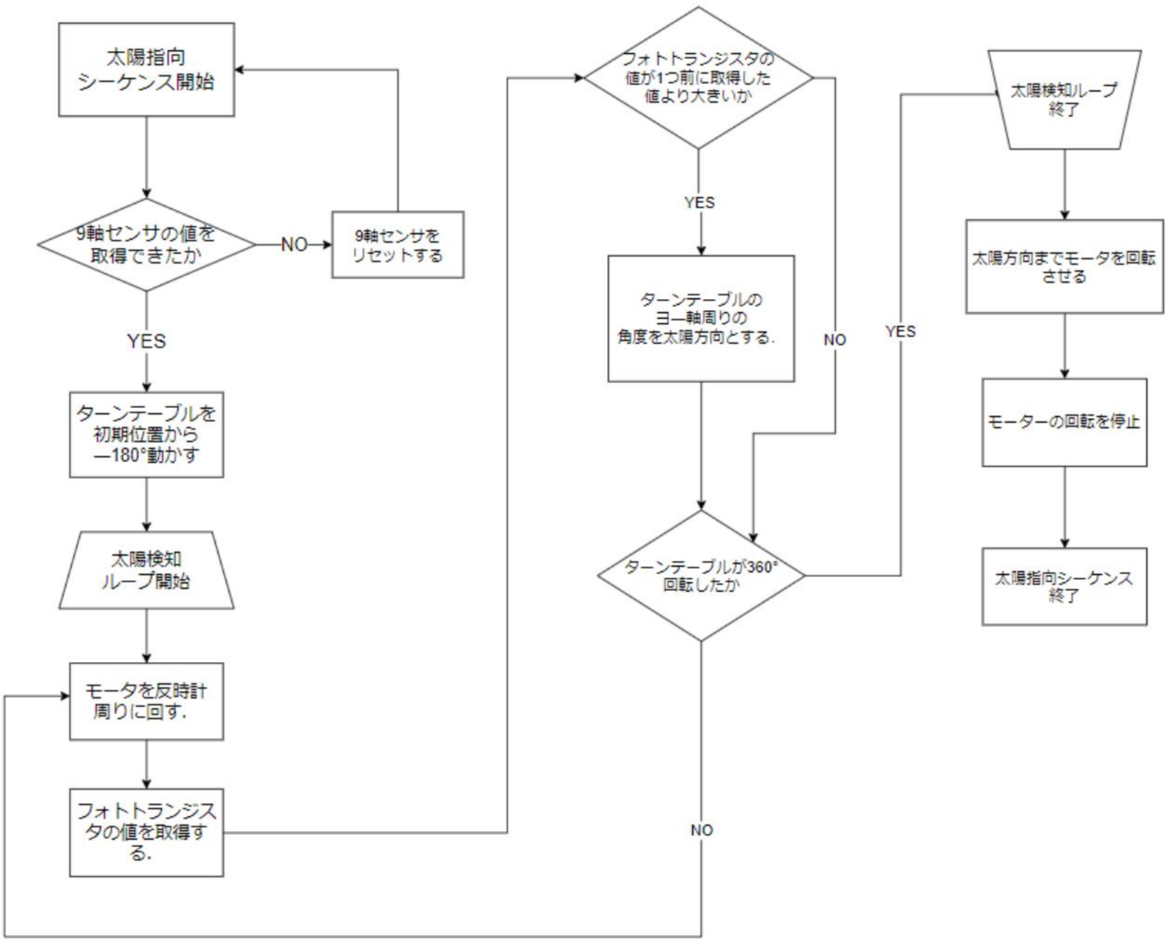

Fig.4.3.2.7 Sun orientation flowchart

Status 5: Data collection sequence

Obtain the values of each phototransistor and temperature sensor, and record the values on the SD card. 1 second

If 10 minutes have not passed since the start of the sequence, it will wait and return to sensor value acquisition. After 10 minutes

Once data acquisition is complete, move on to the sun tracking sequence.

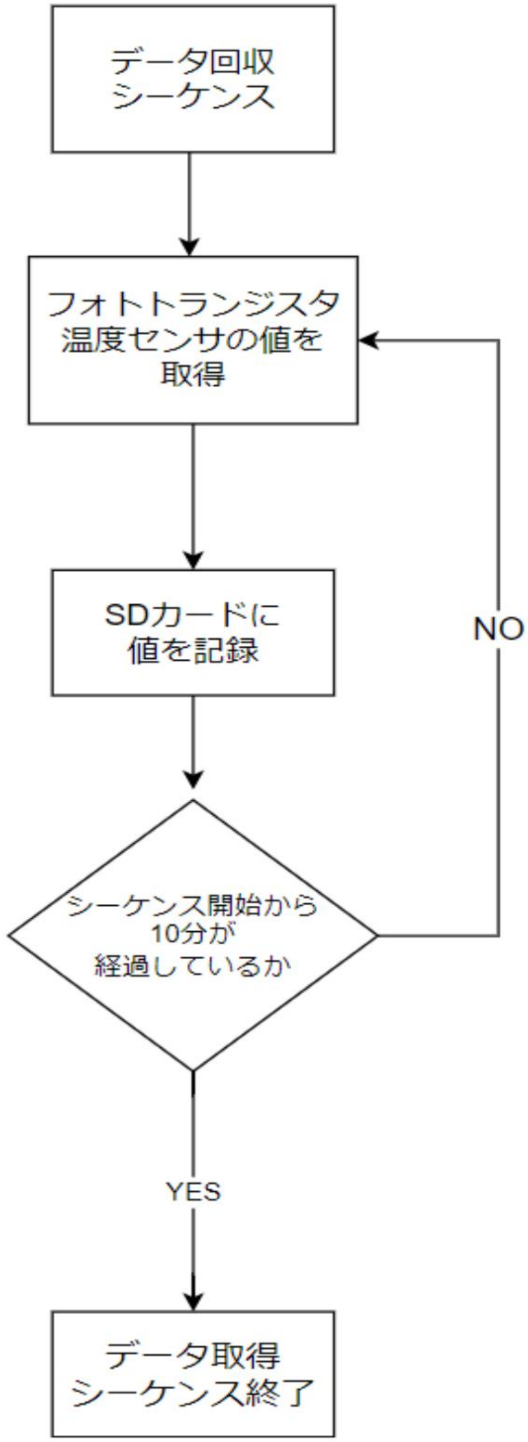

Fig.4.3.2.8 Data collection flowchart

Status 6: Sun tracking sequence

Extreme value search control is used for the sun tracking sequence.

Fig.4.3.2.9 shows the control system for detecting the sun direction in the sun tracking sequence.

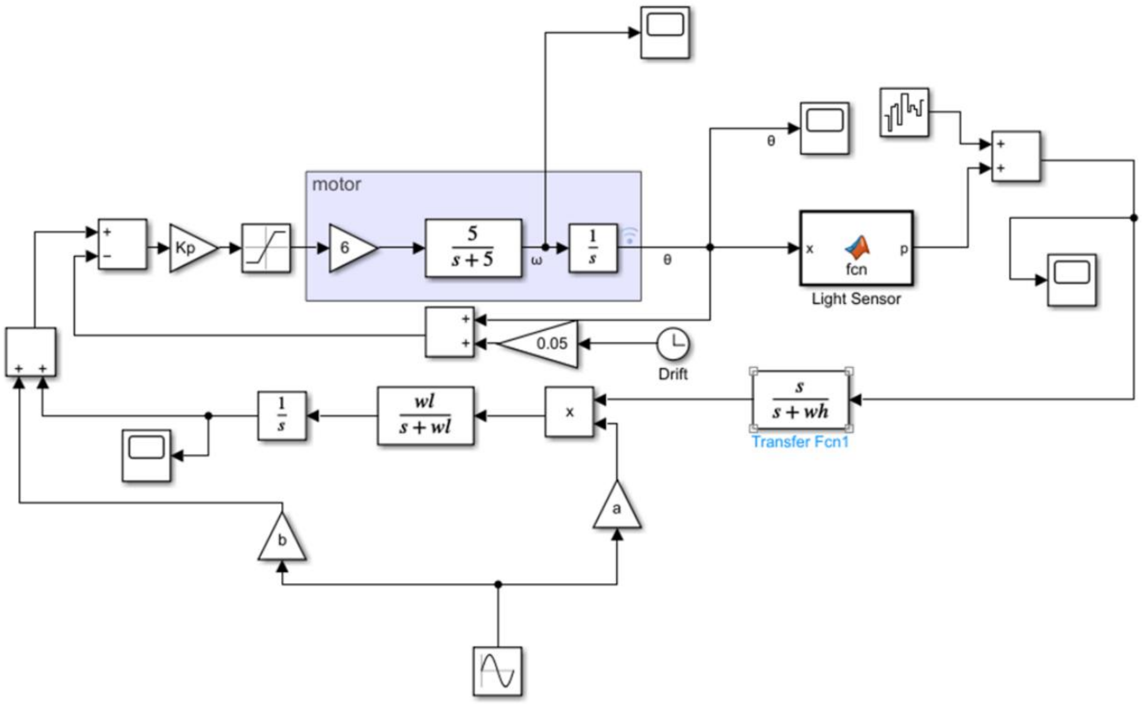

Fig.4.3.2.9 Block diagram of polar search control

Status 7: Standby sequence

Standby with only the function of transmitting GPS information and satellite status.

Chapter 5 Test item settings

number	Verification item name	Corresponding self-examination items Request number(s)	Implementation date
V1	Mass test	S1	8/8
V2	Aircraft storage and release test	S2	8/8
V3	Static load test	S3	8/8
V4	Vibration test	S4	8/7
V5	Opening impact test	S5	8/7
V6	parachute drop test	S6, M1	7/20
V7	Communication distance test	S7	8/6
V8	Communication device power OFF/ON test	S8	8/7
V9	Communication frequency change test	S9	8/7
V10	End-to-end exam	S10	8/6
V11	Landing impact test	M2	8/6
V12	Power durability test	M3	8/7
V13	OBC boot test	M4	8/6
V14	Parachute separation test	M5	8/7
V15	Cover part expansion test	M6	8/5, 8/7
V16	Reflector lifting test	M7	8/5, 8/7
V17	Reflector part deployment test	M8	8/8

V18	Reflector rotation test	M9	8/8
V19	Reflector heat test	M10	8/6
V20	Reflector part wind pressure test	M11	8/3

Chapter 6 Contents of the exam

The videos for each test are uploaded to the following URL.
https://www.youtube.com/channel/UCAbw1JpoO8FLMKTSH6uduMw

[V1] Mass test

• Required items

[S1] The mass of the aircraft to be dropped meets the criteria.

• Purpose

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

confirm.

• Exam date and time

8/8 (Monday) 0:30-1:00

• Test location

Tokyo Institute of Technology Ookayama Campus

• Participants

Tomoyu Tanaka

• Exam content

Measurement was carried out using a mass meter, and all mass including the aircraft and parachute was within the regulatory range.

Make sure that the mass is less than the mass stated in the section (1050 g).

• Results

The mass was 930 g. Figure 6.1 shows how the mass was measured.

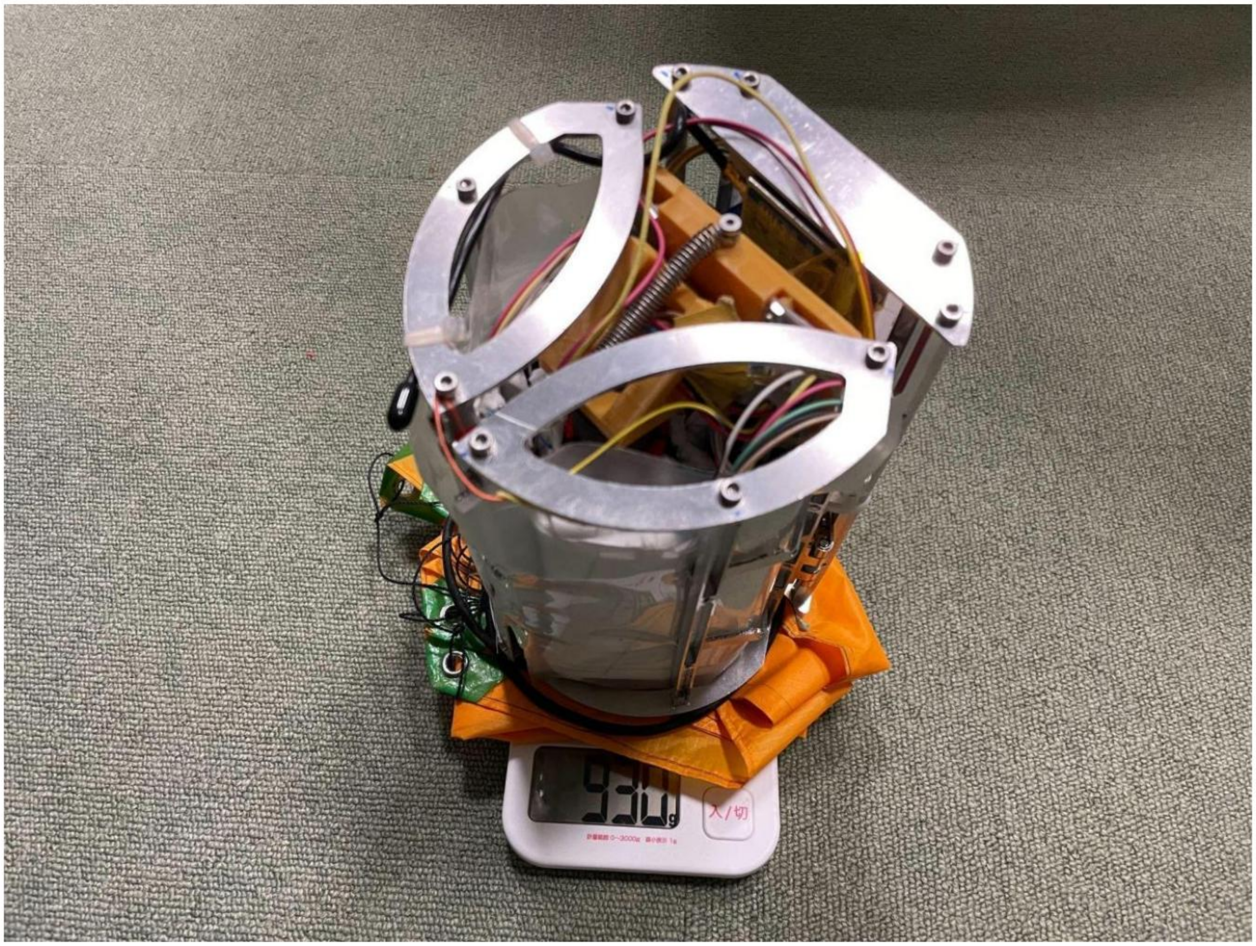

Fig.6.1 Mass test results

[V2] Aircraft storage and release test

• Required items

[S2] Volume meets carrier standards

• Purpose

The combined volume of the CanSat and parachute is the carrier (a cylinder with a height of 240 mm and an inner diameter of 146 mm).

(shape). Also, confirm that it can be released from the carrier by its own weight.

Ru.

• Exam date and time

8/8 (Monday) 1:00-1:30

• Test location

Tokyo Institute of Technology Ookayama Campus

• Participant

Yasuhiro Ishii

Tomoyu Tanaka

• Test method

ÿ Test system

• CanSat •

Parachute

• Career

Fig.6.2 Test system

ÿ Test procedure

1. Create a carrier and check that the inner diameter is 146 mm and the height is 240 mm.

2. Make sure the CanSat and parachute can be stored together in the carrier. 3. The CanSat and parachute stowed from the carrier will be released by their own weight.

Check.

• Test results

The carrier used in the test was within the regulations according to Fig.6.3 and Fig.6.4.
It was confirmed that

Fig.6.3 Carrier height

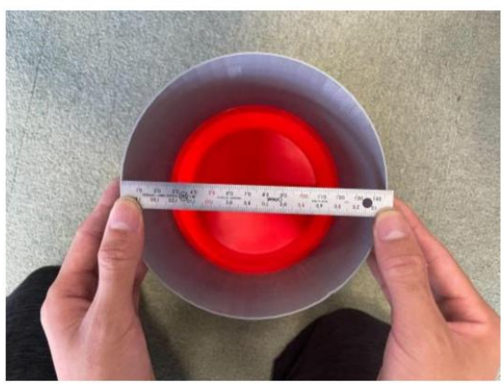

Fig.6.4 Inner diameter of carrier

It was confirmed that the CanSat mounted on the carrier was securely seated as shown in Fig.6.5.
can.

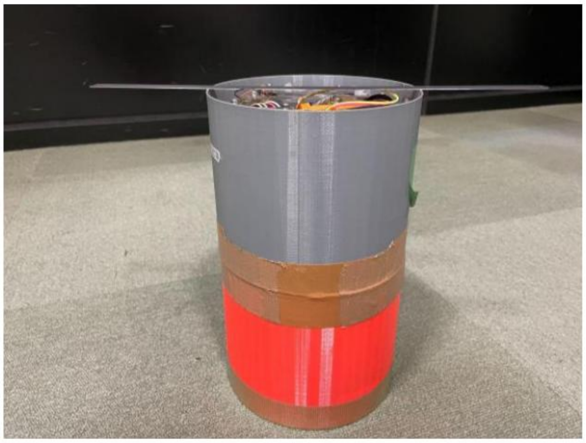

Fig.6.5 CanSat installed

A video of the release test is shown below.

https://youtu.be/s4p8pKnsyPg

0:00: First release test

0:09: Second release test

0:15: Third release test

• Conclusion

The test results show that it meets the specified volume standards and can be released from the carrier under its own weight.

I was able to confirm that.

[V3] Static load test

• Required items

[S3] Quasi-static loads during launch may impair the functionality required to meet safety standards.

Tests have confirmed that this is not the case.

• Purpose

Check whether the aircraft can withstand the load of 10 G that is expected to be applied by the rocket during launch.

I agree.

• Exam date and time

8/8 (Monday)

15:15ÿ15:45

• Test location

Tokyo Institute of Technology Ookayama Campus

• Participants

Taichi Oshino

Nishioriku

Soma Kato

Ryo Saito

Tomoyu Tanaka

Yuki Kawaguchi

Hibiki Shiraishi

Takufumi Suwabe

Yuta Tsukamoto

• Test method

ÿ Test system

• CanSat •

Acceleration sensor • Test

container

Fig.6.6 Test system

ÿ Test conditions

ÿ A quasi-static acceleration of about 10 G is applied to CanSat for about 30 seconds.

ÿ For a load of 10 G, a 2.5 m long rope is attached to the test vessel and the load is applied once per second.

A quasi-static load is reproduced by the centrifugal force obtained by rotating the machine more than one

rotation. The centrifugal acceleration obtained with a radius of 2.5 m and a rotational speed of 2 rad/s is

$$2.5 \times (2 \quad /)^{2} = 98.6960 ÿ / \quad ^{2}$$

Than,

It is thought that it is ^{2}

possible to reproduce an acceleration of 10 ÿ 98.1 / or more.

ÿ Acceleration is measured using an acceleration sensor. For acceleration sensor

Uses ADXL375.

ÿ Test procedure

1. Check that there are no abnormalities in the appearance of CanSat.
2. Attach the acceleration sensor to CanSat.
3. Place CanSat and acceleration sensor into the test container.
4. After confirming the safety of the surrounding area, a person holds the lower end of the rope attached to the test container.

Rotate with a radius of 2.5 m.

5. Stop rotation when a load of 1 rotation per second or more is applied for 30 seconds or more.

6. Remove CanSat from the test container. 7.

Remove the acceleration sensor and collect the data. A load of about 10 G is applied for more than 30 seconds.

Make sure that it is added.

8. Check for external damage. 9. Run the

operation check program and check the functionality.

Table 6.1 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Check static load	Acceleration Check the sensor value	Acceleration of about 10 G is measured for about 30 seconds. what is being measured
2	Confirm that there is no damage to the exterior	Visual inspection	No deformation or damage No misalignment of torque marks The connectors were inserted all the way to remain
3	CanSat's electrical function is abnormal. make sure there is no	Professional for operation confirmation grams execution	Functions should work properly.

• Test results

The acceleration obtained from the test is shown in Fig6.7.

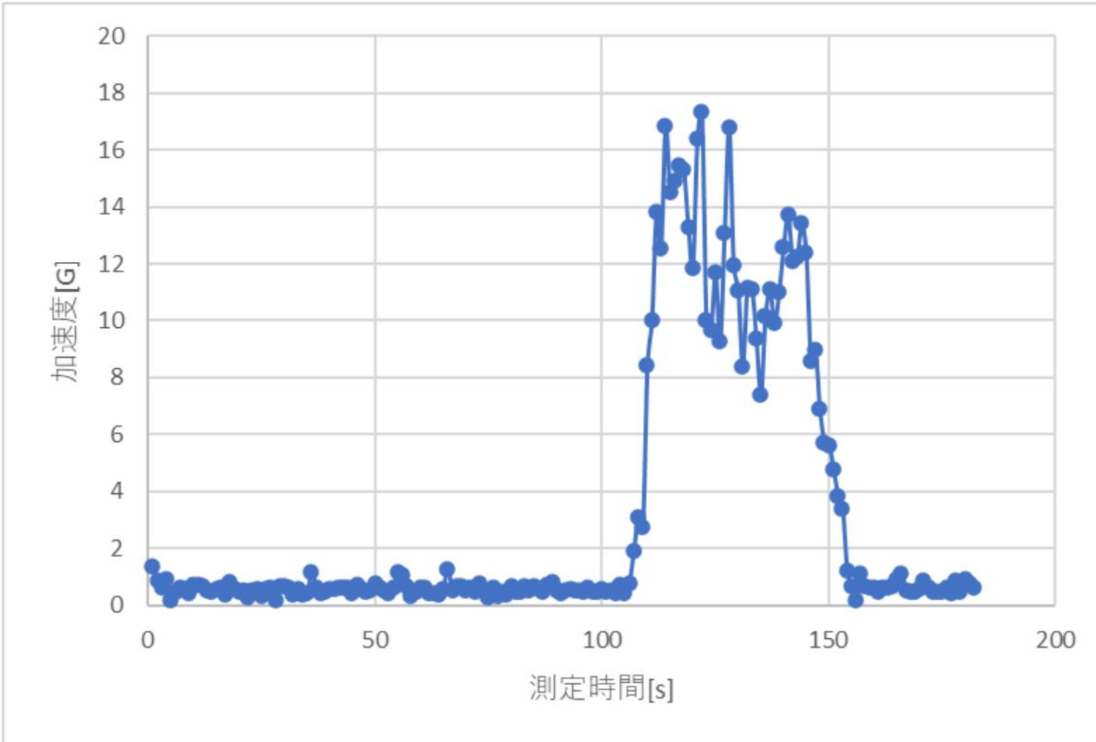

Fig.6.7 Measured acceleration data

As can be seen from the measurement results in Fig. 6.7, from 111 seconds to 145 seconds after turning on the accelerometer. An average acceleration of 11.9 G was applied for 34 seconds, and a load of about 10 G was applied for about 30 seconds. It was confirmed that the target load of 100% was fully met.

The details of the test are shown below.

https://youtu.be/pt6LQXQXTt4

0:01: Aircraft appearance check before static load loading

0:32: Installing the acceleration sensor

1:36: Put the aircraft and sensor into the test machine

2:28: Start of static load loading

3:17: Static load finished

4:07: Aircraft appearance check after static load loading

4:49: Checking the measured acceleration

5:50: Function check

In addition, the data sent from CanSat during the function check of this test is shown in Fig. 6.8 below.

vinegar.

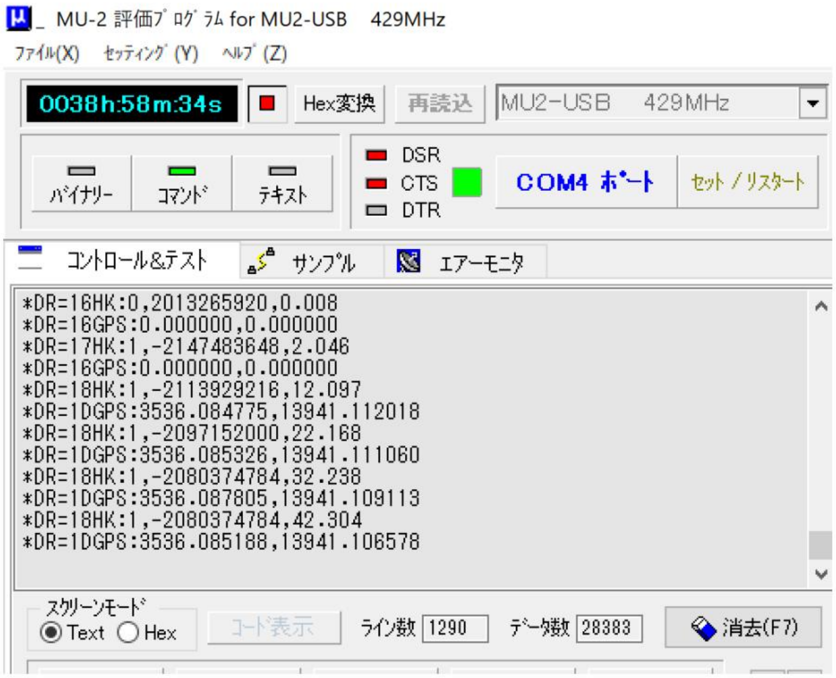

Fig.6.8 Information sent from CanSat

• Conclusion

The test results indicate that this aircraft can withstand the expected static loads.

It was confirmed that the regulations were met.

[V4] Vibration test

• Required items

[S4] The vibration load during launch will not impair the functionality required to meet safety standards.

This has been confirmed through testing.

• Purpose

Confirm that CanSat can withstand the launch vibration environment.

• Exam date and time

8/7 (Sun)

11:00ÿ12:00

• Test location

Tokyo Institute of Technology Ookayama Campus

• Participants

Taichi Oshino

Yuki Kawaguchi

Soma Kato

Takumi Sato

• Test method

ÿ Test system

ÿ CanSat ÿ

Vibration

machine ÿ Vibration controller

ÿ Test conditions

ÿ The excitation conditions are shown in Table 6.2.

Table 6.2 Vibration conditions

	Excitation frequency [Hz]	Acceleration level [G]	Excitation time {s}
Excitation 1	30ÿ500	Five	
Vibration 2	natural frequency	15	60
Vibration 3	30ÿ500	Five	

ÿ Test procedure

1. Perform a visual inspection of the CanSat before shaking to confirm that there are no abnormalities in the aircraft structure.

2. Attach CanSat to the test machine. 3. Check the

natural frequency of CanSat by sweeping vibration from 30 to 500Hz. (Mo

-dal survey test)

4. Excite at 15 G for 60 seconds at the confirmed natural frequency.

5. To confirm that there is no significant change in the natural frequency of CanSat before and after excitation,

Conduct the modal survey test again.

6. After confirming that there is no significant change in the natural frequency, remove the CanSat from the test machine. put out.

7. Perform another visual inspection to confirm that there are no abnormalities in the aircraft structure. 8. Run the function check program and confirm that electrical function is intact.

Table 6.3 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Checking the natural frequency of CanSat	Acceleration waves of waves Definitely from the shape Approval	Frequency at which the amplitude is maximum
2	Must be able to withstand excitation of 15 G.	waves of waves Check from the shape	Can withstand 15 G excitation for 60 seconds thing
	CanSat has structural flaws Confirm that there is no	Visually	No deformation or scratches No misalignment of torque marks The connectors were inserted all the way to remain
3	Confirm that there is no abnormality in the electrical function of CanSat.	Operation confirmation for pro grams execution	Functions should work properly.

• Test results

The modal survey test results before and after vibration are shown in Table 6-7.

Table 6.4 Modal survey test results

	Natural frequency [Hz]
15 G before excitation	217
After 15 G vibration	217

From this result, we can conclude that the natural frequency does not change even after excitation of 15G at the natural frequency.

It was confirmed that

The details of the test are shown below.

https://www.youtube.com/watch?v=gVRA0_MApMo

0:09: Appearance inspection before excitation

2:08: Place the aircraft on the shaker

3:55: Modal survey test begins

4:57:15 G vibration start

6:20: Start of modal survey test after excitation

7:30: Appearance inspection after vibration

8:35: Operation confirmation

• Conclusion

The test results show that this machine can withstand the expected vibration loads.

It was confirmed that the regulations were met.

[V5] Umbrella opening impact test

• Required items

[S5] Satisfies safety standards due to the impact load when the rocket separates (when the parachute is deployed)

Tests have confirmed that the functionality of the product is not impaired.

• Purpose To

ensure that the CanSat and parachute can withstand the impact (approximately 40 G) expected when the parachute is deployed.

Make sure that the

• Exam date and time

8/7 (Sun) 13:00-16:00

• Test location

Tokyo Institute of Technology Ookayama Campus

• Participant

Yasuhiro Ishii

Taichi Oshino

Takumi Sato

Nishioriku

Soma Kato

Yuki Kawaguchi

Takufumi Suwabe

• Test method

ÿ Test system

<Parachute opening impact test> ÿ Dummy mass

(1 kg)

ÿ Parachute

ÿ Acceleration sensor

<Airframe opening impact test>

ÿ CanSat ÿ

Parachute string ÿ Acceleration

sensor

ÿ Test conditions

<Parachute opening impact test>

ÿ Approximately 40 G of impact acceleration is applied to the parachute and the parachute string. ÿ ADXL375 is

used as the acceleration sensor.

<Airframe opening impact test>

ÿ Apply impact acceleration of about 40 G to CanSat. ÿ

ADXL375 is used as the acceleration sensor.

ÿ Test procedure

<Parachute opening impact test>

1. Visually check the appearance of the parachute to ensure that there are no defects and that the strings are securely tied.

Make sure that

2. Attach a dummy mass to the parachute string and also attach an acceleration sensor.

Fix these firmly so that they do not come off due to the impact of opening the umbrella.

3. Hold a parachute with a string with a total length of 2.5 m in your hand and drop the test object.

4. Pull up the dropped test object, read the measured acceleration, and accelerate to approximately 40 G.

Check that the temperature is correct.

5. Check for external damage.

<Airframe opening impact test>

1. Visually check the appearance of the CanSat and confirm that there are no structural abnormalities.

2. Attach an acceleration sensor to the CanSat and securely fix it so that it does not come off due to the impact of opening the umbrella.

do.

3. Fix the end of a 2.0 m long parachute string to a handrail and drop the test object.

4. Pull up the dropped test object, read the measured acceleration, and accelerate to approximately 40 G.

Check that the temperature is correct.

5. Check for external damage. 6. Run the

operation check program and check the functionality.

Table 6.5 Measurement/confirmation items (parachute opening impact test)

No.	Check items	Measuring method How to check	Judgment criteria
1	Check impact load	Acceleration De of Nsa Check the data. Approval	An acceleration of about 40 G was measured. thing
2	Confirm that there is no damage to the exterior	Visual inspection	Tears and fraying in the parachute fabric There is no The parachute string was broken Check that it is not loose or unraveled. and

Table 6.6 Measurement/confirmation items (airframe opening impact test)

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Check impact load	Acceleration De of Nsa Check the data. Approval	An acceleration of about 40 G was measured. thing
2	Confirm that there is no damage to the exterior	Visual inspection	No deformation or scratches No misalignment of torque marks The connectors were inserted all the way to remain
3	Confirm that there is no abnormality in the electrical function of CanSat.	Operation confirmation for pro grams execution	Functions should work properly.

• Test results

The details of the test are shown below. In addition, in order to upload to YouTube, some parts are set to 2x speed. There is. Additionally, due to the shooting equipment, the video was interrupted once at the 4-second mark before the end of the video, but it was shot continuously.

https://youtu.be/Glb3GB7qobQ

0:00: Parachute opening impact test 0:04:

Parachute appearance confirmation

1:34: Drop dummy mass

2:10: Parachute appearance confirmation 4:50:

Acceleration confirmation

5:04: Aircraft opening impact test 5:39:

Aircraft appearance confirmation

6:57: Aircraft dropping

7:40: Aircraft appearance

confirmation 9:37: Acceleration confirmation

11:02: Operation confirmation

<Parachute opening impact test>

Figure 6.8 shows the acceleration data measured during the parachute opening impact test.

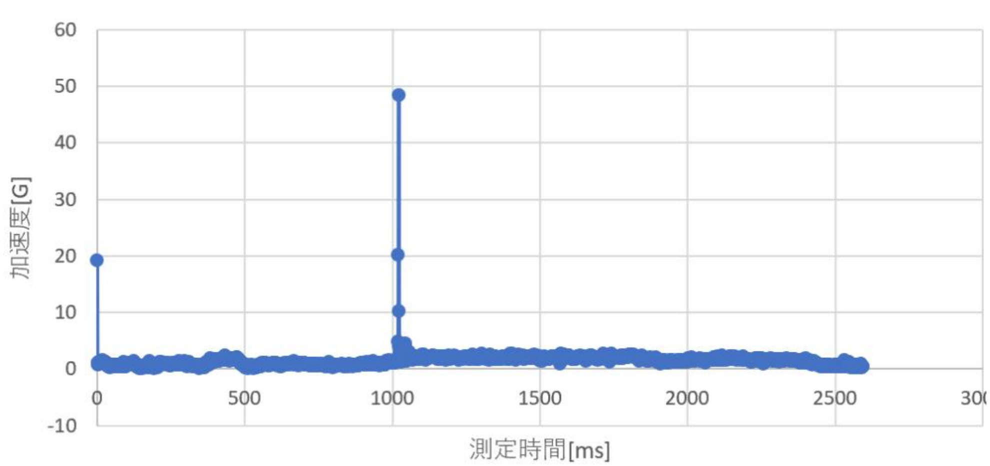

Fig.6.9 Measured acceleration data (parachute)

As can be seen from Fig. 6.8, it was confirmed that the maximum impact acceleration was around 50 G and over 40 G.

did it.

<Airframe opening impact test>

Figure 6.9 shows the impact acceleration data measured during the airframe opening impact test.

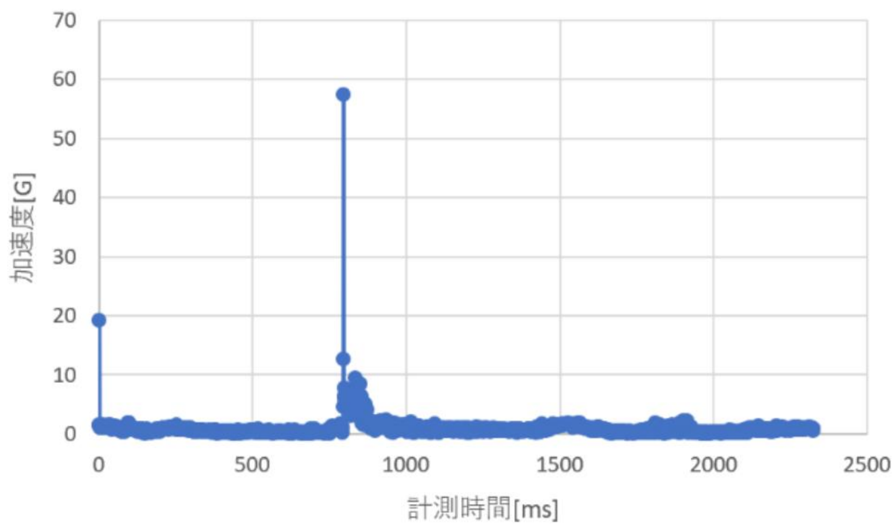

Fig.6.10 Measured acceleration data (aircraft)

As can be seen from Fig. 6.9, the maximum impact acceleration was confirmed to be around 57 G, which is over 40 G. did it.

• Conclusion

The test results show that this aircraft can withstand the anticipated impact of opening the umbrella.

It was confirmed that the regulations were met.

[V6] Parachute drop test

• Required items

[S6] It has a deceleration mechanism to prevent it from falling at a dangerous speed near the ground, and its performance has been tested.

It has been confirmed that

[M1] Parachute can be deployed.

• Purpose

1. Check that the parachute deploys properly.

2. Confirm that the parachute allows the aircraft to reach its terminal velocity. 3. The terminal velocity must be less than 5m/s, which is the descending velocity guaranteed by the aircraft's strength design.

Check that.

• Exam date and time

7/20 (Wed)

6:00ÿ10:00

• Test location

Tama River riverbed Maruko Hashimoto

• Participants

Yasuhiro Ishii

Nishioriku

Seitaro Ueno

Ryo Saito

Tomoyu Tanaka

• Test method

ÿ Test system

• Parachute

• Dummy mass (1 kg) •

Measure

Fig.6.11 Parachute used

ÿ Test procedure

[V6] The parachute drop test has two steps: deployment confirmation and terminal velocity measurement.

1. Attach a parachute to a dummy mass that simulates the aircraft, and fold the parachute.

   Drop it in the folded state and make sure it opens. (Conducted twice)

2. Drop the parachute with it open, confirm that it reaches the terminal velocity, and

   Measure the degree. (Conducted 5 times)

• Test results

Regarding the opening check in step 1, Table 6.7 shows a video of the test and whether or not the opening was successful.

show. In both cases, it was confirmed that the parachutes were deployed without any problems.

Table 6.7 Deployment confirmation test results

	open umbrella	Exam video
First time	success	https://youtube.com/shorts/6Ad80VaGnpE
Second time	success	https://youtube.com/shorts/l-M8PTikYmA

Regarding the measurement of terminal velocity in step 2, a video of the test is shown in Table 6.8.

Table 6.8 Terminal velocity test results

	Terminal velocity [m/s]	Test video
1st time	4.29	https://youtube.com/shorts/YTfDDOAywnI?feature=share
2nd time	4.71	https://youtube.com/shorts/pssvRKvG3-4?feature=share
3rd time	3.67	https://youtube.com/shorts/h0vln1PtQZo?feature=share
4th	4.29	https://youtube.com/shorts/8xM257e4as8?feature=share
5th	5.00	https://youtube.com/shorts/6Hm4pO72S4I?feature=share

The average terminal velocity of the five runs was 4.39 m/s.

• Conclusion

The test results confirmed that the parachute was deployed without any problems. Also, para

As the chute expands, the descent speed reaches the terminal speed, which becomes less than 5 m/s, and the aircraft becomes

We were able to confirm that the descent speed was such that it would be possible to land safely.

[V7] Communication distance test

- Required items

[S7] We have implemented countermeasures against loss, and their effectiveness has been confirmed through testing.

- Purpose

Confirm that position information can be obtained using the GPS module installed in CanSat.

We also confirmed that the radio communication device installed on CanSat and the ground station communication device could communicate over a sufficient distance.

confirm.

- Exam date and time

8/6 (Sat)

4:50ÿ5:50

- Test location

Maruko Bridge

- Participants

Yuki Kawaguchi

Takufumi Suwabe

- Exam content

In the test, a ground station was installed at Maruko Bridge over the Tama River, and the configuration during the mission was

The CanSat installed on the ground is manually moved in the downstream direction. CanSat Gas Bridge

Confirm that communication is possible even if moved to the west side (see Fig.6.12). In this case, between the two parties

The distance is approximately 2.5 km.

This test confirmed that CanSat and the ground station can communicate even if launched by ARLISS.

I agree.

• Results

Figure 6.12 shows the distance between two points that could actually communicate.

Fig.6.12 Map around Maruko Bridge

Also, among the logs of location information data sent from CanSat and received by the ground station, CanSat's

The location information of the starting point and the location of the point where communication was interrupted are shown below.

Starting point :N 35°34.130', E 139°40.385'

Point where communication was lost: Latitude 35°33.837'N, Longitude 139°40.774'E

From the above, while acquiring position information, the communication between the ground station and the communication module MU-2 onboard CanSat is approximately

Communication was possible at a distance of 2.0 km. Also, there are fewer obstacles when actually launching in the desert.

Therefore, it is thought that the communication distance will be extended. Therefore, the results of this experiment and past Tokyo Tech CanSat

Based on the team's experience, it is possible to communicate at a distance of 4 km in the desert, which is sufficient as a countermeasure against lost data.

Conceivable.

[V8] Communication device power OFF/ON test

- Required items

[S8] It has been confirmed that the regulations for turning off the power of radio equipment at the time of launch can be complied with.

- Purpose

Confirm that the power supply for the communication equipment satisfies the regulations.

- Exam date and time

8/7 (Sun)

3:00ÿ3:10

- Test location

Tokyo Institute of Technology Ookayama Campus

- Participants

Yuki Kawaguchi

Takufumi Suwabe

- Exam content

Make sure that the CanSat communication power is OFF when the flight pin is inserted, and that the flight pin is removed.

Make sure that the power turns on when you turn it on.

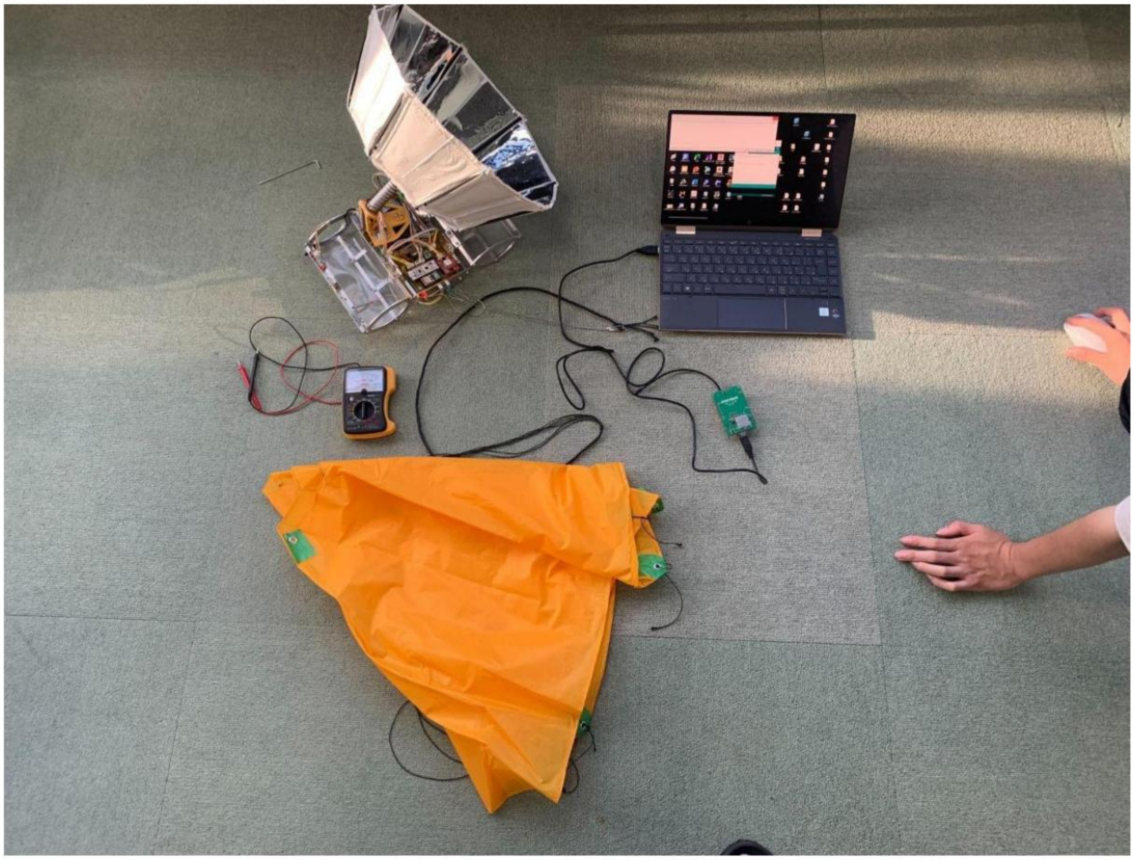

Fig.6.13 Test system

• Results

The test is shown in the video at the URL below.

https://youtu.be/Y7dztQXF7JE

[V9] Communication frequency change test

• Required items

[S9] Confirm that you are willing and able to adjust the wireless channel.

I can recognize it.

• Purpose

Confirm that you are willing and able to adjust the wireless channel.

Ru.

• Exam date and time

8/7 (Sun)

1:00ÿ1:30

- Test location

Tokyo Institute of Technology Ookayama Campus

- Participants

Yuki Kawaguchi

Ryo Saito

- Exam content

CanSat equipped communication device MU-2 (frequency can be changed from 429.2500Hz to 429.7375Hz), and

Change the channel of the communication device MU-2 on the ground station side from 09 (frequency 429.2750 MHz) to 1B

(frequency 429.5000 MHz), transmit data from the communication device MU-2 equipped with CanSat, and transmit the data on the ground station side.

Confirm that it can be received using transmitter MU-2.

- Results

The test results are shown in the video at the URL below.

https://youtu.be/DTc_HbILgcI 0:14: Set

the aircraft side channel to 09

1:30: Set the receiving station channel to 09

1:50: Aircraft power on, communication confirmed

2:26: Set the aircraft side channel to 1B

4:34: Aircraft power on

4:53: Confirm the channel change on the aircraft side radio

5:02: Set the receiving station side channel to 1B and check communication

[V10] End-to-End exam

- Required items

[S10] Simulated the process from loading the rocket to starting the mission and recovering after launch.

End-to-end testing has been conducted, and there will be no major design changes related to safety in the future.

• Purpose

In order to prevent major design changes related to safety after submission of safety test documents, safety review By using the used aircraft, it is possible to carry out everything from dropping from the carrier to completing the mission. To verify that.

• Exam content

The mission sequence was divided into the following four phases and confirmed.

1. Rocket loading ~ Rocket ignition
2. Deploying the parachute
3. Removing the flight pin, deploying the cover, raising the reflector, deploying the reflector, Transition to standby mode
4. Retrieving the log storage device and checking the log

Regarding Phase 1, [V1] Mass test, [V2] Aircraft storage/release test, [V3] Static The load test and [V4] vibration test confirm that the aircraft complies with the mass and size regulations and can be used on location. It was confirmed that the aircraft's functionality was not impaired by installing the kit. Regarding phase 2 (V5) Opening impact test, [V6] Parachute drop test, and [V11] Landing impact test confirmed that the aircraft's functionality was not impaired from rocket release to landing. Therefore, In this study, we plan to conduct Phase 3.

The sequence of the end-to-end test to be conducted is shown in Fig. 6.13.

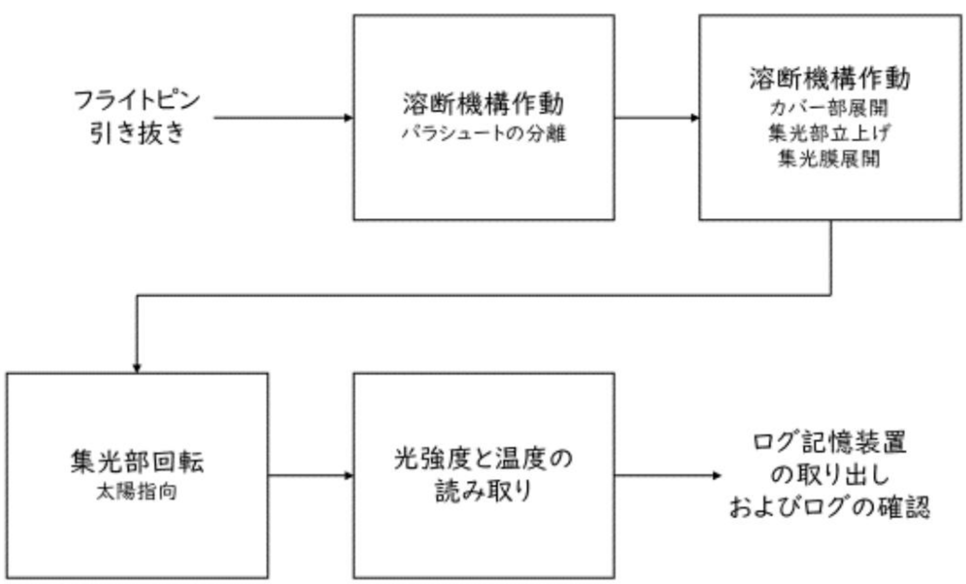

Fig.6.14 End-to-End test sequence

In the end-to-end test, the goal is to achieve full success in the success criteria, so the advanced successes of ``the turntable follows the direction of the sun by rotating'' and ``the reflector collects heat'' were We decided not to perform any verification.

• Exam date and time

8/6 (Sat)

19:00ÿ20:00

• Test location

Ota City Ishikawacho 2-chome Children's Park

• Participants

Yasuhiro Ishii

Taichi Oshino

Soma Kato

Takumi

Sato Riku

Nishio Ryo Saito

Tomoyu Tanaka

Hibiki Shiraishi

Takufumi Suwabe

• Test results

A video of the test is shown below. https://youtu.be/eunLItiMoPY

0:03: Remove flight pin

0:12: Landing detection timeout 0:39:

Fusing mechanism activated, parachute separated 3:40:

Fusing mechanism activated, cover deployed, reflector raised, reflective mirror deployed 3:52: Reflected mirror rotated, sun pointing

4:46: All operations completed

• Conclusion

End-to-end tests ensure that all functions operate normally and all sequences are completed.

I was able to confirm that.

[V11] Landing impact test

- Required items

[M2] The impact load upon landing may impair the functionality required to accomplish the mission.

Tests have confirmed that this is not the case.

- Purpose

The CanSat was not damaged by the impact of landing at a maximum falling speed of 5m/s when the parachute was deployed.

Confirm that location information can be obtained.

- Exam date and time

8/6 (Sat)

20:00ÿ21:30

- Test location

Ota City Ishikawacho 2-chome Children's Park

- Participant

Yasuhiro Ishii

Taichi Oshino

Soma Kato

Takumi Sato

Nishioriku

Ryo Saito

Tomoyu Tanaka

Hibiki Shiraishi

Takufumi Suwabe

- Test method

ÿ Test system

  - CanSat
  - Major

• Play equipment

Fig.6.15 Test system

ÿ Test conditions

• The height at which CanSat is dropped in free fall is 2 m (this is the height that is 6.26 m/s when calculated ignoring air resistance to ensure that the terminal velocity exceeds 5 m/s). do

ÿ Test procedure

1. Freefall CanSat from a height of 2 m with the CanSat horizontal (0 degrees to the ground).
2. Visually check that the cover is not distorted or damaged. 3. Check if position information can be obtained.
4. Freefall the CanSat vertically (at a 90 degree angle to the ground) from a height of 2 m.
5. Same as 2
6. Same as 3
7. Let the CanSat fall freely from a height of 2 m at an angle of approximately 45 degrees with the ground.
8. Same as 2
9. Same as 3

Table 6.9 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Frame is not distorted	Visually	Visually check that the frame is warped to the extent that it will not hinder deployment. Ru
2	Location information can be obtained	pc	Make sure location information is sent to your PC

• Test results

CanSat was free-falled from a height of 2 m, was not damaged by the landing impact, and was able to acquire position information.

I have confirmed that it is possible.

The details of the test are shown below. In addition, in order to upload it to YouTube, some parts are set to 2x speed.

ing

https://youtu.be/DiVumO_K3xY 0:00:0

degree test start

1:05: Fall

1:30: Check appearance

2:22: Location information acquisition confirmation

5:53: Successful location information acquisition

6:00: 90 degree test begins

7:06: Fall

7:21: Check appearance

8:15: Confirm location information acquisition

9:16: Successful location information acquisition

9:22: 45 degree test begins

10:53: Fall

11:04: Check appearance

11:48: Confirm location information acquisition

12:03: Successful location information acquisition

• Conclusion

The test results show that CanSat was not damaged by the landing impact with a terminal velocity of 5 m/s and was able to acquire position information.

I have confirmed that it is possible.

[V12] Power durability test

• Required items

[M3] Tests have confirmed that sufficient power can be supplied to perform the sequence.

• Purpose:

To supply power to the electrical system and provide a continuous and stable supply of power until CanSat completes its activities.

Check whether The battery has enough power and the system will stop due to overcurrent.

The points that do not work are subject to evaluation.

• Test date and

time 8/7 (Sun)

0:00ÿ5:00

• Test location

Tokyo Institute of Technology Ookayama Campus

• Participant

Yuki Kawaguchi

Ryo Saito

• Test method

ÿ Test system

• CanSat •

Clock

•PC

• MU-2-USB-429

ÿ Test procedure

Perform an End-to-End test to ensure that the battery runs to the end of the sequence without running out of power.

Check that it can be done.

In the test, in order to take into account the time from loading the aircraft onto the rocket to dropping it,

Wait for 1 hour with the light pin inserted, then remove the flight pin and

perform the operation of starting the session.

The time required for each sequence is shown in the table below.

Table 6.10 Required and elapsed time for each sequence

number	sequence	Implementation time	Total elapsed time
	Waiting for launch	1 hour	1 hour
1	Fall/landing detection	20 min	1 hour 20 minutes
2	parachute melting Waiting for discovery	1 hour and 30 minutes	2 hours 50 minutes
3	Cover deployment/standby	10 minutes	3 hours
Four	sun oriented	5 minutes	3 hours 5 minutes
Five	Data collection	5 minutes	3 hours 10 minutes
6	sun following	50 minutes	4 hours
7	Mission completed stand-by	1 hour	5 hours

Table 6.11 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Operation of all sequences	Visually	Each sequence is operating normally. Ru.
2	Completing the sequence	PC MU-2-USB-429	Sequence number sent by CanSat is "7",

• Test results

After waiting for 1 hour, I pulled out the flight pin, all sequences worked normally, and the sequence I was able to confirm the completion message.

The details of the test are shown below.

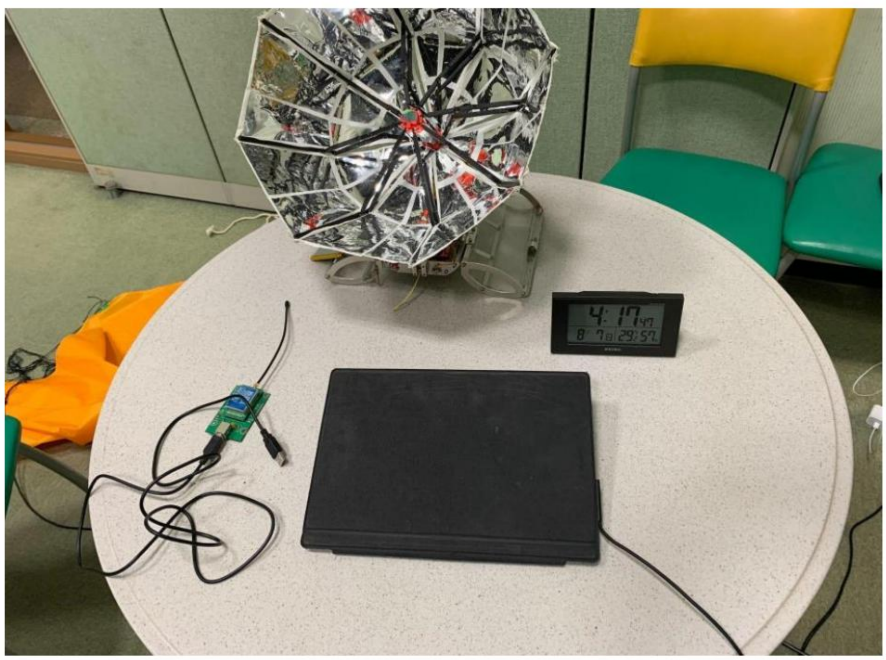

Fig.6.16 Condition of the test system at the start of the test

Also, the log written to the SD card is as follows.

https://docs.google.com/document/d/1Nmnj0vKOk-d526NV2AfcNRO7OsZijSmUXyUv6mdLBAw/edit

The state of the test system after 5 hours is shown in Fig.6.16.

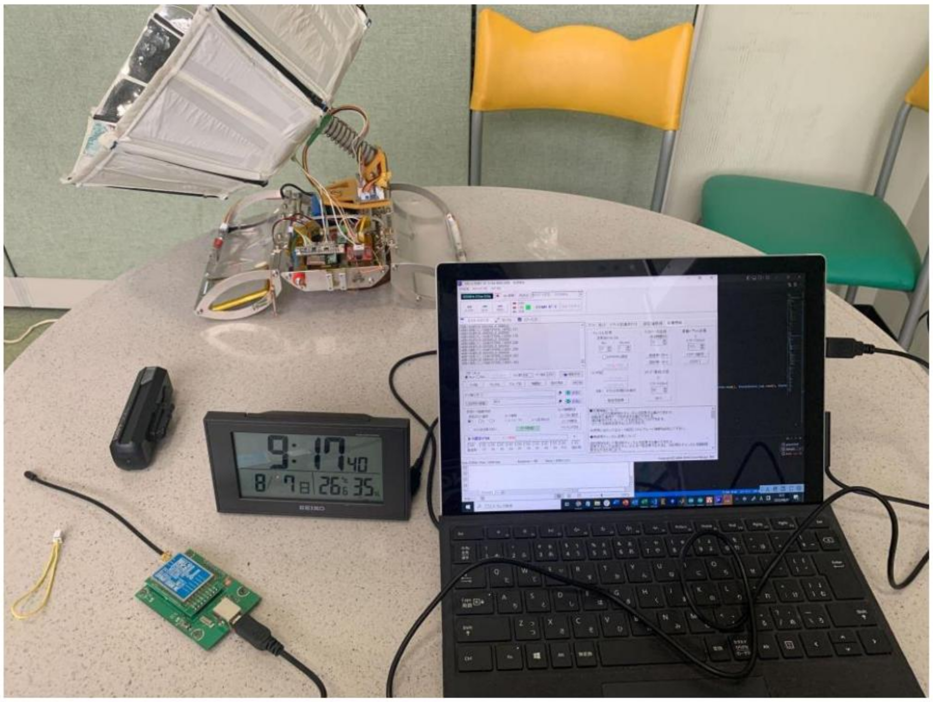

Fig.6.17 Sequence end state

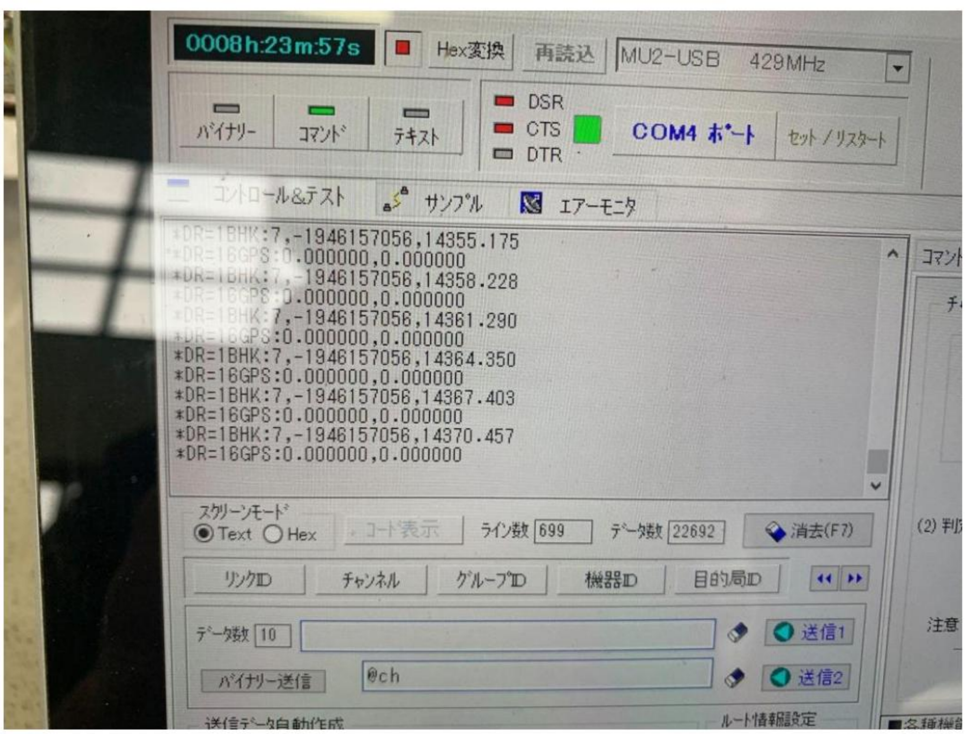

Fig.6.18 Reception status in standby status

After 4 hours of mission time has elapsed, the location information for the next 1 hour will be downloaded for lost countermeasures.

Communication with CanSat continued even after linking, indicating that the battery capacity was sufficient.

It was confirmed that this is the case.

- Conclusion

The test results confirmed that sufficient power could be supplied to perform the sequence.

[V13] OBC startup test

- Required items

[M4] OBC starts normally.

- Purpose

Verify that OBC can start successfully

- Exam date and time

8/6 (Sat)

3:00ÿ3:10

- Test location

Tokyo Institute of Technology Ookayama Campus

- Participant

Yuki Kawaguchi

Takufumi Suwabe

- Test method

ÿ Test system

- CanSat •

Voltmeter

•PC

- MU-2-USB-429

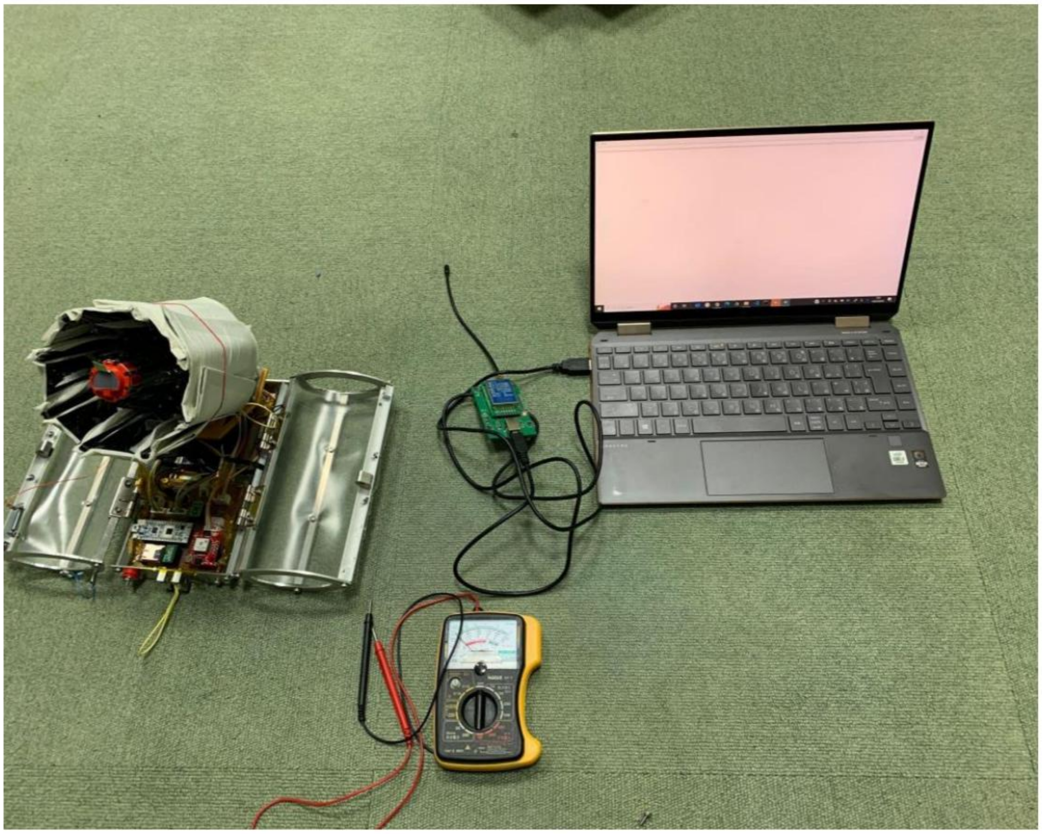

Fig.6.19 Test system

ÿ Test procedure

This test is performed at the same time as the communication device OFF/ON test.

1. With the flight pin connected, measure the power supply voltage of the radio and check that the power is turned on.
   Make sure it is OFF.
2. Remove the flight pin, start the OBC, measure the power supply voltage of the radio, and turn on the power.
   Confirm that
3. The OBC activation message has been received on the ground station radio and the radio is operating.
   Check.

Table 6.12 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	OBC power supply voltage	Voltmeter	When flight pin is connected: 0 V Flight pin separated: 3.3 V
2	Program startup message	PC MU-2-USB-429	After flight pin separation, startup message page will be displayed.

• Test results Power

supply voltage

Flight pin connected: 0 V

Flight pin separated: 3.3 V

A startup message was displayed after the flight pin was separated.

The details of the test are shown below.

https://youtu.be/v38iNPzRtnE

0:00: Explanation of the exam system

0:15: Confirmation when connecting flight pin

0:50: Flight pin separation

0:54: Confirmation when separating the flight pin

• Conclusion

The test results confirmed that OBC startup was performed normally.

[V14] Parachute separation test

• Required items

[M5] Parachute can be separated.

• Purpose

Confirm that CanSat and parachute can be separated using the fusing circuit.

- Exam date and time

  8/7 (Sun)

  23:10ÿ23:20

- Test location

  Tokyo Institute of Technology Ookayama Campus

- Participants

  Soma Kato

  Ryo Saito

  Tomoyu Tanaka

  Nishioriku

- Exam content

  The parachute can be reliably burned off with the specified amount of current and time, and the parachute can be installed without any problems.

  Visually confirm that the can be separated.

  ÿ Test system

  - CanSat
  - Parachute

Fig.6.20 Test system

• Results

The details of the test are shown below.

https://youtu.be/cRpQ50UzXFs

In this way, the fusing mechanism operates without any problems and the parachute can be separated from the aircraft.

I was able to confirm that.

• Conclusion

It was confirmed that the parachute could be separated without any problems using the fusing mechanism installed on the aircraft.

Ta.

[V15] Cover part deployment test

• Required items

[M6] Expand the fuselage cover, and the reflector section faces upward.

• Purpose

Even if the reflector part is not facing upward when landing, the cover part can be expanded by melting the legs.

Make sure that the reflector section is facing upward.

• Exam date and time

8/3 (Wed)

17:00ÿ18:00

8/5 (Fri)

10:00ÿ11:00

8/7 (Sun)

22:00ÿ23:00

• Test location

Ota City Ishikawacho 2-chome Children's Park

Tokyo Institute of Technology Ookayama Campus

• Participants

Yasuhiro Ishii

Yuki Kawaguchi

Soma Kato

Takumi Sato

Tomoyu Tanaka

Taichi Oshino

Nishioriku

Hibiki Shiraishi

• Exam content

Place the aircraft on the ground and confirm that the outer shell structure of the aircraft can be deployed based on the detected signal.

• Test conditions

Make sure that the reflector is facing up in any position.

• Test procedure

Change the inspection surface to the bottom surface, right cylindrical surface, and left cylindrical surface and repeat steps 1 to 3 below three times for each surface.

cormorant.

1. Perform a visual inspection of the CanSat to confirm that there are no abnormalities in the aircraft structure.

2. Place the test side down on the ground. 3. Remove

the flight pin and activate the cover deployment fuser circuit to open and deploy the cover.

Confirm that it is performed correctly.

- Results

It was confirmed that the cover expanded properly in all conditions. The situation is as follows

It's a video.

https://youtu.be/Elvn2yZaGXE

0:00: Bottom 1st time

0:32: Second time on the bottom

0:53: Bottom 3rd time

1:12: First time on the right side

1:30: Second time on the right side

1:55: Third time on the right side

2:19: 1st left side

2:40: Second left side

3:00: Third time on the left side

- Conclusion

With the current structure, it is confirmed that the cover deployment can be fully accomplished during mission execution.

I was able to recognize

[V16] Reflector lifting test

- Required items

[M7] The reflector part can be lifted and maintained by 45 degrees.

- Purpose

Check whether the lifting mechanism functions under the condition where the weight of the reflector is applied. the

rear , to confirm that it can be maintained in a lifted state in a windy environment.

- Exam date and time

  8/5 (Fri)

  10:00ÿ11:00

  8/7 (Sun)

  22:00ÿ23:00

- Test location

  Tokyo Institute of Technology Ookayama Campus

- Participants

  Yasuhiro Ishii

  Yuki Kawaguchi

  Soma Kato

  Takumi Sato

  Tomoyu Tanaka

  Taichi Oshino

  Nishioriku

  Hibiki Shiraishi

- Exam content

  The reflector is fixed so that it does not lift up, and by removing the fixation, it can be rotated to a 45-degree angle with a stopper.

  Check if the angle can be maintained at 45 degrees.

- Test procedure

  This test will be conducted at the same time as the [V15] cover expansion test.

1. [V15] During the cover expansion test, fix the reflector so that it does not lift up, and then remove the fixing.

   Verify that it will lift up to the stopper's 45 degrees and stop.

- Results

By releasing the fixation, the reflector part will be lifted up 45 degrees, and then it will be able to be held without falling under its own weight.

It was confirmed that the elevated state was maintained.

- Conclusion

It was confirmed that the lifting mechanism was in a condition capable of withstanding the mission.

[V17] Reflector part deployment test

- Required items

[M8] Reflector part can be expanded

- Purpose

Check whether the light-collecting structure can be opened sufficiently by the unfolding mechanism or whether it can function as a light-collecting structure.

Check if you can do it.

- Exam date and time

8/8 (Monday) 15:00-16:00

- Test location

Tokyo Institute of Technology Ookayama Campus

- Participants

Taichi Oshino

Nishioriku

Hibiki Shiraishi

Seitaro Ueno

- Exam content

The cover can be removed by loosening the string used to secure it while it is stored in the cover part.

Deploys the mirror part, lifts the reflector part, and deploys the reflector part. At this time, regarding the development of the reflector part.

Check to see if it is fully expanded.

• Test system

ÿ CanSat

• Test procedure

1. Close the cover of the CanSat body using the fusing mechanism.
2. Operate the fusing mechanism by hand to deploy the cover, raise the reflector, and deploy the reflector.
conduct.
3. Check that each mechanism is working properly

Table 6.13 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Deployment status of cover part	Visually	The unfolding of the reflector and the cover are dry. I haven't interfered.
2	Deployment status of reflector part deployment structure	Visual inspection	The lower wheel is pushed up to the stopper.
3	Other structures near the deployable structure of the reflector part	Visually	Other structures of CanSat were not destroyed by the deployment of the reflector.

• Test results

The reflector deployment structure operates without problems in all situations, and the reflector deploys normally.

Ta.

The details of the test are shown below.

https://youtu.be/vGQQmQMDAxc

0:02: Cover part unfolds, reflector part rises, reflector part unfolds

0:09: Deployment status of the cover and confirmation of other structures near the deployable structure of the reflector part

0:37: Checking the deployment status of the reflector deployment structure

• Conclusion

With the current structure, it is confirmed that the reflector section can be fully deployed during mission execution.

I recognized it.

[V18] Reflector rotation test

- Required items

[M9] Change the direction of the reflector to face the sun

- Purpose

Confirm that the direction of the sun can be detected and directed using the turntable mechanism.

- Exam date and time

8/8 (Monday)

- Test location

Tokyo Institute of Technology Ookayama Campus

- Participants

Nishioriku

Takufumi Suwabe

- Exam content

Place the turntable and superstructure in random directions relative to the sun. the

rear , the direction of the sun is detected by a sensor. Based on the detected direction, it points toward the sun.

- Test system

ÿ CanSat

ÿ Illuminance meter

- Test procedure

1. Expand the reflector section
2. Orient it in a random direction relative to the sun
3. Detect the direction of the sun with a sensor
4. Point the reflector toward the sun

5. Check that you are pointing correctly using a light meter

6. Repeat steps 2~6 3 times

• Results

In all situations, the reflector could be directed toward the sun.

The details of the test are shown below.

Table 6.14 Test results

	initial direction	Results	Examination
1	Sun direction	Success	https://youtu.be/fJjFG6w5L3w
2	Opposite direction to the sun	Success	https://youtu.be/sPsq0kKcKiA
3	towards the sun 90° direction	Success	https://youtu.be/d_1r9GijQpc

1. Sun direction

0:12: Start pointing towards the sun

0:31: Sun orientation finished

0:40: Check if the sun is pointing with the illumination meter

2. Opposite direction to the sun

0:11: Start pointing towards the sun

0:51: Sun orientation finished

1:02: Check if the sun is pointing with the illumination meter

1:31: Check the direction of the sun

3. 90° direction to the sun

0:12: Start pointing towards the sun

0:39: Sun orientation finished

0:46: Checking whether the sun is oriented using the illumination meter

1:15: Check the direction of the sun

In addition, to confirm that the sun is pointing correctly, measure the shadow of the ruler and the angle of the center rod of the reflector.

I calculated it. The results are shown in Fig.6.21. From Fig.6.21, it can be seen that the sun orientation is possible.

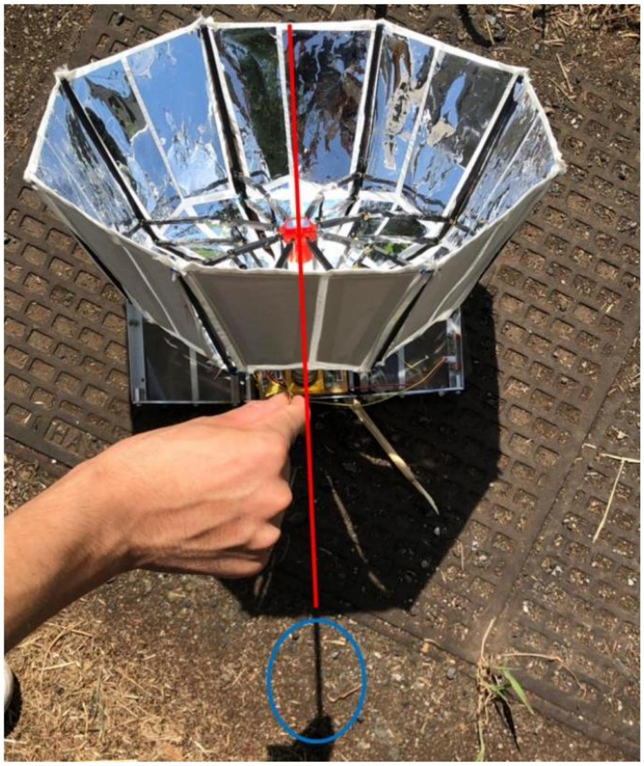

Fig.6.21 Confirmation of sun orientation using the shadow of the ruler and the angle of the center rod

• Conclusion

It was confirmed that it is possible to point the reflector toward the sun during mission execution.

Ta.

[V19] Reflector heat test

• Required items

[M10] The reflector part can withstand heat while concentrating light.

• Purpose

When the reflector was left facing the sun for one hour on a clear day (900W/m^2 irradiance), bone temperature was measured.

The temperature rises to about 50ÿ. Under these conditions, the bone material used for the reflector may become deformed.

Check whether the light-collecting structure can be maintained without

• Exam date and time

8/6 (Sat)

10:00ÿ11:00

• Test location

CanSat member home

• Participants

Taichi Oshino

• Exam content

With the reflector unfolded, heat the entire reflector section to 60 degrees using a nichrome wire heater.

Ru. An infrared temperature sensor confirms that the specified temperature has been reached, and the bone is functioning properly.

Check that.

• Test system

ÿ Reflector section

ÿ Infrared heater

ÿ Infrared temperature sensor

• Test procedure

1. Expand the reflector part.
2. Measure the temperature of the bone before heating.
3. Heat to 60ÿ using an infrared heater.
4. Check that it is being heated using an infrared temperature sensor.
5. Check the heated reflector section to ensure that the film expansion function is not lost.

   confirm.

Table 6.15 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Temperature of the bone structure of the reflector	Infrared temperature sensor	It's over 60 degrees Celsius.
2	Functional confirmation of membrane deployment	Visually	The film bends excessively compared to before heating. Not there.

• Test results

The bony structure of the reflector maintained sufficient strength through heating, and the function of membrane expansion was not lost.

The details of the test are shown below.

https://youtu.be/melTgdhc_h0

0:07: Temperature measurement of reflector bone structure before heating

0:18: Heating by infrared heater of reflector part

1:25: Temperature measurement of reflector bone structure after heating

1:42: Functional check regarding film development on the reflector part

• Conclusion

It was confirmed that the heating of bones by sunlight has no effect on mission execution.

[V20] Reflector part wind pressure test

• Required items

[M11] CanSat will not fall over and the reflector will not be damaged when the wind speed is 5m/s while concentrating light.

• Purpose

The CanSat will not fall over and the reflector will not be damaged even if the CanSat is exposed to wind speeds of 5m/s from any direction.

Check.

• Exam date and time

8/3 (Wed) 17:00-18:00

• Test location

Tokyo Institute of Technology Ookayama Campus

• Participants

Nishioriku

Taichi Oshino

Hibiki Shiraishi

Seitaro Ueno

• Exam content

Rotate the turntable to see when the reflector is parallel and perpendicular to the cover.

Apply wind at a speed of 5m/s to CanSat.

• Test system

ÿ CanSat

ÿ Electric fan

• Test procedure

1. Make the direction of the reflector parallel to the cover.
2. Apply wind at a speed of 5 m/s to CanSat with the reflector facing the direction of the wind.
3. Apply wind at a speed of 5 m/s to the sides and back of the reflector.
4. Place the reflector perpendicular to the cover and do steps 2 and 3.
5. Point the reflector in the opposite direction to step 1 and perform steps 2 and 3.

Table 6.16 Measurement/confirmation items

No.	Check items	Measuring method Confirmation method	Judgment criteria
1	Damage to the reflector	Visually	Not a single reflector has come off.
2	Make sure the reflector and cover are parallel. Will the CanSat fall over in this condition?	Visually	won't fall down
3	Make sure that the reflector and cover are perpendicular. Will the CanSat fall over in this condition?	Visually	won't fall down

• Test results

Not a single reflector was damaged. Additionally, the aircraft may fall due to the torque of the wind hitting the reflector.

I didn't have to worry about it.

The details of the test are shown below.

https://youtu.be/aSRq_H5JHRk

0:00: Reflector and cover are parallel

0:01: Wind enters from the back side of the reflector part

0:09: Wind enters from the side of the reflector part

0:19: Wind enters from the front of the reflector part

0:32: Reflector and cover are perpendicular

0:33: Wind enters from the back of the reflector part

0:40: Wind enters from the back of the reflector part

1:00: Wind enters from the back of the reflector part

• Conclusion

In carrying out the mission sequence, the aircraft must be able to withstand the wind sufficiently and complete the mission.

It was confirmed that this did not affect the line.

Chapter 7 Gantt chart (process control)

Gantt chart

https://docs.google.com/spreadsheets/d/1jblcrlmS6402Ubsy1avSmdtZQm35UuZq/edit?usp=sharing&ouid=116440725000498462204&rtpof=true&sd=true

Chapter 8 Summary of self-safety examination results by the responsible teacher

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

1.Safety standards review

request number	Self-examination items	Self-examination result Fruit	Comments from the responsible teacher (if there are any noteworthy items)
	ARLISS2022 Safety Standards		
S1	The mass of the aircraft to be dropped meets the criteria.	ÿ	
S2	volume meets carrier standards	ÿ	
S3	Verify that the quasi-static loads during launch do not impair functionality to meet safety standards. This has been confirmed through testing.	ÿ	
S4	Vibration loads during launch cause safety standards to be exceeded. The functions necessary to satisfy the requirements are not impaired. has been confirmed by testing	ÿ	
S5	Collision during rocket separation (when parachute is deployed) Tests have confirmed that the impact load does not impair the functionality required to meet safety standards. coming	ÿ	
S6	To prevent falling at dangerous speeds near the ground. It has a speed reduction mechanism, and its performance can be confirmed by testing. ing	ÿ	
S7	Measures against S7 loss have been implemented, and their effectiveness has been tested. This has been confirmed by experiment. (Examples of measures: location information transmission, beacons, fluorescent color paint, etc.)	ÿ	
S8	It has been confirmed that the regulations for turning off radio equipment during launch can be complied with (FCC certification and	ÿ	

	Devices with a power output of 100mW or less do not need to be turned off. Ma In addition, if you use a smartphone, it must be FCC certified and have software or hardware (can be turned off with switch)		
S9	Willing to adjust radio channel, We have also confirmed that adjustments can actually be made. Ru	ÿ	
S10	We have been able to conduct an end-to-end test that simulates the loading of the rocket, the start of the mission, and recovery after launch, and we plan to make major design changes in the future. There is no	ÿ	

1.Responsible teacher's impressions

In this mission, we will demonstrate light focusing technology using a deployable structure, which is expected to be applied to a power generation system useful in the exoplanet region. With an eye toward future applications in space exploration, the members have spent time developing ideas and developing concepts. With a thorough understanding of safety, the team members developed a plan and carried out all the necessary steps for both development and testing. interesting mission I hope it can be done.

Chapter 9 Tournament Results Report

1. Purpose

The mission of EURECOS is to develop membranes to expand the usable range of solar cells in outer space.

"Demonstration of light concentration/heat collection technology by structure" and demonstrated membrane deployment structure, light concentration/heat collection technology, and solar direction tracking.

The purpose of verification at ARLISS is to perform it as a technology demonstration.

2.Results _

(i) First drop

The first drop was carried out on September 12, the second day of ARLISS.

During the adjustments we made on-site the day before, we found that the communication distance with the aircraft on the ground was approximately 100m.

The issue was that it was extremely shorter than the standard. As a countermeasure, raise the receiving antenna position.

Measures were taken such as fixing it.

The communication distance test was conducted again on the morning of the second day, and the communication distance was slightly improved compared to the previous day.

Ta. After that, the first launch took place around 3:00 p.m. I had been concerned about communication since the day before.

In this case, GPS information was successfully acquired from the aircraft within 1 to 2 minutes after launch, and the GPS information was successfully acquired after release from the rocket.

The results showed that communication was possible immediately after the power was turned on.

The purpose of this is to set the mission time in advance to prevent malfunction of the parachute separation during the fall.

There was a time lag of 20 minutes after the power was turned on until the parachute was separated. Also, communication with the aircraft

In case things go wrong and the search takes time, you can visually check the cover deployment.

A 60-minute time lag was provided from parachute separation to cover deployment to ensure that

Since communication was possible immediately after the power was turned on, the aircraft was discovered about 10 minutes after launch.

Met. The wind blows and pulls the parachute for about 20 minutes after landing until the parachute separates.

It was confirmed that the vehicle had shifted and traveled a long distance. Afterwards, the parachute is separated, the cover is deployed, and the reflector is

The lifting of the mirror and the deployment of the reflector were visually confirmed.

After the cover was deployed, progress to the sun pointing sequence was confirmed from radio information, but visual observation showed that

I could not see any directional movement. After waiting for several minutes, the first mission was completed.

Completed.

Table 9.1 shows the degree of achievement of the success criteria in the first deployment.

Table 9.1 Success criteria achieved in the first release (displayed in yellow)

function	Minimum success (5/5)	Full success (1/3)	Advanced Success (0/3)
parachute	Parachute deployment [Visually check]		
	Parachute separation [Visually check]		
Cover part	The cover part expands and The mirror section faces upwards. [Turntable section and Make sure there is no interference. Check visually]		
Reflector part	Expand the reflector section [The role of a stopper] There is a screw head that Hey, go down there. is moving Check visually]	focus light [Tip and center of reflector section] Photo installed in the light section using transistors Measure the illuminance and compare the values. 1x that's allÿ	Light focusing accuracy is the same as the theoretical value to make [Fully expanded in advance The structure created focuses light, Compare with the value at that time. ratio The values to be compared are based on the magnification of the light intensity in the condensing part and the normal part. Error within 15% Make sure that]
			The reflector part collects heat [the tip of the reflector part and the light collecting part are placed outside] Measure with a radiation thermometer and compare the values]
Lifting part	Lift the reflector section [Visually check]	Keep the reflector section at 45 degrees from the ground [Measure with a protractor]	
Turntable section		The reflector part is turned rotated by bull facing the sun	The reflector part is a turntable By rotating the Follow the positive direction [Angle within 15°]

		[Confirmation using external illumination meter, measuring stick By measuring the angle between the shadow of and the middle bar confirmation. Angle within ±15°ÿ	

(ii) Second drop

The second drop was carried out on September 15, the last day of ARLISS.

Due to strong winds on the 13th and 14th, we decided not to launch the project and worked on making corrections based on the failure of the first attempt. correction The points are described in Chapter 10. The day was sunny with no wind and few clouds in the morning. Because of this, it was able to be dropped in good condition.

After the aircraft is released from the rocket, it can be visually confirmed that the parachute has been deployed. Ta. After that, I tried to acquire GPS, but it was not possible immediately after deployment. However, after some time I was able to obtain it. Since the wind was not strong, it took about 10 minutes to land. Also, Because GPS was available when the aircraft was discovered, it was discovered immediately after landing. In the first drop, After landing, the parachute was blown by the wind, causing the aircraft to be dragged, but the second drop brought it down. Since there was no wind, the parachute was not dragged away by the wind before it was fused. Ta. The situation after landing is shown in Fig.9.1. It was visually confirmed that the parachute had been detached. Figure 9.2 shows the state before the cover is deployed. Afterwards, we visually confirmed the success of the cover and reflector deployment. Figure 9.3 shows the state after the cover is deployed and the reflector section is deployed. Next is the sun-oriented sequence. It was confirmed that it was working without any problems, and it was confirmed visually that it was pointing toward the sun. I recognized it. You can also confirm from the log that the next solar direction tracking sequence has started, and the program can be programmed without any problems. It was confirmed that the RAM was successfully terminated. It was also confirmed visually that the direction of the sun was being followed. Ta. Figure 9.4 shows how the sun is pointed. Here, we visually confirmed whether the sun was pointed by the shadow of the yellow ruler and the direction of the reflector. From Fig.9.4, it is possible to point with a pointing error of ±15°. I know that there is. However, it is difficult to confirm whether the light is being focused using data from the photocell and temperature sensor. I was planning to check it, but the data was not saved on the SD card. Therefore, the light is concentrated It was not possible to evaluate the The cause of this will be discussed in Chapter 9, 3.(v). Finally, the radiation temperature Using a diagonal meter, we measured the tip of the reflector and the condensing part from the outside.

Fig.9.1 Condition after landing

Fig.9.2 Condition before cover part is expanded

Fig.9.3 Cover and reflector after unfolding

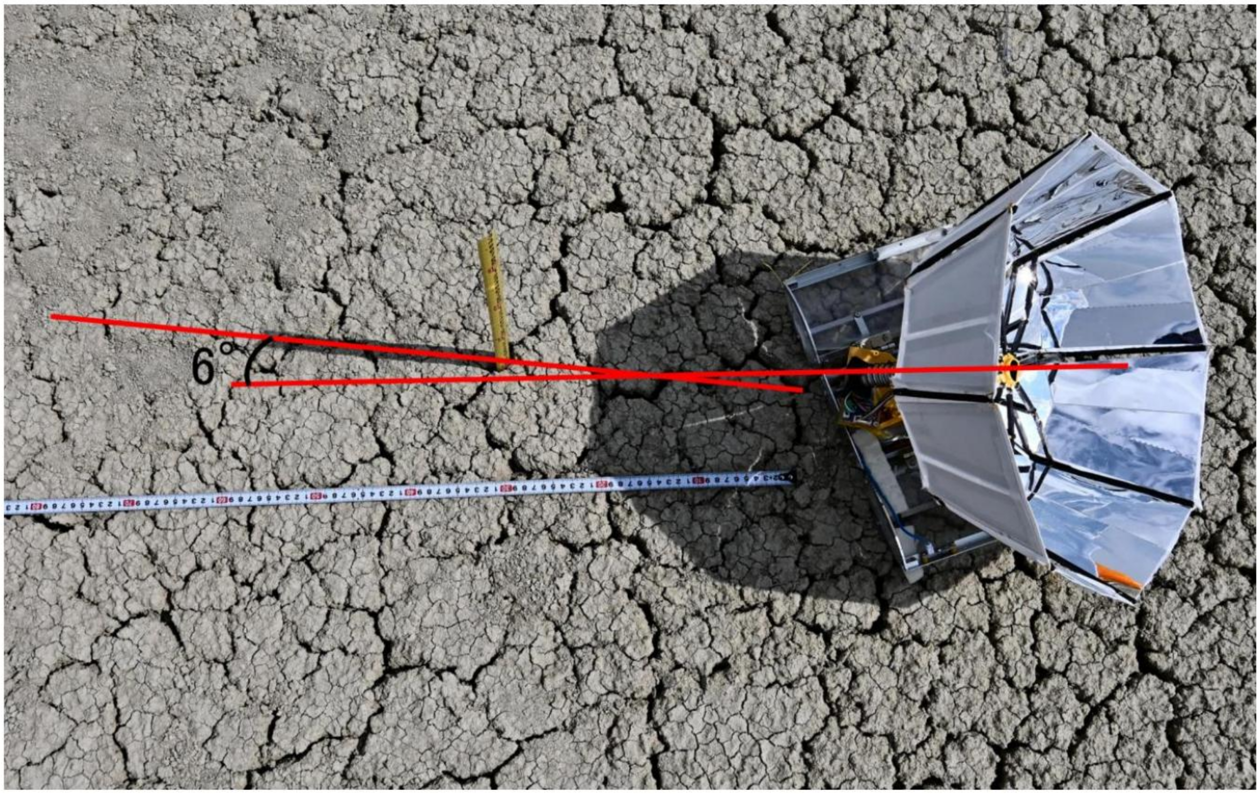

Fig.9.4 View after pointing to the sun (yellow ruler indicates the sun's shadow)

Table 9.2 shows the degree of achievement of the success criteria in the second deployment.

Table 9.2 Success criteria achieved in the second drop (displayed in yellow)

function	Minimum success (5/5) Full success (2/3)		Advanced Success (1/3)
parachute	parachute deployment [Visually check]		
	Parachute separation [Visually check]		
Cover part	The cover unfolds and the reflector faces upward. [Turntable section and Make sure there is no interference. Check visuallyÿ		
Reflector part	Expand the reflector section [The role of a stopper] Because there is a screw head that moves, you can tell that the wheel is moving that far. Check visually]	Collecting light [Measure the illuminance using a phototransistor mounted on the tip of the reflecting mirror section and the condensing section, and compare the values.] 1 times or moreÿ	Light focusing accuracy is the same as the theoretical value to make [Fully expanded in advance The resulting structure collects light and compares it with the value at that time. The values to be compared are those of the condensing part and the normal The ratio is determined by the magnification of the light intensity of Compare. Try to keep the error within 15%.]
			The reflector part collects heat [the tip of the reflector part and the light collecting part are placed outside] Measure with a radiation thermometer and compare the values]
Lifting part	Lift up the reflector [Visually check]	Continue to maintain the reflector section at 45 degrees from the ground [measured with a protractor]	

Turntable section		The reflector part is turned rotated by bull facing the sun [Confirmed using an external illumination meter and by measuring the angle between the shadow of the ruler and the center bar. Angle within ±15°ÿ	The reflector part is a turntable By rotating the Follow the positive direction [Angle within 15°]

After the mission ended, we conducted two additional experiments. The first is that the solar tracking stage is determined by sensor values. We checked whether the light collection magnification was at its maximum from the sensor values. child At that time, CanSat was carried out in the sequence after the cover part and reflector part were deployed. Also, during pointing and following has not been touched by humans. The second method is to visually orient the sun and collect data on the light concentration magnification at that time. was obtained. At this time, the human hand is pointing towards the sun. These analyzes are also discussed in the discussion. Ru.

3. Discussion

(i) Parachute

Both of the two drops deployed without any problems, landed without covering the aircraft, and the parashoes were Separation of the parts has also been completed. However, for the first drop, the landing time is determined by the falling time. As a result, there was a time when the aircraft was dragged by the strong wind before the parachute detached. It happened. During the second drop, landing was determined based on changes in air pressure based on the atmospheric pressure data obtained during the first drop. He was able to quickly separate the parachute before it was blown away by the wind.

(ii) Cover part

Both drops were successful without any problems. The success criteria for the cover section is There is only Nimam Success, but there are some obstacles to Full Success in other parts of the Success Criteria. The level of achievement was so ideal that it didn't make any difference.

(iii) lifting section;

During the first drop, it was confirmed that after the cover opened, it rose at an angle of 45° from the horizontal. Ta.

In the second drop, the success criteria reached full success, and the wind blew for a long time. It maintained a constant elevation angle even when

(iv) Sun pointing and tracking of the condensing surface

During the first drop, the turntable part did not rotate and full success failed. the aircraft After disassembling and checking, it was confirmed that the inside of the motor box was filled with sand. When the parachute was dragged before separation, a large amount of sand and dirt entered the aircraft, damaging the motors and This is thought to have hindered the movement of the turntable.

In the second drop, the sand countermeasures around the motor box (Fig. 9.5) were successful, and the sand was removed from the surface. The condensing surface follows the sun for an hour without obstructing the movement of the cable, creating an extra Achieved success. Fig.9.6 is a photograph of the aircraft immediately after the mission ends, showing the shadow and light condensing surface. The angle is approximately 4deg, which is less than ±15deg. Also, Fig.9.7 and Fig.9.8 show the tip light when following the sun. This is a log of the sensor and turntable angle. From Fig.9.7, especially from 1500s to 3200s, It can be seen that the value continues to stably reach the maximum value. Unstable parts before 1500s and 1500s Temporary decreases in sensor values that have been observed periodically since then may be due to clouds covering the sun.

It is. In Fig.9.8, the apparent angular velocity of the sun is found to be 3.66deg/h from the slope of the stable part after 1500s. This also agrees with the fact that in Fig. 9.6, the initial angle (measure angle) and the angle at the end (1h after the start) (shadow angle) are approximately 4deg.

It can be said that the sun was accurately tracked from the beginning to the end. Simulation using simulink in advance

As expected in the simulation, the instability of the angle before 1500s is due to the maximum value used here.

This is thought to be because the search algorithm converges slowly and is vulnerable to short-term changes such as cloud shadows.

It will be done.

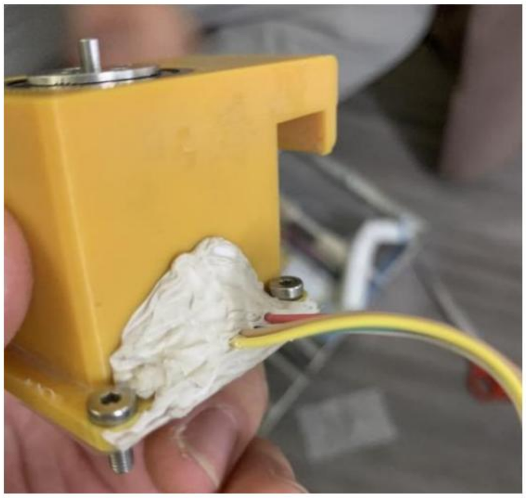

Fig.9.5 Measures to prevent sand from entering the motor box

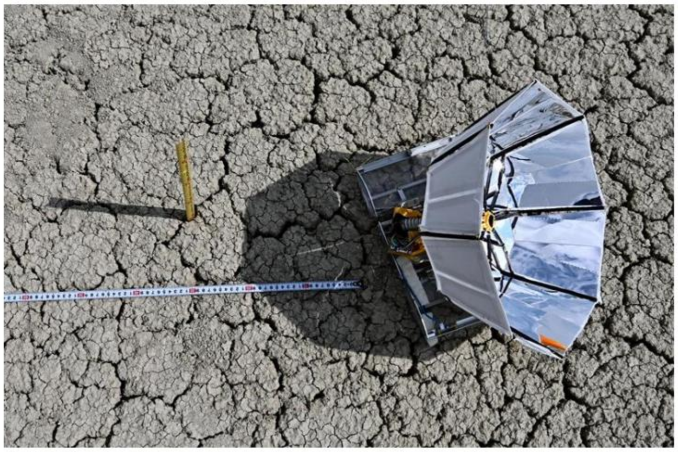

Fig.9.6 Condition of the aircraft immediately after the second mission

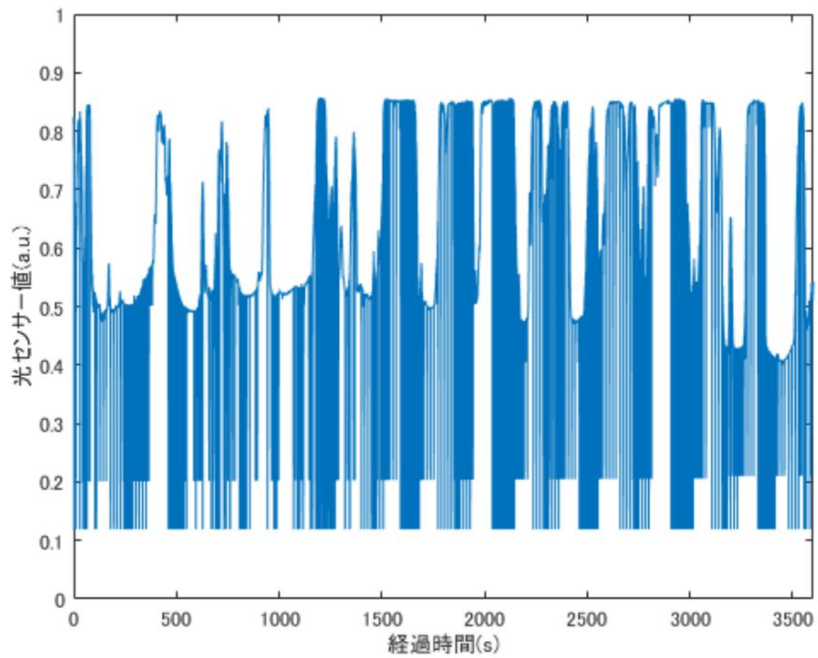

Fig.9.7 Light sensor log when following the sun

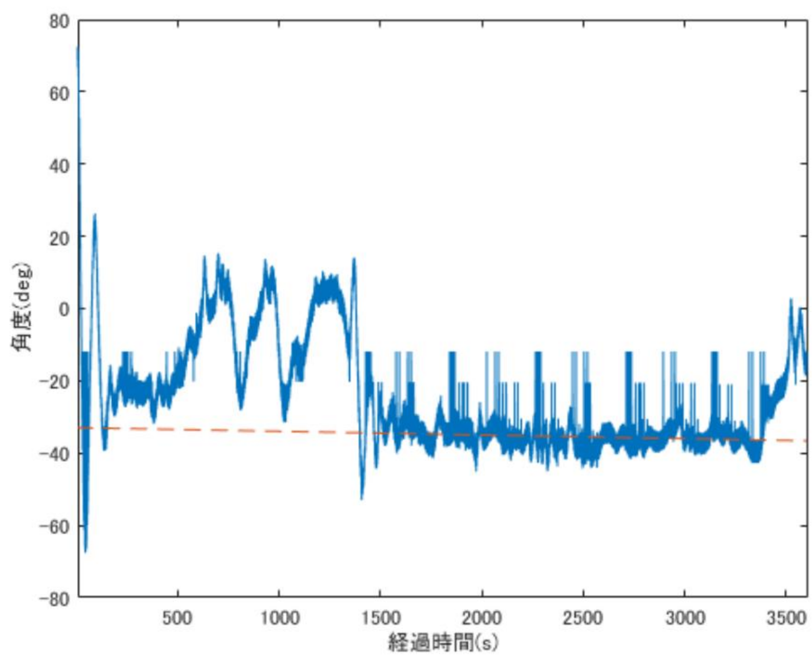

Fig.9.8 Log of turntable angle when following the sun

(v) Obtaining focused data

During the first drop, the mission did not progress until data acquisition due to a motor problem.

In the second injection, it was possible to obtain the values of the radiant intensity and temperature of the non-concentrating part and the temperature of the condensing part. However, due to a malfunction of the sensor board, it was not possible to obtain the value of the radiation intensity of the condensing part, and full operation was not possible. I was unable to achieve this goal. Failure of the sensor board is caused by the soldered part of the board. This is because the electrical connection between the photodiode and the microcontroller was broken. Second launch At the time, I used a different aircraft than the first time, but I neglected to check the operation of the sensor by opening the umbrella, and the umbrella was opened. Since we only checked the umbrella when it was closed, we did not notice that the light condensing sensor inside the umbrella had malfunctioned during transportation. This is due to the fact that

(vi) Mission (reflector part)

Regarding the reflector part, it took time for the parachute to separate during the first drop, so The aircraft was dragged away by the strong winds. During this process, sand adheres to the mirror surface and the surface becomes uneven. The emissivity is in a state where it has clearly decreased, and it is a state that can cause a decrease in the light collection magnification. was confirmed. During the first drop, the mission did not advance to the sun-directing and light-gathering stage. Although it was not possible to quantitatively measure the actual degree of impact due to the If a similar event occurs, assuming the mission progresses smoothly, the success criteria will be It was expected that this would have a significant impact on the degree of achievement of Ria.

Therefore, during the second drop, the clear file was cut to prevent sand from covering the reflective chest. A countermeasure was taken by attaching the cut piece to the cover. In the end, during the second drop, the parachute This effect could not be confirmed because the separation occurred smoothly.

During the second drop, smooth deployment of the reflector part was confirmed. Regarding solar orientation However, by placing a stick nearby and checking the direction of the shadow, it was confirmed that the child was facing the expected direction. Ta. However, during the second drop, it was not possible to obtain the value of the radiant intensity of the condensing part. Therefore, it was not possible to quantitatively evaluate light collection efficiency and heat collection.

Chapter 10 Summary

1. Points of improvement/effort (hardware, software, management)

(i) Mission

There are two points in which we devised and made efforts regarding the mission.

The first is that when defining the mission, we made the evaluation axis clear and evaluated the mission. is. Specifically, we will focus on uniqueness/novelty, technical feasibility, experimental verification on the ground, and what CanSat can do. The mission was evaluated based on whether the system was appropriate. Current status of actual space exploration and development Taking this into consideration, this mission is characterized by the fact that it has set out a particularly novel and useful issue as its mission. This is one of the improvements to the version.

Second, we appropriately divided the scope of our technology demonstration. Our mission this time The system statement is ``Membrane deployment structure aimed at expanding the usable range of solar cells in outer space.'' "Demonstration of light concentration/heat collection technology". This is a technology demonstration aimed at generating power during deep space exploration. Therefore, assuming a deep space mission, light concentration/heat collection, power generation, and power output after power generation (operation in space) are required.) can be considered as a mission flow. We considered the scope of our verification. As a result, we conducted a deep space mission to experimentally verify the effects of light intensity and temperature on light and heat concentration. One of the ingenious points of this mission was that we were able to clarify the most important points in our assumptions. Ru. As a result, from the perspective of mission usefulness and mission significance, it has become an unwavering foundation during development. Ta.

(ii) Airframe structure

There are three points that the aircraft structure department devised and worked hard on.

The cover of this aircraft is the outermost part, which is the part that receives the most impact, and the parachute If the structure is distorted or broken due to the impact of opening the umbrella or landing, the cover will not expand or the interior will be damaged. It is possible that the product may be damaged due to impact. However, structurally and materially strengthening Improving its impact resistance was a great success, and after landing, the aircraft looks like it did before launch. There was no distortion.

Furthermore, thanks to this, the spring hinge, which is responsible for the expansion force of the cover part, did a perfect job. The spring hinge opens as per our design and fully contributes to the success of the internal reflector and lifting parts. Ta. Even after it was deployed, the spring hinge continued to maintain its opening force, contributing to the stability of the aircraft.

Also, the fact that the structure did not distort was very significant for the development of the cover itself.

Ta. This machine has a force acting in the direction of opening at all times due to the spring hinge mentioned above, and in order to keep it closed.

It is equipped with a bolt-like mechanism, which is pulled out using a tension spring and a fusing thread, and the aircraft deploys.

Is Umono. We were able to prevent interference between the bolt and the member through which it passes due to distortion.

Of course, we also paid attention to the placement of internal components. In this mission, the cover section will be expanded.

Therefore, by installing the electrical components that mainly account for the weight on the bottom at the design stage of the internal layout, it is possible to prevent them from rolling.

We devised a way to prevent the interior of the aircraft from facing the ground after the cover was deployed. Reflector as large as possible

Because the reflector section occupied a large part of the interior of the aircraft, the remaining parts were

It was a pain to place other functions in such a way as to squeeze them into the space.

Improvements made at the site after the first drop included countermeasures against sand and soil intrusion. Front flap

By applying a film, the amount of intrusion can be reduced, and around the harness of the motor box where there was a problem,

In addition to the original hot glue, we used locally procured adhesive rubber to adhere.

(iii) Parachute section

First, there are two points when designing a parachute. The first point is drag considering the shape of the parachute.

Various parameters are used, such as determining atmospheric density based on coefficients and the average altitude of the Black Rock Desert where the event will be held.

This is a point estimated in as much detail as possible in the parameters. The second point is that the parachute does not move after landing.

The point is that convex springs are used along the shroud line so that they do not overlap the body.

In addition, when manufacturing the parachute, we used ripstop material that is light and resistant to tearing.

A particularly ingenious point was that the fabric used for the parachute was cut using a paper pattern.

(iv) Electrical section

One of the improvements in the electrical equipment section is that the value of the optical sensor can be corrected from the value of the temperature sensor installed on the aircraft.

Here are some things I did. The optical sensor used in this machine suffers from temperature increase as the temperature of the sensor increases.

There was a characteristic that the output value of the sensor increased exponentially. In addition, the temperature sensor also increases as the temperature increases.

It had a characteristic that the error occurred on the order of several degrees Celsius. You can measure illuminance with high precision from flight logs.

First, a correction function is determined from the temperature-related characteristic curves and experimental values of both sensors, and the mission evaluation is performed.

Made it easier to do.

In addition, regarding the electrical board, since a microcontroller with few I/O ports was used, the main

The sensor was devised to be integrated using I2C communication. This allows you to record logs to microSD via SPI communication.

This enabled us to use UART communication, allowing us to adopt a more reliable logging method.

When developing software, use the thread function of mbed OS to record and read sensor information. It has been made possible to perform sloping and GPS downlinks independently. Also, it is possible to By using the while statement, you can write a specific sequence instead of writing a new program. It is now possible to check the operation of

For sun-oriented programs, sun orientation is performed multiple times to reduce the influence of external disturbances. I decided to do it. Specifically, with one rotation of the turntable, the numerical value of the rotation angle of the encoder and the light Record the combination of sensor values and rotate multiple times until the same combination of values is obtained consecutively. I decided to continue.

In addition, regarding the sun tracking program, it is possible to perform tracking with only one analog sensor. By adopting a control method, it is now possible to continuously point toward the sun as the sun's direction changes.

(v) Reflector section

The reflector section is the mechanism for this mission that has been improved through the most prototypes. Therefore The reflector section is further disassembled into the reflective membrane section, bone section, and central rod section, and the improvements for each section are described. Ku.

First, regarding the reflective film part. This is the part responsible for focusing the light in this mission, and how should it be used? The challenge was how to fit it into the CanSat size. The first point to consider is how to create creases. It will be done. The basic mechanism was designed with reference to a common folding umbrella, but the folds in the membrane are made from bones. It is located in a position that is far away from the center between the two. This is because a reflective plate is attached to the reflector part. It is necessary to consider the thickness of the membrane itself, and this result takes into account the difference in circumference when wrapping it around the middle rod. In addition, three types of cloth and three types of reflective plates were selected for the material of the reflective film, and each material had different characteristics such as expandability, light collection rate, and weight. After repeated evaluations and prototypes, we selected the appropriate one. As a result, the flight model does not have sufficient folding. We selected cotton that can be seen and has a certain degree of durability, and for the reflector we used the strongest material. Maintain flatness and do not remove the protective film attached to the reflector until just before launch. By doing so, we suppressed the decrease in reflectance due to desert sand.

Next, about the bones. This part was the first structure that our organization worked on after starting its activities. Moreover, it was a structure that had to be adjusted until the very end. The mechanism uses a general link mechanism, and the material is manufactured using micro carbon fiber filled nylon and a 3D printer. Joint of each link This is done using eyelets, which have a structure in which one member is sandwiched by the other, which prevents uneven rigidity. Along with the dust, each link maintains its strength so that it will not break. In addition, the micro carbon used in the material Fiber-filled nylon has a density similar to that of the nylon used in typical 3D printers.

It is a material with higher strength and heat resistance. This allows it to withstand the temperature rise in the bone caused by condensing light. Not only that, but also able to withstand exposure to the wind after deployment, while keeping the weight down. It became possible.

In addition, thread is used to connect the light-collecting membrane part and the bone part as mentioned earlier. Here are some methods in practice After conducting prototype production and testing, we decided to create a new design by hand sewing the holes and fabric in each part of the bone. I was able to get the most desired functionality.

Third, regarding the middle stick. This structure supports the above parts in the reflector section, and also supports various internal parts. This is an important part that holds the sensor. The required function is to reduce the temperature expected by condensing light. It must be strong enough to withstand high temperatures, strong enough to withstand the effects of wind, and the internal sensor part must be protected. It is a material that can be processed in detail to maintain its durability. From the above points, aluminum can be used as a ball. It was created by performing board processing. This will allow you to endure this mission until the end. The parts are ready.

(vi) Start-up section

The requirements for the launch section in this mission are to lift the reflector section and fix the angle. be. A technical difficulty is that the deployment of the reflector requires lifting and fixing due to the expansion of the structure itself. There is an increase in required torque and the influence of wind disturbance. Initially, a small spring butterfly was used due to space considerations. I tried to satisfy the deployment torque with only the number, but the torque was insufficient. Therefore, the combination of spring hinge and tension spring This method ensures sufficient deployment force through the combination, and the rotation locking mechanism is not installed in the closing direction. It has a mechanism that allows it to return even if it is temporarily closed due to wind.

2. Issues

(i) Airframe structure

The spring hinge was selected because it was used by the previous generation, so the safety of the aircraft during and after deployment was reduced. I assembled it as is without calculating the torque required for stabilization. It turned out well in the end I think it may have been better because it was a little more difficult.

The fuselage was deployed using a fusing mechanism, but it turned out to be a complicated mechanism to set up. Also, that The method requires some ingenuity and tricks, so it needs to be improved.

(ii) Parachute section

The parachute generally worked well, but we had to make sure that the parachute did not cover the aircraft after landing. Although the convex spring used for the first launch did not cover the fuselage after the first launch, The convex spring was bent and not functioning. Therefore, the arrangement of convex springs We need to consider this further.

(iii) Electrical section

First, the communication distance after landing was extremely short. When I checked the log, I found that the aircraft Although communication was possible when the aircraft was in the sky, communication between the aircraft and the ground station was lost after landing. The distance was such that the aircraft could be seen visually. The main cause is the failure of the communication module. The antenna layout was not sufficiently considered, and the maintenance of the antenna on the ground station side was not carried out properly. It is possible that this was not done.

Another issue is that the MCU was being reset while the aircraft was falling. to this During the first flight, there was a significant delay in detecting the landing, and a large amount of sand got inside the aircraft. Yes. Since the MCU was not reset after landing, it seems likely that the ring was lost when the parachute fell. It is necessary to consider the environment.

(iv) Reflector section

The main problem with the reflector section was that the reflective film was not a perfect cone but was made up of eight surfaces. Here are some points. Since the center rod is a thin cylinder, when light is reflected from eight surfaces like this time, There will also be reflected light that does not hit the center rod, which is inefficient. In addition, the reflected light is In order to apply it perpendicularly to the axis, the reflective film must be conical. Therefore, reflected light can be used more efficiently. In order to focus the light on the central rod, we are investigating a structure that makes it possible to make the reflective film more conical. It is necessary to discuss this matter.

(v) Start-up section

The challenge for the start-up department is to consider the balance with the success criteria for this mission. The key point is that the design has a fixed launch angle. Ideally, the solar altitude should be changes, so it is desirable to have a mechanism that follows it. Therefore, the angle can be adjusted arbitrarily depending on the solar altitude. It is necessary to consider a structure that can be controlled to change.

3. Future prospects

Although the activities of EURECOS will end this fiscal year, there are plans for future research fields and actual satellite development.

We would like to utilize the knowledge gained through the development of this CanSat.

In addition, for those who will be participating in CanSat development in the future, we would like to ask seniors in the laboratory and CanSat development experience.

We recommend that you listen to many stories and ask questions. I'm sure they'll be happy to tell you.

is. By doing so, you should be able to see what you should think about for yourself.