ARLISS2022 report

Submission date: November 20, 2022

• Main examination report 1st examination
  • Submission deadline: July 7th
  • Examination items
    ÿ Chapter 3 "Setting Required Items"
      • System requirements are set to ensure safety around the launch site and personnel, and design/manufacture Has the health of the aircraft been evaluated?
      • Is the setting of mission requirements appropriate for achieving the mission?
    ÿ Chapter 6 "Test Items"
      • The "purpose" and "test content" are written, and the test is designed to meet the requirements. Is it valid?
• Main examination report 2nd examination
  • Submission deadline: August 8th
  • Examination items
    ÿ 6 [Test items] "Test results" and "discussion" for each experiment are entered, and the test results are Can you say that the requirements are met?
    ÿ You can confirm that the minimum success criteria have been achieved through the end-to-end exam. Ruka

• Examining faculty

Examining faculty member name	
email address	
Judging comments	
Other words	

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CanSat class	Open class

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ÿTo study and research through CanSat

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Chapter 1 Mission Statement

It learns the 3-axis acceleration of CanSat's vibrations while running, uses machine learning to estimate whether it is on flat ground, uneven ground, or when it is stuck, and controls the running speed and steering wheel values appropriate for the situation.Additionally, Object Detection recognize the goal in real time and aim for the 0m goal.

[State estimation by machine learning of vibration]

When driving CanSat Comeback, various road surfaces are expected. For example, ARLISS has a relatively flat road surface, with some ruts here and there. In this case, if you drive slowly, you are likely to get stuck in ruts, and the road surface will take over your steering, making it difficult to drive straight and stably. Therefore, it is better to set the speed as fast as possible. On the other hand, on uneven roads with many clumps of grass, such as the one at the Noshiro Space Event, if you drive at high speeds, you will often run onto the grass and flip over, making it difficult to drive stably. Can not do it.

In addition, stuckness is determined using GPS position information, but in this case, the object is not stuck, but the moving distance per unit time is short, such as when the object is slowly climbing up the grass and moving from side to side. There is a problem in which it may be incorrectly determined to be a stack. However, if we set the travel distance long to avoid such misjudgments and try to avoid stack detection as much as possible, there is a problem that it is difficult to detect a stack when the object actually gets stuck.

Therefore, using CanSat's vibration, we can calculate the road surface like ARLISS and Noshiro from the acceleration data. By learning various vibration conditions such as the road surface, the CanSat ground condition is estimated by machine learning, and the CanSat runs in a way that is suitable for that ground, aiming for more stable driving control than before for the CanSat.

If it is determined from the vibration data that the aircraft is traveling on uneven ground, such as at the Noshiro Space Event, the aircraft will travel at a slower speed, as the aircraft is more likely to overturn if the vehicle is traveling too fast. Also, since the handle can be taken off by uneven surfaces, the handle parameters should be set large. Similarly, if it

is determined from the vibration data that the vehicle is traveling on a flat surface such as ARLISS, the traveling speed is set to a high speed, and the parameters are set to a small value so that the steering wheel does not touch the ground. Even if there are occasional ruts, if your driving speed is fast, there is a high possibility that you will be able to use the momentum to overcome them. Furthermore, when it is determined that a vehicle is stuck based on the vibration data, the aim is to achieve control that can more reliably determine that the vehicle is stuck by making the determination together with GPS position information.

By converting CanSat's vibration, 3-axis acceleration data and 3-axis gyro data from time domain to frequency domain using FFT and learning, the ground state is estimated by machine learning when CanSat is running.

An example of an FFT image from acceleration data is shown in Fig.1. The FFT image has frequency components from 0 to 50 Hz on the vertical axis and 5 seconds of time every 0.1 s on the horizontal axis, and is expressed as a 50 × 50 pixel color image. The magnitude of the frequency component is indicated by the color and brightness of the image, and is expressed by changing the color of HSV from blue when it is small to red when it is large. In Fig. 1-1, the left side of the image shows the deep blue state when CanSat is stopped, and the right side of the image shows a color change including yellow and green when it starts running.

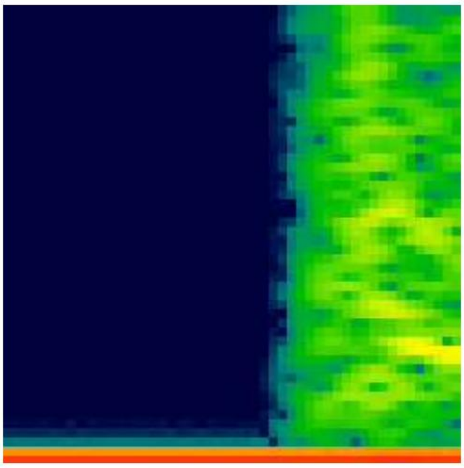


Fig.1-1 Example of FFT image

This FFT image is used as learning data for vibration in each state. For learning, we prepared 5 patterns of driving conditions using FFT images. The five classifications are shown in ÿ-ÿ below.

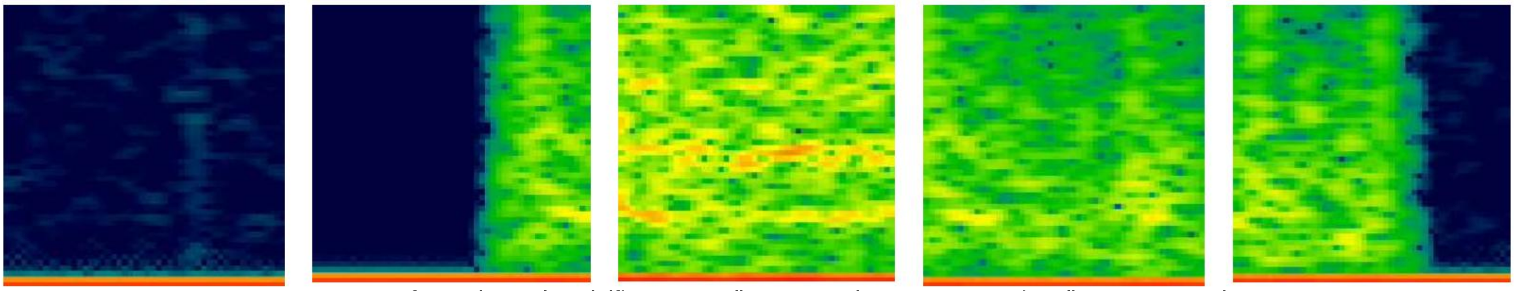
ÿ A state in which the FFT image is completely blue when CanSat is completely stopped is determined to be halt. ÿ When CanSat starts running and the FFT image changes from bright blue to the FFT image of the running state,

It is judged as start of running. ÿ When

CanSat is running on hard, flat ground, it is judged as hard. ÿ When CanSat is running on uneven ground with grass, it is determined to be grass. ÿ When CanSat stops moving and changes from the FFT image of the running state to the bright blue image of the stopped state,

It is judged as stop running.

Figure 1-2 shows an example of the driving state of an actual FFT image.



ÿ halt (when stopped)

ÿ start of running ÿ hard (flat ground) ÿ grass (uneven grassland) ÿ stop running

Fig.1-2 Example of FFT image of vibration in each state

The current state is estimated from the FFT image using deep learning image recognition. If the state estimation results indicate that the rover is running on grass, the rover's running speed is set to a slow speed that will prevent it from overturning. Similarly, if the state estimation results indicate that the vehicle is hard (driving on a hard road like ARLISS), a high speed is set to ensure smooth travel. In other words, if the road surface is determined to be grass after the start of driving, it will be determined that the road surface is grass, such as in the Noshiro Space Event, and the speed will be reduced. On flat ground like ARLISS, it is judged as hard and aims to run faster.

[0m goal with Object Detection] With Object

Detection, you can detect multiple objects from one image and know where they are in the image. In addition to the goal, a single image can also detect people, balloons, etc., and the location of each object can also be obtained from coordinate information. Although the processing time per processing time is longer than Image Classification, conventionally, to search for the goal, the screen was divided into 3 or 5 ROIs, and the ROI was moved up and down. Since there is no need to do this, it is thought to be particularly resistant to inclinations in the tilt direction of CanSat.

In addition to goal recognition, the system can also detect multiple other objects, so even if a person wearing the same red clothes as the goal or a red balloon appears in the same image, it can be identified as the goal, improving recognition accuracy. Can be improved. The problem is that Object Detection is more complex to process than conventional Image Classification, and requires more calculations and memory usage, so there are concerns about whether it can be implemented without problems on the Raspberry Pi Zero. However, with the Mobile Net SSD v2 model, it can be recognized in a few seconds, and if an accelerator such as Coral is used, it can be recognized in less than one second, so it is possible to implement it.

Fig.1-3 shows an example of goal discovery in Object Detection.

Fig.1-3 Example of goal discovery using Object Detection

[Mission sequence]

The mission sequence required to accomplish this mission is shown below.

1. Store the CanSat in the balloon carrier. 2. Release the
CanSat body from the balloon carrier.
3ÿ Open the CanSat's parachute to slow down its falling speed. Four. The aircraft
lands on the ground without any damage.
Five. Separate the CanSat protective case from the main body and separate it from the parachute.
6. Based on GPS position information, the vehicle drives toward the goal by controlling the motor rotation speed, estimates the state of the ground it is traveling on using acceleration data, and performs control appropriate for the ground
(mission). 7. The vehicle uses its tires to overcome large grass that is likely to become stuck, and when it determines that it is stuck in a rut, performs a rut escape operation and escapes from the rut.
8. When the GPS information shows that the robot is within 10m of the goal, it slows down and runs towards the goal. 9. Once
within 4m, the goal is detected using the camera image using Deeplearning Object Detection. (Mission) 10. After discovering the goal using the camera image,
run towards the goal. 11. When it gets close enough to the goal from the camera image, it determines
the goal and stops.

The above mission sequence is shown in Fig.1-4.

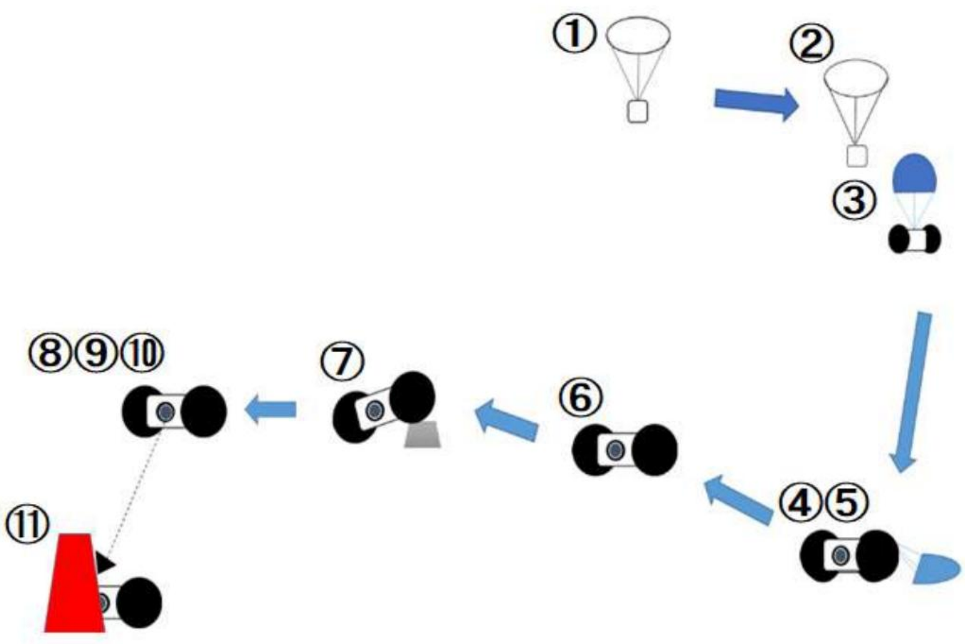


Fig.1-4 Mission sequence

Chapter 2 Success Criteria

There are one or more mission items and system configurations for this mission statement, and success criteria is a detailed and quantitative description of their success stages.

(Reference material: Guidelines for creating success criteria)

minimum success	After the CanSat is released and falls, it lands without damage, separates from the parachute, and travels over 10m by controlling the motor rotation speed based on GPS position information.
middle success	After CanSat reaches near the goal, Object Detection reaches the goal 0m
full success	When CanSat runs on the ground, it determines whether the ground is flat or uneven, controls the speed and steering wheel according to the situation, and uses Object Detection to reach the 0m goal.
advanced success	When CanSat travels on the ground, it determines whether the ground is flat, uneven, or stuck, performs travel control according to the conditions, and uses Object Detection to reach the 0m goal.

Chapter 3 Setting requirements

3.1 System requirements (requirements for ensuring safety and regulation)

Request number	System requirements (ARLISS launch safety standards)
S1	The mass of the aircraft to be dropped meets the criteria.
S2	volume meets carrier standards
S3	Tests have confirmed that the quasi-static load during launch does not impair the functionality required to meet safety standards.
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 confirmed through testing.
S7	We have implemented countermeasures against S7 loss, and their effectiveness has been confirmed through testing (examples of countermeasures: 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-certified devices with a power output of 100mW or less do not need to be turned off. Also, if a smartphone is used, it must be FCC-certified and have a software or hardware switch).)
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

- Please write the requirements for CanSat to accomplish the mission. If you want to add or delete something, please add a line.

- If individual tests are necessary to meet each mission requirement, each organization will set them as appropriate and describe them in Chapter 4. please

- By analyzing the mission requirements, requirements that need to be described will become apparent, so each team I look forward to the uniqueness of the system and the definition of detailed requirement settings.

number	Mission requirements
	After the M1 mission, the specified control history report will be submitted to the management and examiners for logging and acquisition. It is possible to explain the data obtained.
	M2 Tests have confirmed that the impact load upon landing does not impair the functionality needed to accomplish the mission.
	M3 Driving performance on poor environmental conditions has been confirmed through testing.
	The cone placed at the goal point of the M4 mission is detected by Object Detection, and the 0m goal is detected. We have confirmed through testing that it is possible to
	By estimating the ground conditions on which the vehicle is traveling based on the vibrations of the M5 transmission, it is possible to control the vehicle appropriately. This has been confirmed through testing.

Chapter 4 System specifications

4.1 Aircraft appearance

• Please briefly explain the appearance of the aircraft using CAD drawings and photographs, and the diameter and height dimensions using arrows, etc.
(Place a ruler in the photo, write numbers on the diagram, etc.)

• Please show views from at least three sides (e.g. front view, top view, right side view, bird's eye view).

• When showing diagrams and photographs, please keep the margins as small as possible.

• If the dimensions change due to mechanical deformation such as expansion or storage, please also indicate the front and rear dimensions.

Diameter [mm]	145
Height [mm]	200
Mass [g]	850

The aircraft has an electronic circuit installed between two tires. In the measurement, the total length is the left and right tires.
A ruler was placed on the outside of the tire, and the height was measured by placing a ruler between the top and bottom of the tire. Measure the entire length
Fig. 4-1-1 shows a photograph taken with the . Also, the height is shown in Fig. 4-
It is shown in 1-2.

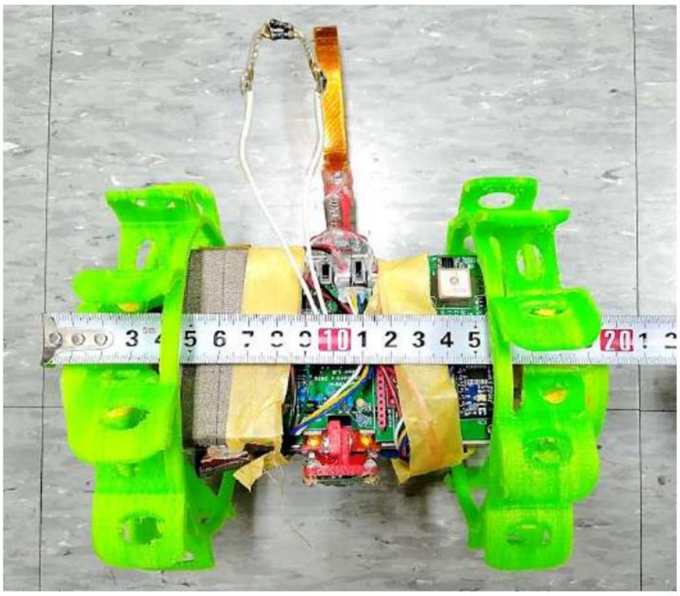


Fig.4-1-1 CanSat total length

Fig.4-1-2 CanSat height

4.2 Aircraft interior/mechanism

[Aircraft]

The aircraft body has left and right motors attached to a single polycarbonate board, and the electronic circuit is mounted on the back side of the motor. In addition, to avoid getting stuck in the grassy area at the Noshiro Space Event where it is easy to get stuck, we installed tires with a hollow design on the inside so that they can overcome the grass. An oblique view of CanSat is shown in Fig.4-2-1. A front view of CanSat is shown in Fig.4-2-2. Fig.4-2-3 shows CanSat viewed from above and from below.

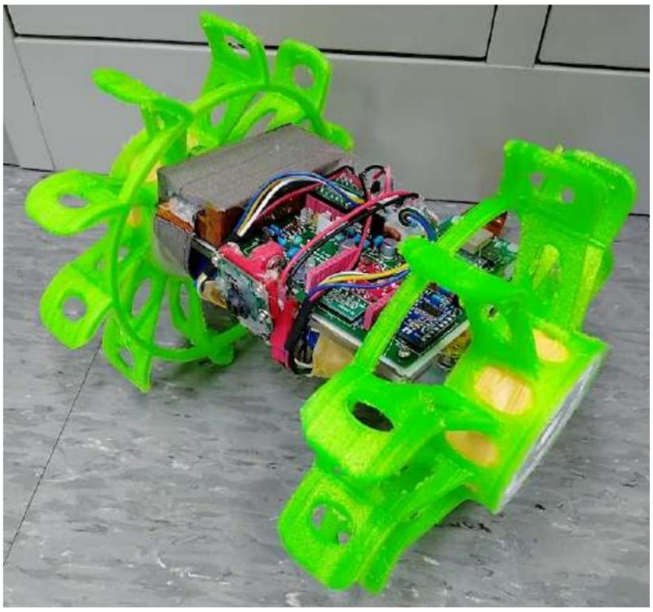


Fig.4-2-1 CanSat viewed from an angle

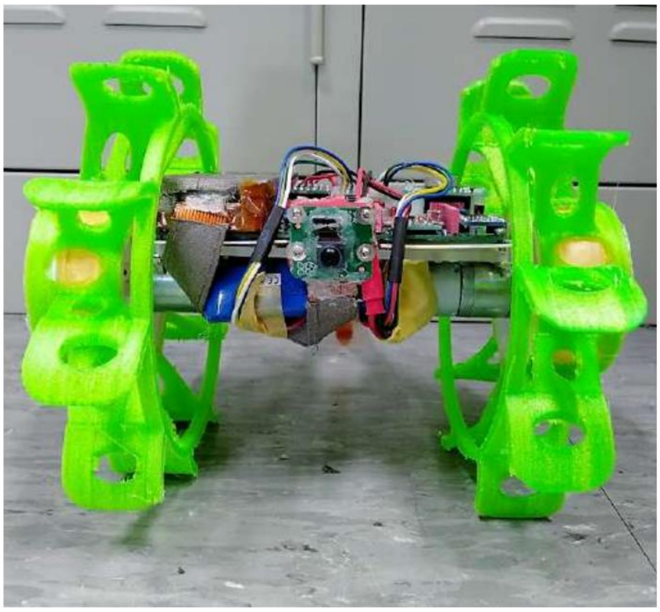


Fig.4-2-2 CanSat front view

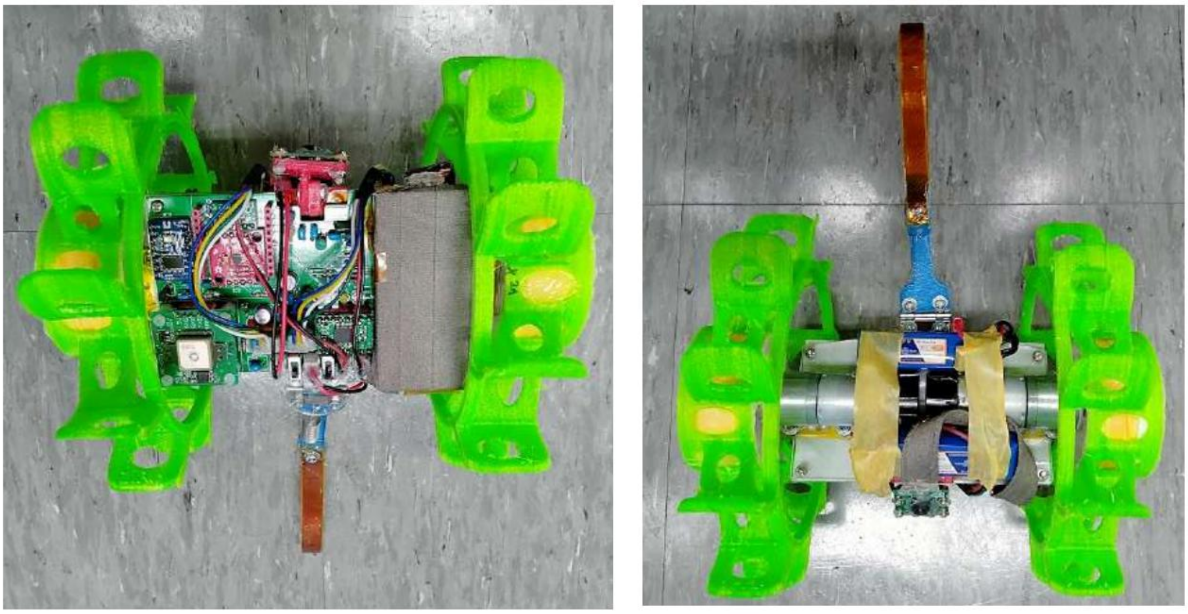


Fig.4-2-3 CanSat viewed from above (left), CanSat viewed from below (right)

Conventional tires use natural rubber sponge to withstand the impact of landing, and are designed to absorb impact upon landing. Among 3D printers, by using TPU material (thermoplastic polyurethane), which has a softness similar to that of rubber, it is possible to create more complex shapes than natural rubber sponge. We have created a tire that can prevent getting stuck. In addition, due to its softness, the size of the carrier can be easily reduced. Figure 4-2-4 shows how TPU tires are softer than the NR sponge material used previously.

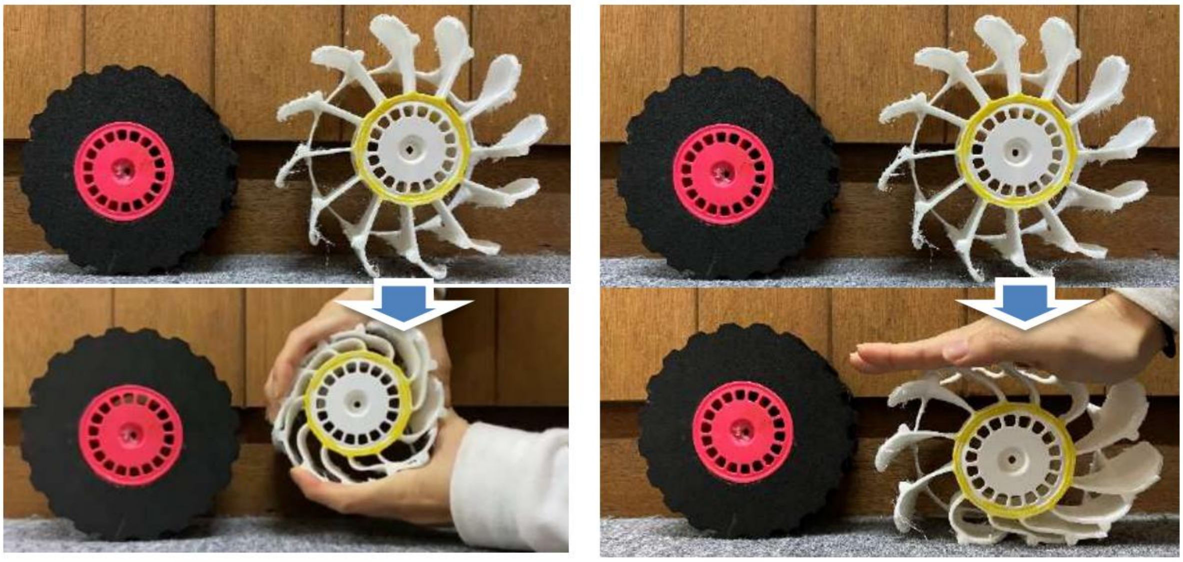


Fig.4-2-4 Storage capacity of TPU tires (right), softness of TPU tires (right)

The aircraft body is made of polycarbonate, which is the hardest material among plastics, and it bends slightly upon impact when landing. It is designed to absorb shock. A diagram showing the softness of polycarbonate is shown in Fig. 4-2-5.

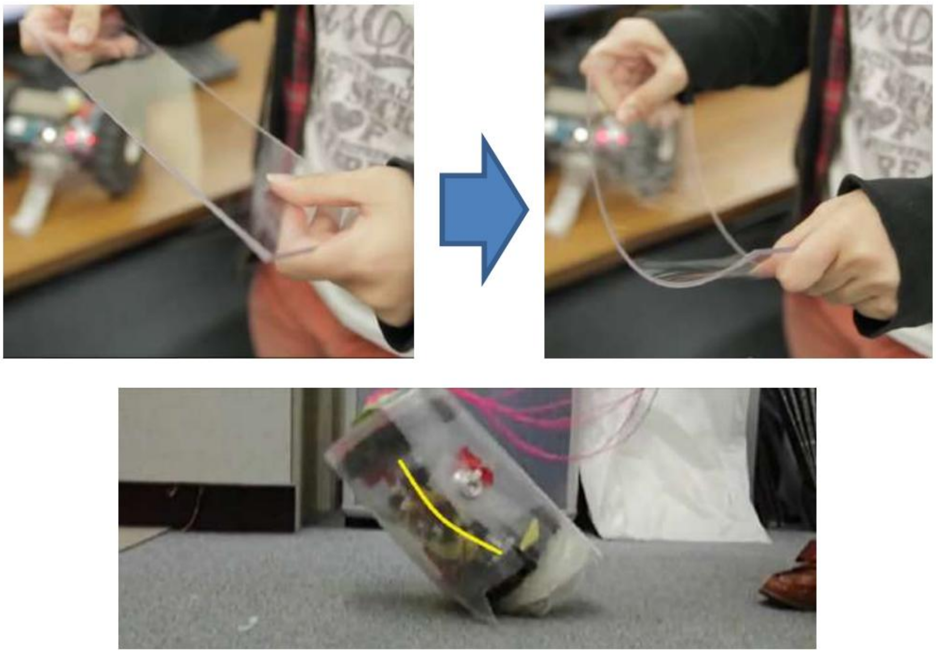


Fig.4-2-5 Polycarbonate shock absorption

[Deceleration mechanism

parachute] The deceleration mechanism parachute incorporates materials and structures to prevent entanglement with CanSat.

Ru.

An image of the parachute is shown in Fig.4-2-6.

•Parachute fabric Made of

hard and smooth fabric that is hard to tear and can withstand impacts, even when the CanSat travels on top of it.

Made it less likely to get wrapped around the tire.

- String 1

Metal wire, which is a material that does not easily bend, was used to prevent it from wrapping around the aircraft. with fabric

There are six connections, which are firmly crimped using clamp rings.

•String 2:

By using a metal tape measure that does not bend unless strong force is applied, the parachute can be attached to the CanSat.

The structure allows the CanSat to land at a distance from the CanSat without falling, thereby preventing entanglement.

•CanSat case Even if

a parachute were to fall onto the aircraft, it would be repelled when opened, preventing direct entanglement.

In addition, the connection between the CanSat and the parachute string and the separation mechanism were provided in two locations through the case.

By doing so, we prevented the opening impact from being applied to the CanSat separation part and mitigated the impact.

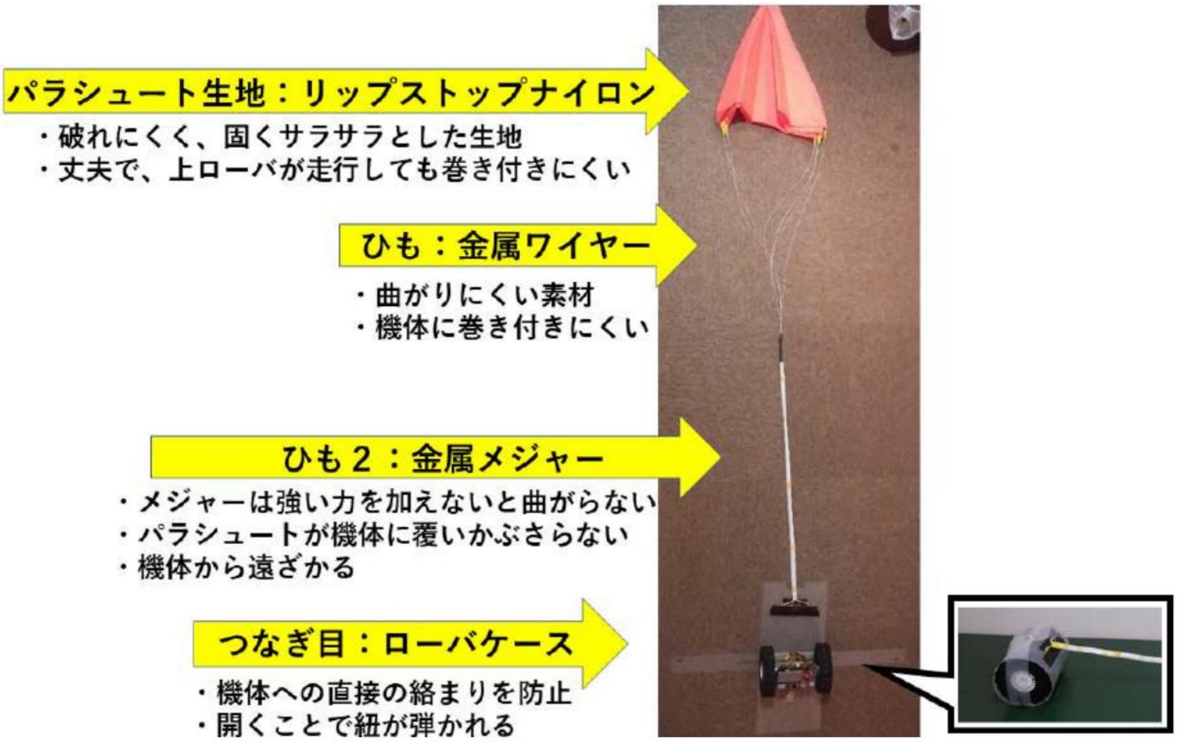


Fig.4-2-6 Parachute

4.3 System diagram (list of specifications for instruments mounted on the aircraft)

[Microcomputer, motor]

Use RaspberryPi Zero 2 W as a microcontroller and acquire location information with Michibiki Compatible GPS. The angle between the current position and the target position is calculated, and the TB6612 Dual Motor Driver is used to rotate to the target position. outputs the PWM control value and outputs it to the motor.

[Sensors]

Acquired ±16G acceleration/gyro with LSM9DS1, 200G acceleration with H3LIS331DL, Obtain atmospheric pressure and temperature using BME280. Acceleration and gyro are based on the impact value of CanSat and when CanSat is flipped upside down. The air pressure and temperature are used to adjust the altitude of the CanSat and the computer This is used as a reference for the temperature of heat applied to the motor.

In addition, when the barometric pressure sensor fails, the MCP3208 monitors the brightness to see if it is emitted using the Photo IC Diode. A/D conversion is performed using an A/D converter for measurement.

[Long distance

communication wireless] In addition, when falling over a long distance, position information is transmitted using IM920 wireless communication, It is used to identify the current location.

[Camera]

Raspberry Pi to perform guidance control using image recognition using machine learning after approaching several meters from the goal. Camera v2 takes a photo, determines whether the goal pylon is visible, and provides guidance.

Fig.4-1 shows the system diagram. In addition, Table 4-3-1 lists the electronic components actually used. It is shown in

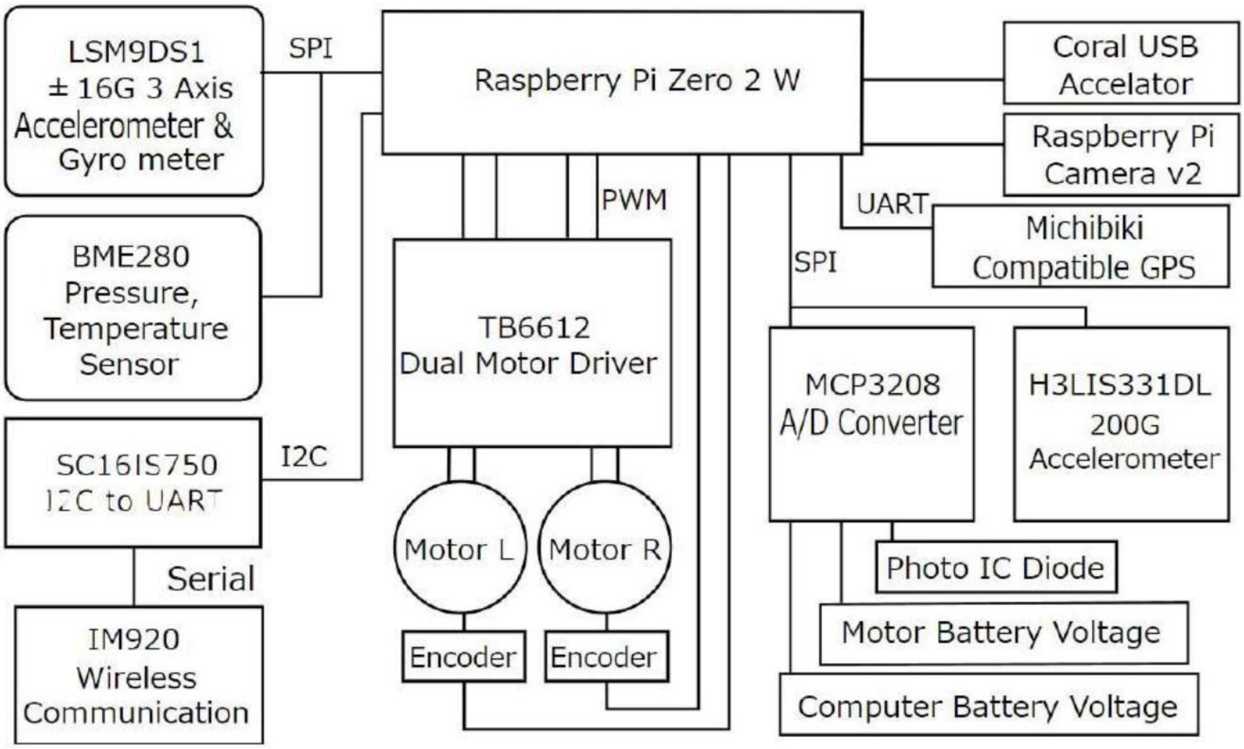


Fig.4-3-1 System diagram

Table 4-3 Parts used

classification	Name/model number	Source/reference information, etc.	URL

GPS	AE-GYSFDMAXB Akizuki Electronics		http://akizukidenshi.com/download/ds/akizuki/AE-GPS_manual_r1.06_s.pdf
Microcomputer	Raspberry Pi zero 2W	SWITCH SCIENCE	https://www.switch-science.com/catalog/7600/
200G acceleration sensor	H3LIS331DL	SWITCH SCIENCE	https://cdn.sparkfun.com/assets/c/6/5/8/d/en.DM00053090.pdf
16G acceleration sensor	LSM9DS1	SWITCH SCIENCE	https://cdn.sparkfun.com/assets/learn_tutorials/3/7/3/LSM9DS1_Datasheet.pdf
I2C serial conversion	SC16IS750	SWITCH SCIENCE	https://www.switch-science.com/catalog/2310/
A/D converter MCP3208		Akizuki Electronics	http://akizukidenshi.com/download/MCP3208.pdf
Motor driver TB6612		Akizuki Electronics	http://akizukidenshi.com/download/ds/Toshiba/TB6612FNG_datasheet_ja_20141001.pdf
5V 3 terminal regulator rater	V78-1000	Akizuki Electronics	https://www.marutsu.co.jp/contents/shop/marutsu/ds/v78xx-1000.pdf
3.3V3 terminal regulation rater	48033	Akizuki Electronics	http://akizukidenshi.com/download/ta48033s.pdf
Communication device	IM920	Akizuki Electronics	https://www.interplan.co.jp/solution/wireless/im920/im920c.php
atmospheric pressure sensor	AE-BME280	Akizuki Electronics	http://akizukidenshi.com/download/ds/bosch/BST-BME280_DS001-10.pdf
camera	Raspicam V2	SWITCH SCIENCE	https://www.switch-science.com/catalog/2713/
motor	POLOLU Geared Motor 99:1	POLOLU	https://www.pololu.com/product/4867
battery (for motor)	Hyperion G5 3S 850mAh LiPo 25C (Described from this examination change)	Hyperion	https://hyperion-world.com/en/p2601952-hp-g550-0850s3-14323
battery (for computer)	Bos Lipo Lipova Battery 7.4V 1100mAh 2S 25C (Described from this examination change)	Amazon	https://www.amazon.co.jp/gp/product/B09TF32517/ref=ox_sc_act_title_1?smid=A2RF2YPOTPHH3L&th=1

ÿalgorithmÿ

ÿ Fall judgment - parachute release After the

program starts, the value of the barometric pressure sensor is measured, and the altitude is determined to determine whether the CanSat has fallen to the ground after rising above the ground.Then, the parachute is detached and the parachute is placed in the direction in which the CanSat is traveling. It turns using image recognition. Detach the parachute and check whether data can be acquired. If not, perform control again after detaching. If data necessary for control such as GPS cannot be acquired, repeat the sequence until it can be acquired.

ÿ Travel control ~ Goal

Travel control is started from GPS position information, and if the parachute is in the travel direction, turning control is performed. The driving condition is estimated using acceleration data, and the steering wheel parameter values are adjusted if the road surface is found to be rough. If it gets stuck, perform an escape motion from the back motion or rotation motion of stack processing. When the vehicle approaches the goal within 10 m, it slows down and runs in a manner that allows it to approach the goal more easily. When it gets within 4m of the goal, it uses deep learning to turn around until it finds the goal. When the goal is found, it runs in the direction of the goal, and the goal 0m point and Deep It stops when judged by Learning.

The flowchart is shown in Fig. 4-3-2.

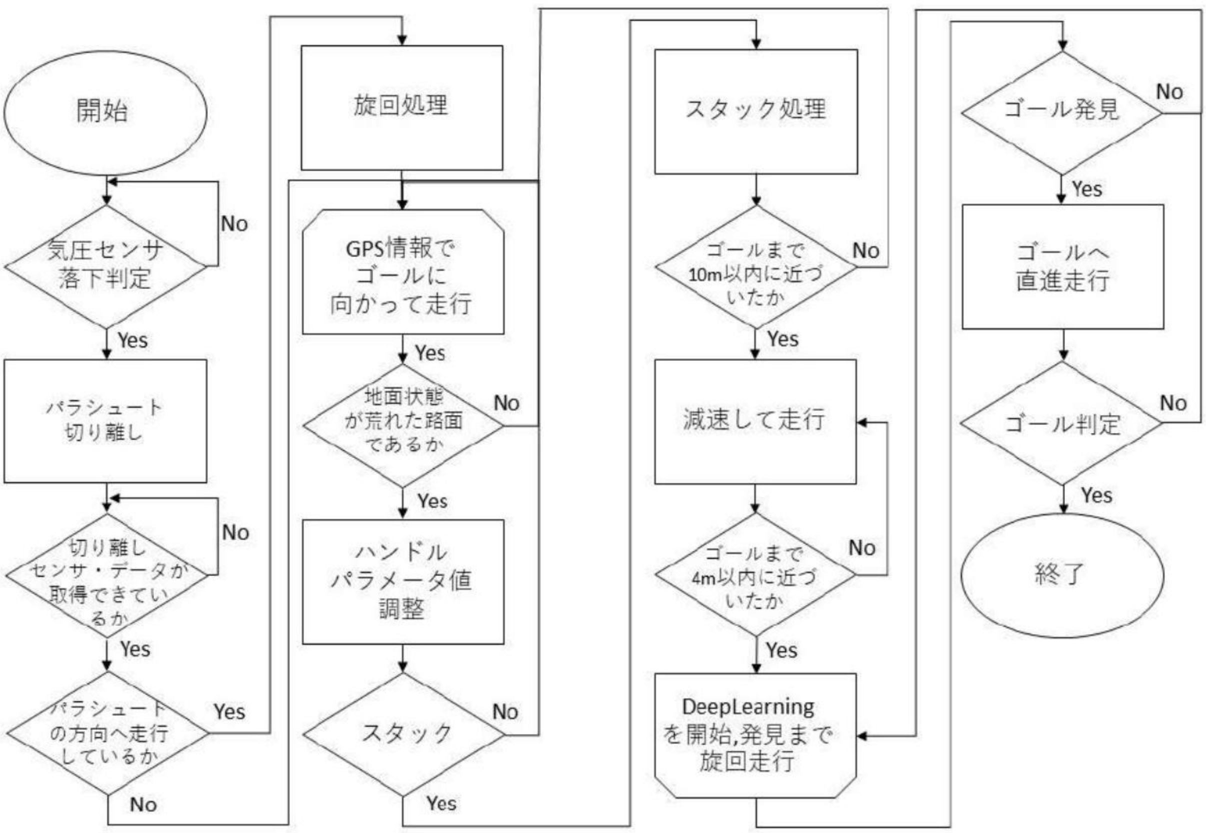


Fig. 4-3-2 Flowchart

Chapter 5 Test item settings

number	Verification item name	Corresponding self-examination items Request number(s)	Scheduled implementation date
	ÿItems related to system requirementsÿ		
V1	Mass test	S1	6/25
V2	Aircraft storage and release test	S2	6/25
V3	Quasi-static load test	S3	7/9
V4	Vibration test	S4	7/29
V5	separation (parachute deployment) impact test	S5	7/17
V6	drop test	S6	6/28
V7	GPS data downlink test	S7	6/11
V8	Communication device power OFF/ON test	S8	6/15
V9	Communication frequency ch change test	S9	6/14
V10	End-to-end testing	S10	7/27
	ÿItems related to mission requirementsÿ		
V11	Control history report creation test	M1	7/20
V12	Landing impact test	M2	6/27
V13	Driving performance confirmation test	M3	7/8
V14	Goal detection test	M4	7/8
V15	Driving state estimation test	M5	8/4

Chapter 6 Contents of the exam

<Notes> •

The test conditions for the quasi-static load test, vibration test, and separation (parachute deployment) impact test are provided in the attached "CanSat

Please refer to "Regulations at ARLISS"

• In the end-to-end test, perform the same steps as the actual test, from dropping the CanSat to deploying the parachute, executing the mission (if it is a runback), and retrieving data, and submit a video that confirms that each sequence can be performed. please. Also, in the video, please make sure to confirm that at least the minimum success criteria are met.

• If you use videos for other exams, please also include the URL (please avoid submitting files).

v1. Mass test • Purpose Confirm that

the combined

mass of CanSat and parachute meets the specified mass of 1050g or less.

• Test content

The CanSat and parachute were measured using a mass meter, and the weight was measured according to the regulations. Confirm that the mass is less than (1050g).

All equipment to be stored in the carrier on the day of the actual event (CanSat main body, circuit parts, protective case, etc.) We measured the mass of the parachute (such as a parachute) and confirmed that it was less than the predetermined mass. During actual production, CanSat is stored in a carrier with a protective case covered, so measurements are taken by placing it on a measuring instrument with the protective case covered. The protective case is stored in Fig.6-1-1.

A diagram of CanSat is shown.

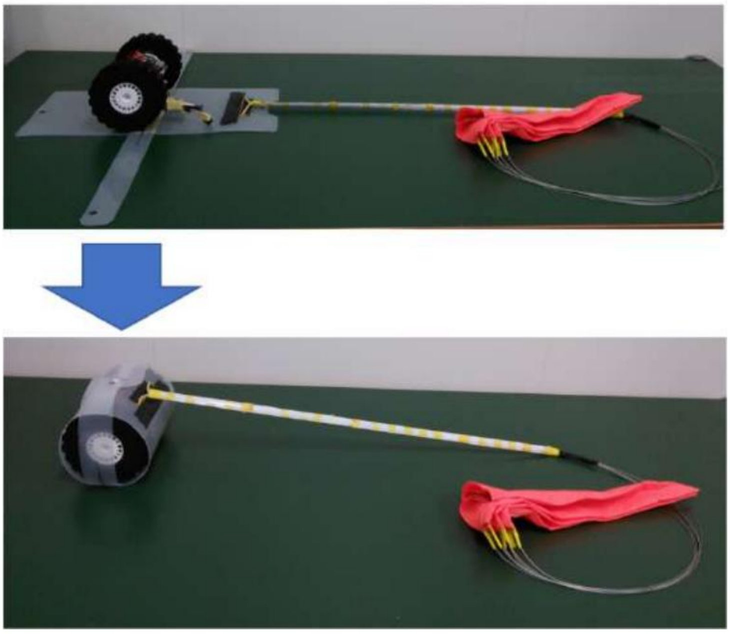


Fig.6-1-1 CanSat stored in a protective case

• Results

The total weight of CanSat and parachute was 850g , which was confirmed to be less than the regulation of 1050g. Figure 6-1-2 shows the mass measurement results.

Fig.6-1-2 Mass of parachute and CanSat

•

Consideration Is the total weight of CanSat including the mass of the parachute meeting the regulations?
It turns out that

v2. Aircraft storage/release test • Purpose : Can be stored in a carrier

(inner

diameter 146mm, height 240mm) and released under its own weight.

It was confirmed. We also confirmed that the carrier storage time was less than 5 minutes.

• Test details To

prove that the carrier can be stored, we confirmed that the carrier purchased from ARLISS was of the specified dimensions.

The carrier dimension depth is shown in Fig.6-2-1 and the outer diameter is shown in Fig.6-2-2.

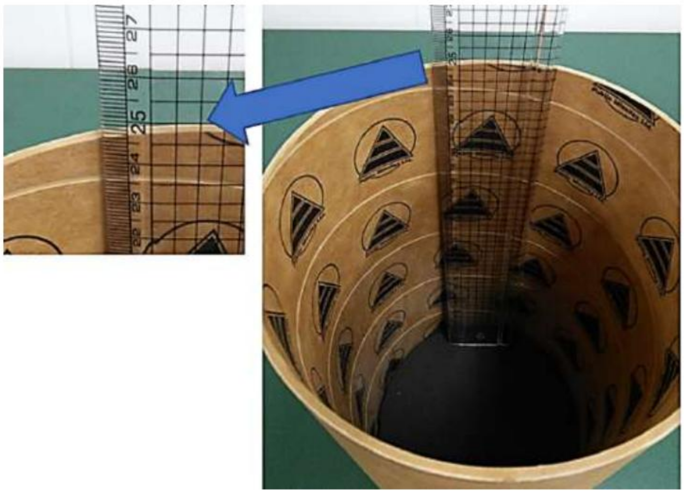


Fig.6-2-1 Depth dimension of carrier storage case

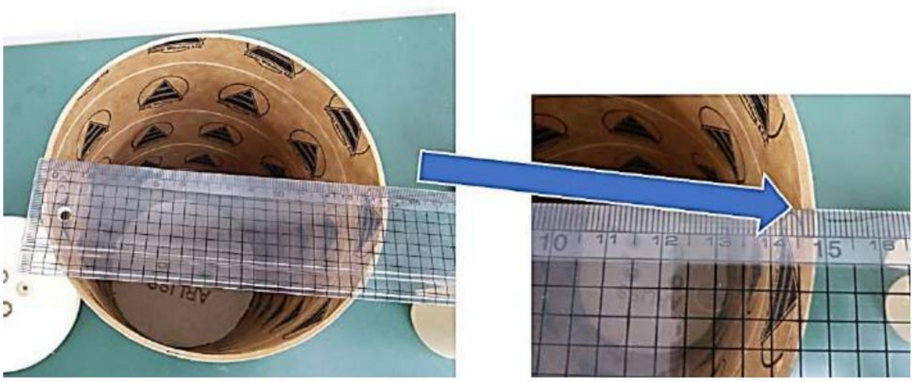


Fig.6-2-2 Outer diameter dimensions of carrier storage case

From Fig.6-2-1 and Fig.6-2-2, the carrier had the specified depth of 240mm and outer diameter of 146mm. In Fig.6-2-1, the

scale indicates a depth of 245mm, but since the ruler has a margin of 5mm, the depth of the carrier is 240mm. In addition, since

CanSat is stored in the carrier while covered with

a protective case, the protective case is not required.

Measure with the device covered by a cloth.

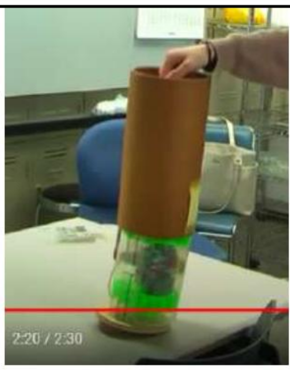
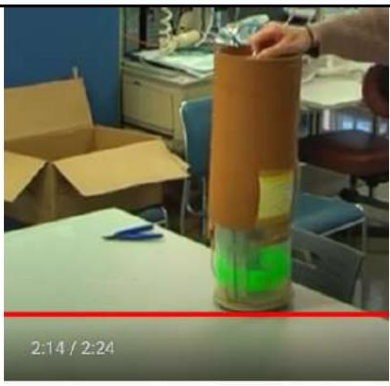
We confirmed that the CanSat can fall under its own weight after being stored in a carrier storage case within the specified size.

Check that the time it takes to store the carrier is within 5 minutes.

• As shown

in Results Table 6-2-1, it was confirmed that CanSat was released under its own weight after being stowed 3 out of 3 times.

Table 6-2-1 Results of carrier release experiment Release judgment

number of times	Experiment video	
1	 https://youtu.be/seNspw_fWRE	I was able to release it under my own weight. The video time was 2:30, and the carrier could be stored within 5 minutes.
2	 https://youtu.be/8UtMT1DaQ00	I was able to release it under my own weight. The video time was 2:24, and the carrier could be stored within 5 minutes.
3	 https://youtu.be/ejuqgNlhzcg	I was able to release it under my own weight. The video time was 2:22, and the carrier could be stored in less than 5 minutes.

• Discussion

From the dimensional measurement results, it was confirmed that the aircraft can be stored in the specified carrier and that it can be stored within 5 minutes.

v3. Quasi-static load test • Apply a static load

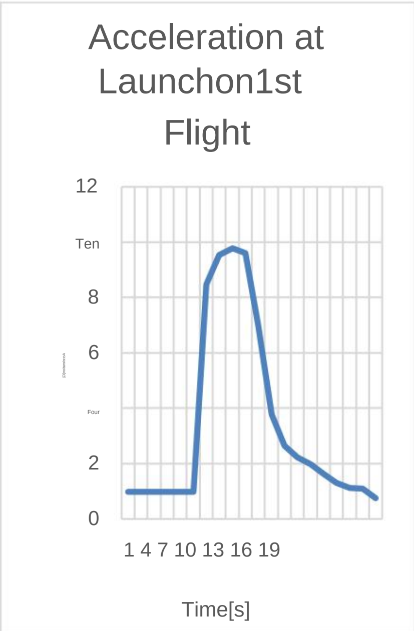
to CanSat

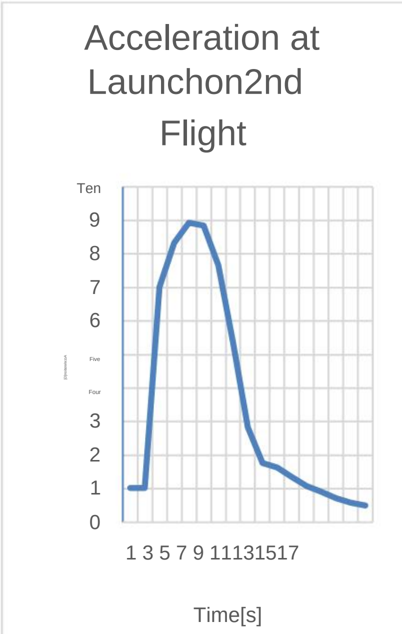
that is expected to be applied during the launch of the target rocket, and demonstrate that CanSat can withstand it.

• The test content

regulations recommend a quasi-static load value of 10[G].

In addition, in order to set the time for applying the load, we will refer to the rocket launch time that our organization actually measured at ARLISS2019. ARLISS2019 During the three launches, the value and time of the quasi-static load that the rocket was actually subjected to was a maximum of approximately 9.78[G] for the first launch and 7[s], and a maximum of approximately 8.93[G] for the second launch . 8[s], the third maximum was about 8.32[G] and 8[s]. Since the quasi-static load value is below the regulation value of 10[G] and the time is within 10[s], a quasi-static load of 10[G] was applied for 10[s] in the experiment. The ARLISS2019 graphs under actual loads are shown in Fig.6-3-1 for ARLISS 1st quasi-static load, Fig.6-3-2 for ARLISS 2nd quasi-static load, and ARLISS 3rd quasi-static load. The target load is shown in Fig.6-3-3.





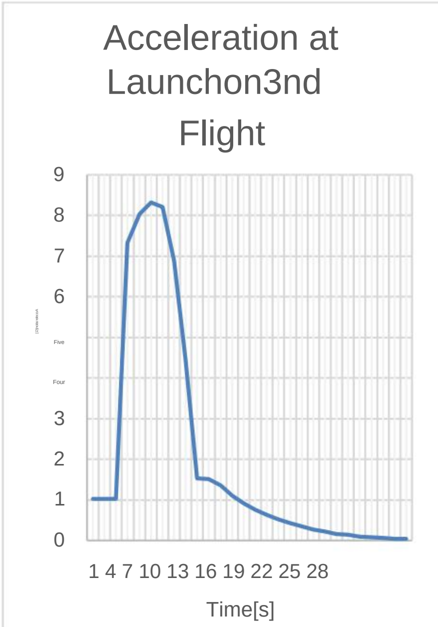


Fig.6-3-1 1st quasi-static load Fig.6-3-2 2nd quasi-static load Fig.6-3-3 3rd quasi-static load

After confirming in advance that the sensor and power system are working properly, the device is mounted on a CanSat, placed in a tote bag with a long rope attached to it, and the tote bag is swung around by the string. Gives an acceleration of 10G. Figure 6-3-4 shows an experimental photograph of the actual load being applied.

Fig.6-3-4 Appearance of 10G applied by centrifugal force

The value of the acceleration sensor mounted on the carrier is confirmed on a PC screen via wireless communication, and once the force exceeds 10G, rotational motion is continued for 10 seconds without loosening the force, and acceleration is applied continuously

by centrifugal force. Afterwards, we released the CanSat from the carrier and confirmed that the various sensors and power system were operating normally, confirming that the CanSat could withstand static loads.

• Results

After applying 10G three times for 10 seconds or more, the sensors installed on the CanSat (light, acceleration, gyro, temperature, atmospheric pressure, GPS) will operate normally, and the CanSat will then be able to release the parachute without any problems and run normally. It was confirmed. Figure 6-3-5 shows a graph of an acceleration data log that was actually observed at 10G for more than 10 seconds.

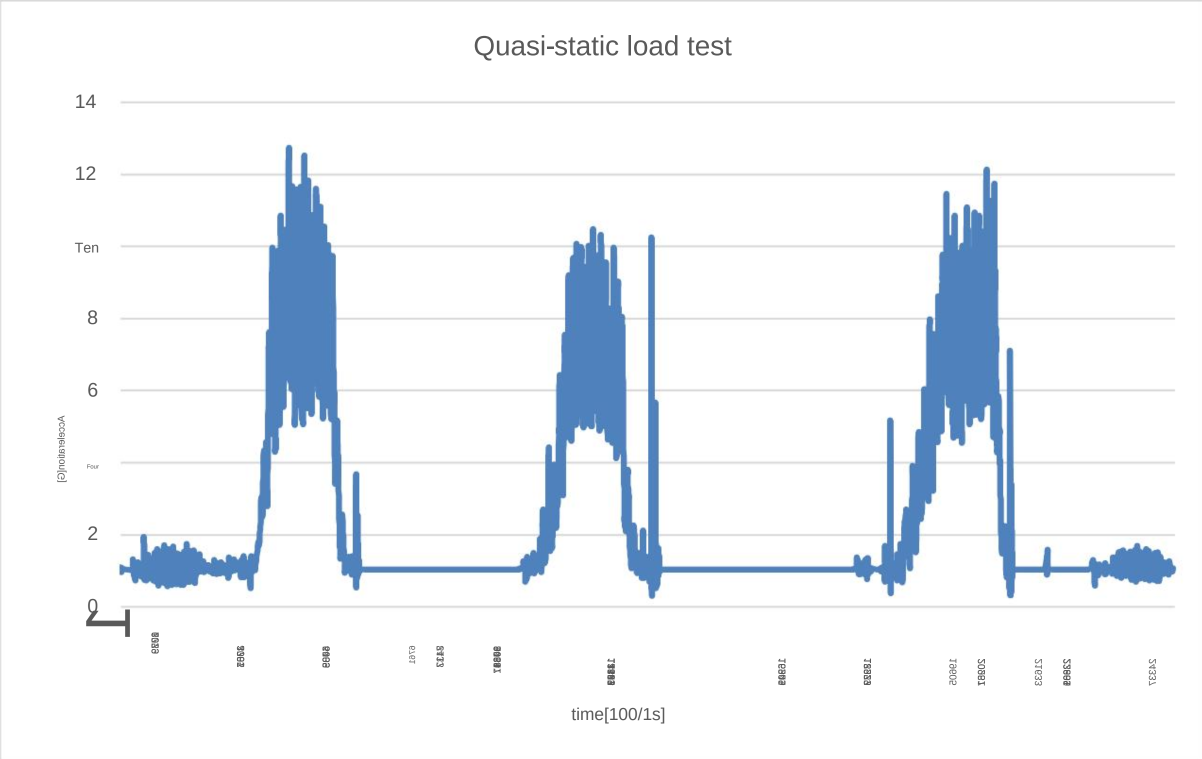


Fig.6-3-5 Numerical value of acceleration sensor (vertical axis is applied acceleration [G], horizontal axis is time [100/1s])

The static load test was videotaped and records were made to confirm whether there were any abnormalities, and no abnormalities were found in the aircraft. (See URL below)

•Static load test video URL: https://youtu.be/0zAlQskb808 (Pre-confirmation of sensor values 0:50~, Static load exercise ÿ 2:27~, Static load exercise ÿ 3:35~, Static load exercise ÿ 5 :05~, sensor confirmation 7:37~, parachute release mechanism, motor drive, and aircraft confirmation 9:36~)

• Consideration

We were able to confirm that CanSat could withstand the static loads expected when launching CanSat with a rocket.

v4. Vibration test • Purpose To

check

whether CanSat can withstand the vibrations of a rocket launch.

• Test details : As

a vibration condition for CanSat during rocket launch, random vibrations of 30Hz to 2000Hz of 15G are applied in a flat pattern as recommended by the regulations. It was confirmed that the vibration time was less than 10 seconds based on the rocket launch time based on data from three ARLISS2019 V3 quasi-static load tests, but a longer vibration time was set in order to confirm errors and testing machine parameters. After setting the vibration for 1 minute and vibrating the CanSat, check whether there are any problems with the operation of the electronic circuit, parachute release mechanism, motor, and aircraft body.

A vibrator manufactured by IMV Japan Advanced Reliability Evaluation Testing Center was used. A photo of the actual vibrator is shown in Fig.6-4-1, a photo of the PC screen for setting the vibration conditions is shown in Fig.6-4-2, and the vibration system settings are shown in Fig.6-4-2. 3. The entire control target is shown in Fig.6-4-4, and the input channel is shown in Fig.6-4-5.

After the vibration, a shock wave (shock test) with a separation impact of 40G was applied. Shock wave is a half-sine wave Standard JIS Vibration acceleration 392 m/s^2 (equivalent to 40G) Duration 0.01 sec (break point reached in 0.05 sec, then attenuated) Control frequency band 5000 Hz was given. The excitation system information for the separation shock is shown in Fig. 6-4-6, and the target waveform is shown in Fig. 6-4-7.

Fig.6-4-1 Actual vibrator (CanSat stored in a brown tube)

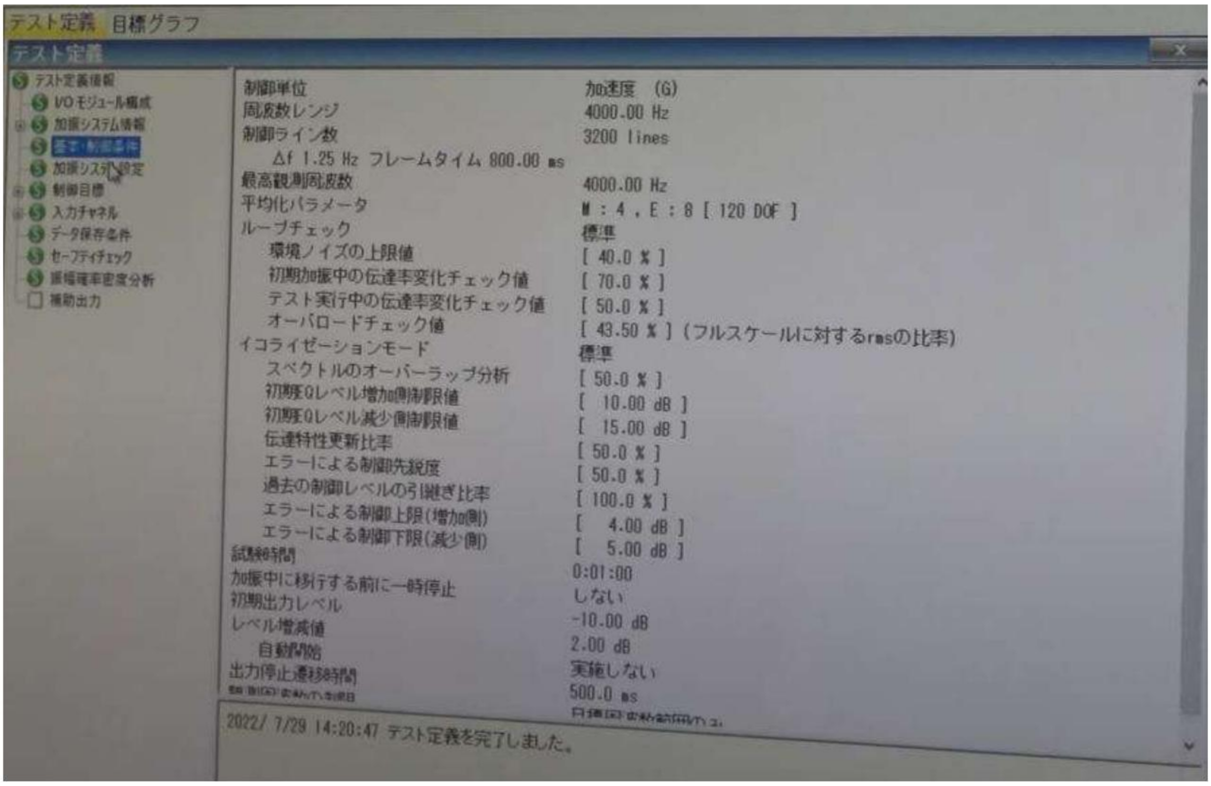


Fig.6-4-2 Basic/control conditions

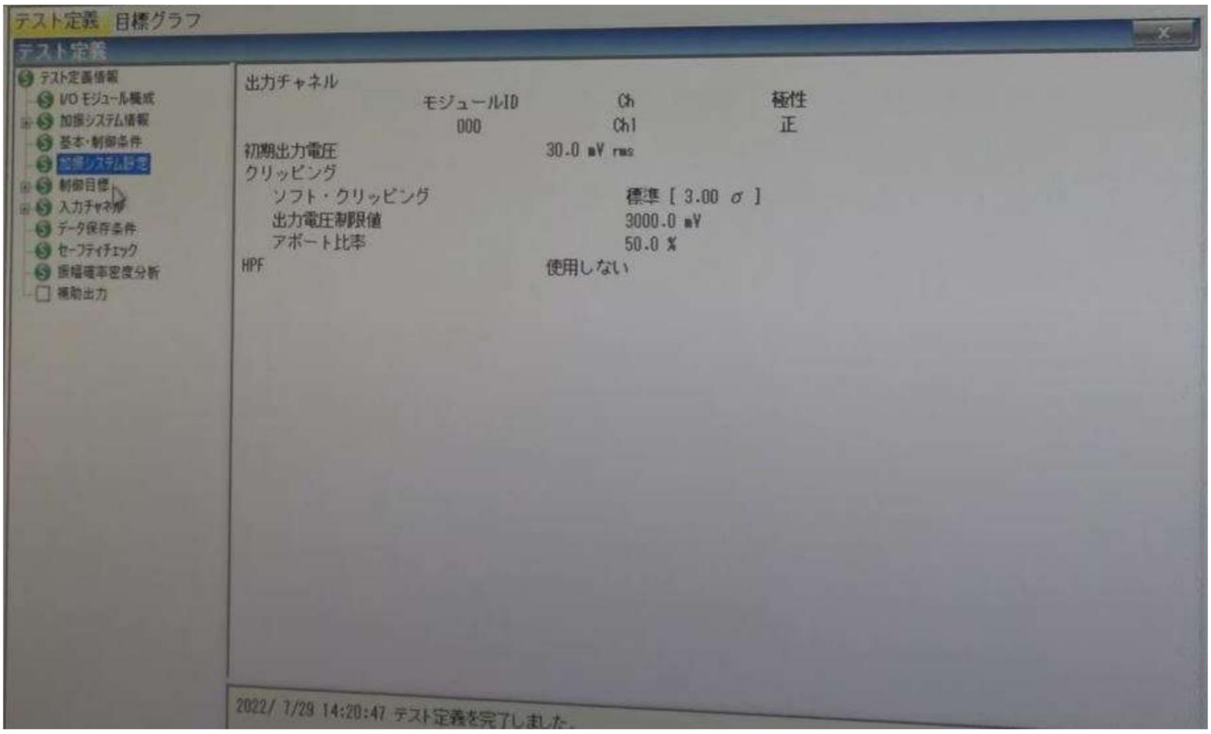


Fig.6-4-3 Vibration system settings

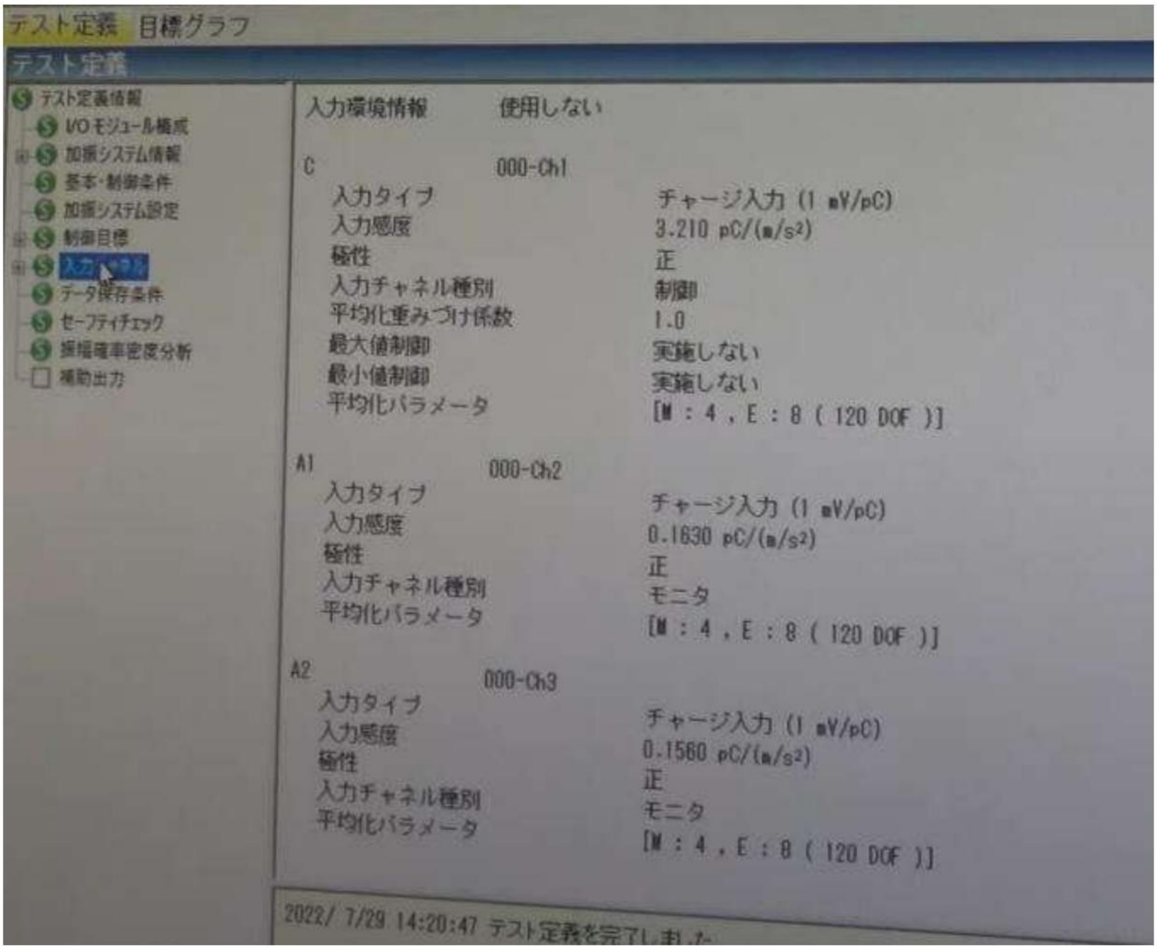


Fig.6-4-4 Control target_overall

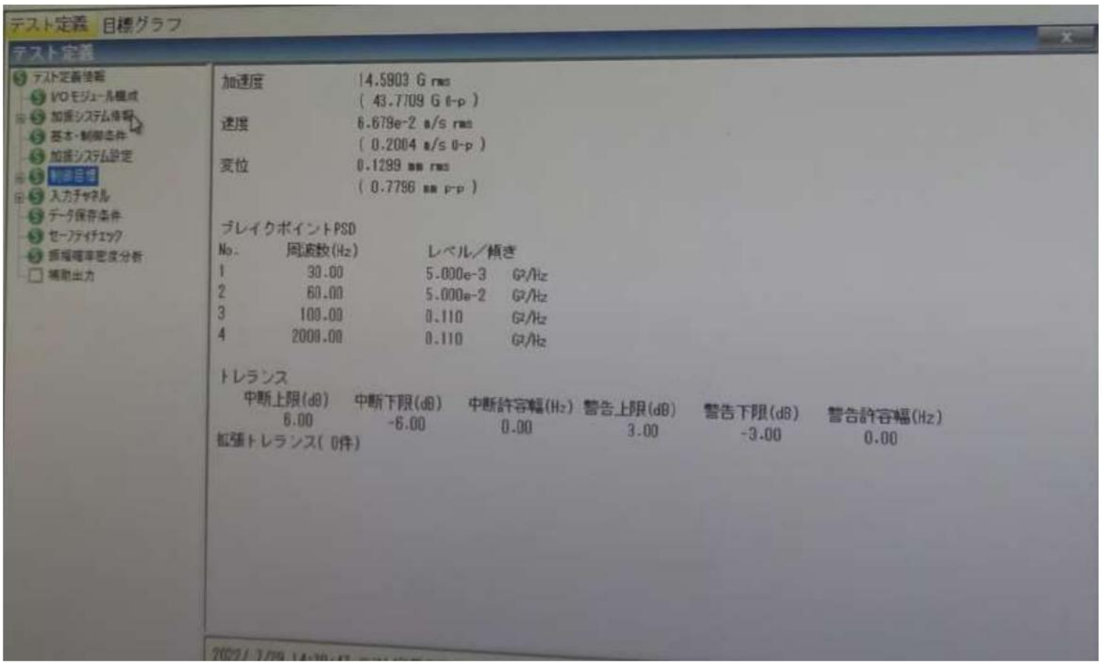


Fig.6-4-5 Input channel

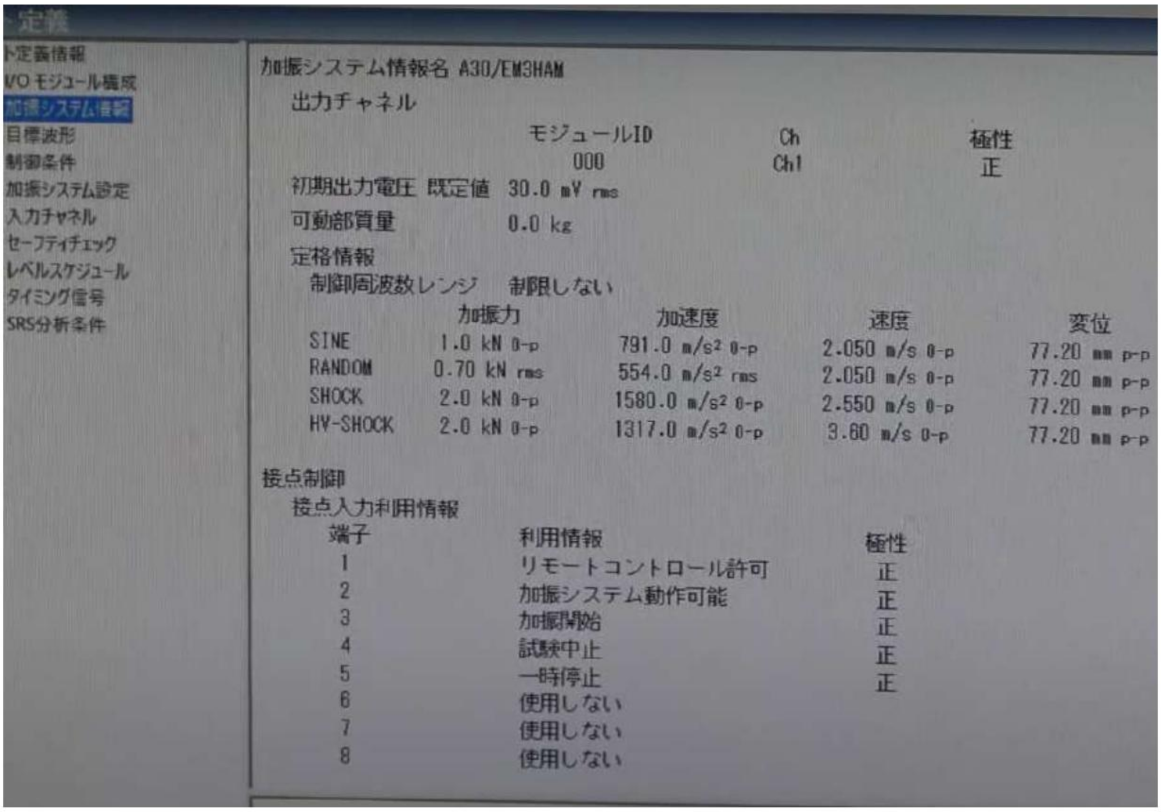


Fig.6-4-6 (Separated shock shock wave) excitation system information

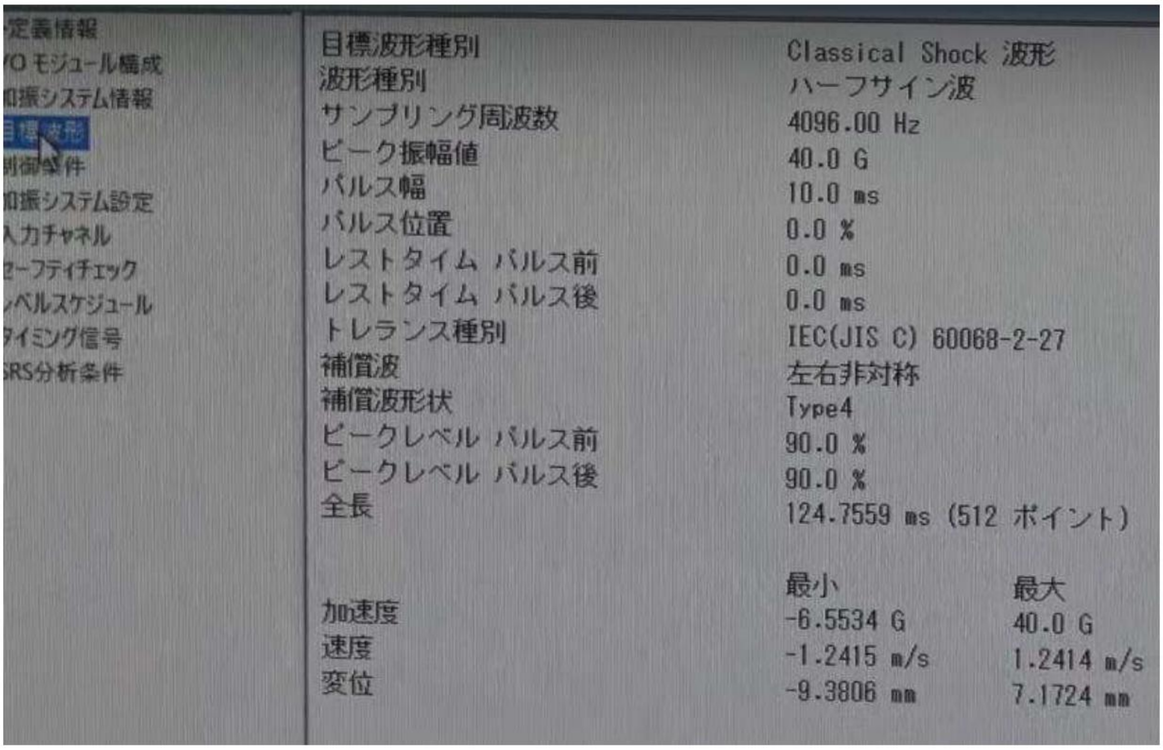


Fig.6-4-7 (Separated shock Shock wave) Target waveform

- Results

As a result of applying vibration to CanSat, electronic circuit operation, parachute release mechanism, motor operation, There were no problems with the aircraft.

Also shown is the control and output data provided by IMV from the vibrator that actually applied vibration. The output level is shown in Fig.6-4-8, the target G is shown in Fig.6-4-9, the control response G is shown in Fig.6-4-10, and the control m/s2 is shown in Fig.6-4-11. It is shown in

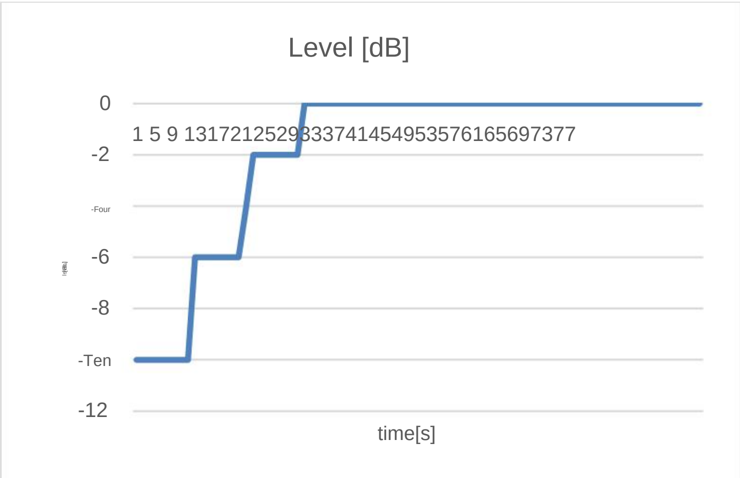


Fig.6-4-8 Output level

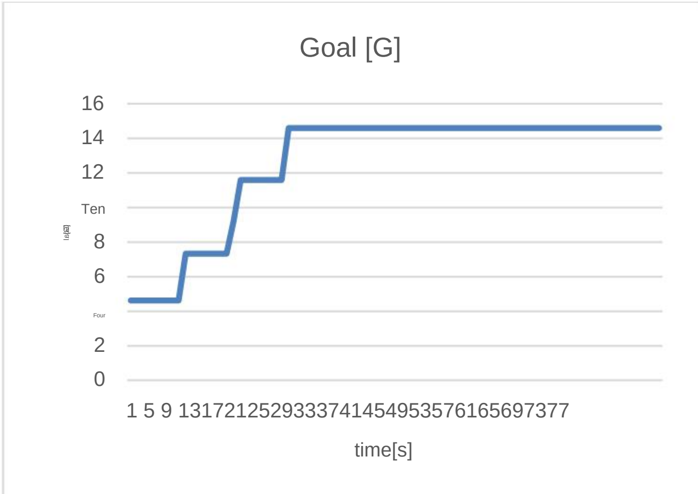


Fig.6-4-9 Target G

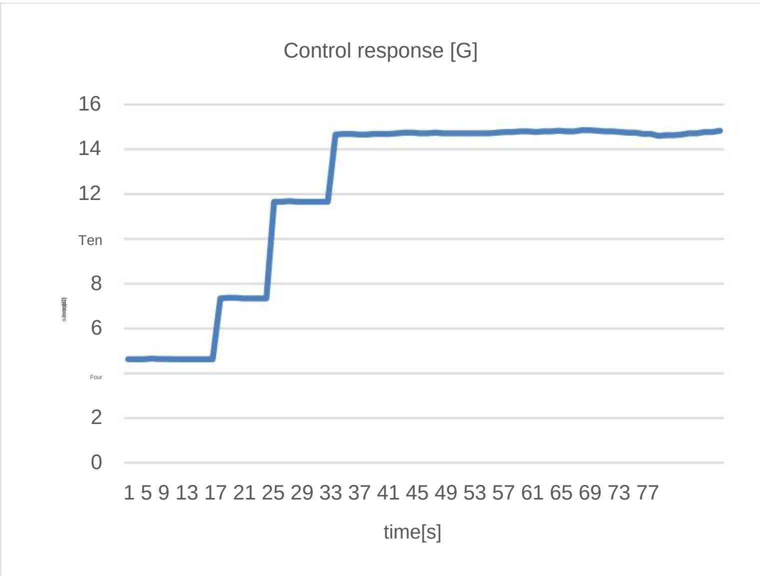


Fig.6-4-10 Control response G

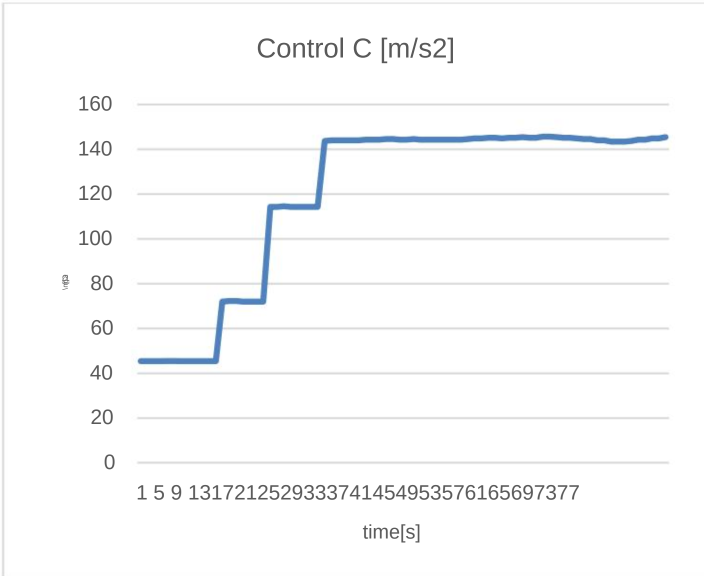


Fig.6-4-11 Control m/s2

Machine Translated by Google

Additionally, during the vibration test, acceleration sensors from IMV were installed on A1 above the circuit microcontroller and A2 on the bottom of the CanSat. The data of the acceleration sensor at that time is shown in Fig. 6-4-12 for the A1 acceleration sensor and Fig. 6-4-13 for the A2 acceleration sensor.

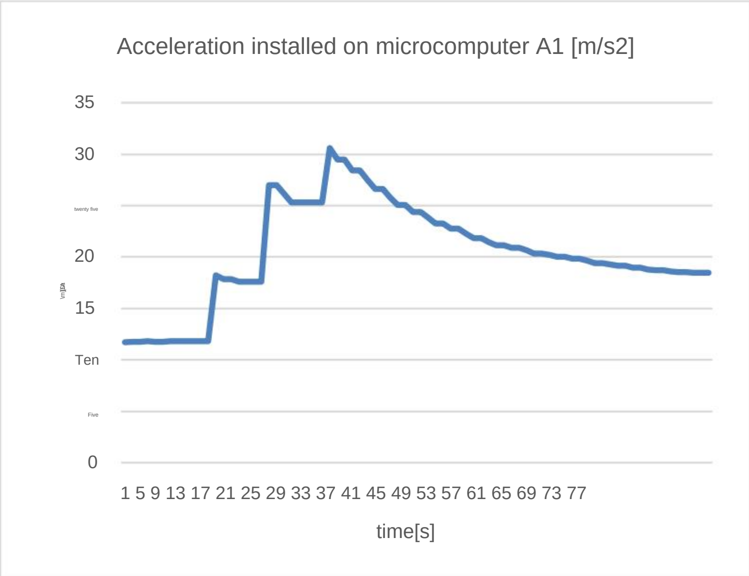


Fig.6-4-12 Acceleration installed on microcomputer A1[m/s2]

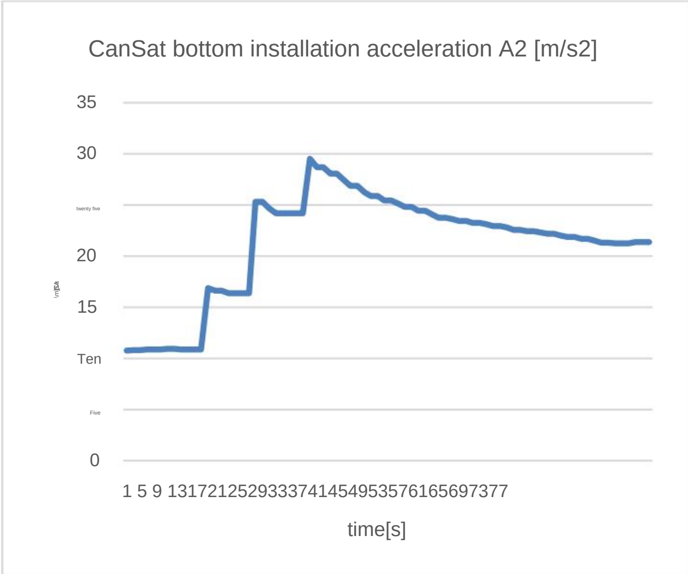


Fig.6-4-13 CanSat bottom installation acceleration A2[m/s2]

In addition, the shock result graph of the separated shock shock wave is shown in Fig.6-4-14.

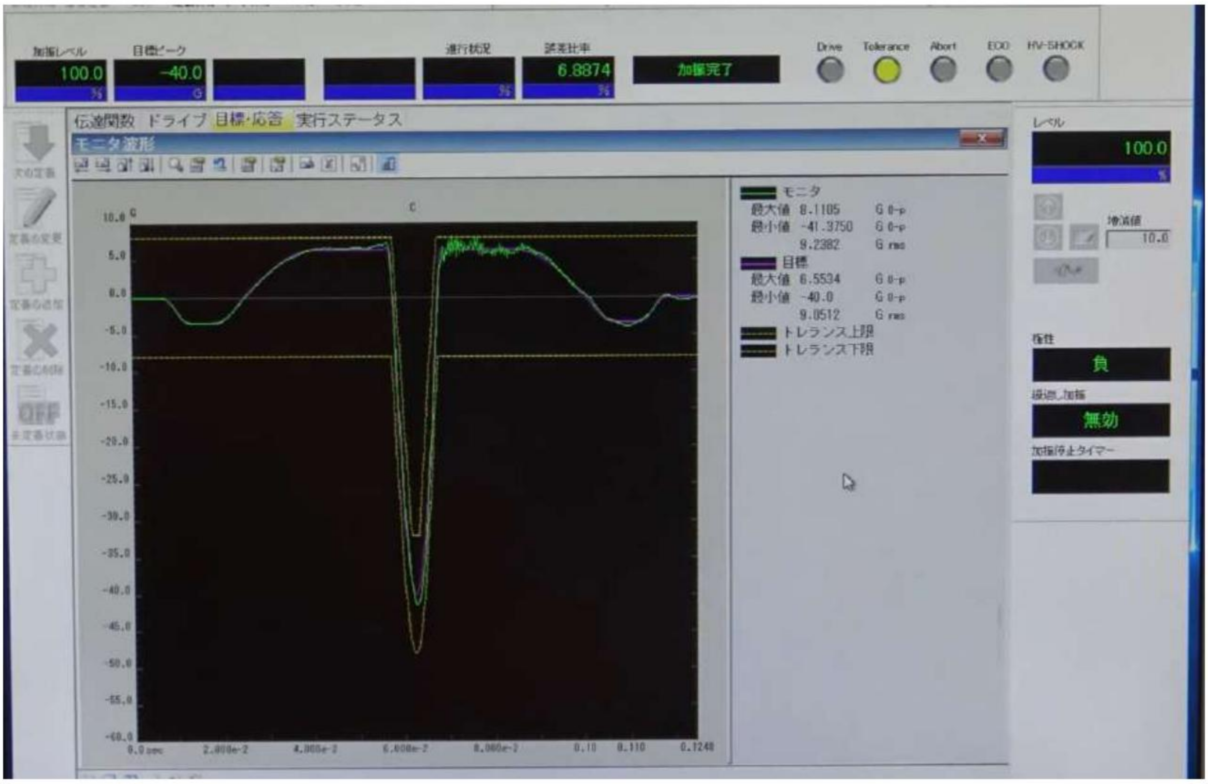


Fig.6-4-14 Shock result graph of separated shock Shock wave

In addition, Fig.6-4-15 shows the vibration data of the own acceleration sensor installed on CanSat.

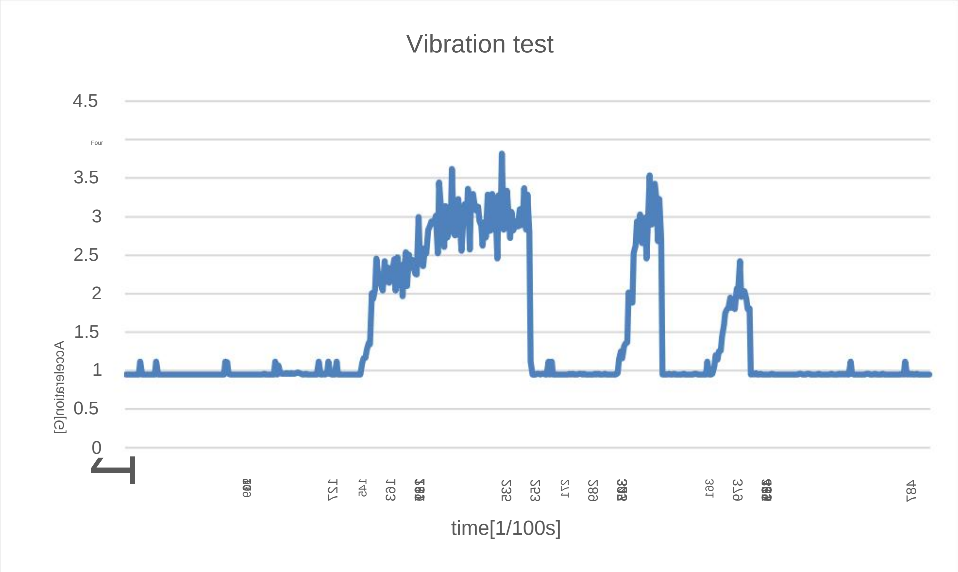


Fig.6-4-15 Acceleration sensor data (of your organization)

In addition, a video of the actual vibration test is shown at the URL below. Vibration test video: https://youtu.be/aox9CFF_uos *Be careful when watching as it is 4K quality

(00:00 Installation of acceleration sensor provided by IMV on the aircraft, 05:30 Parachute connected to CanSat, 08:27 Carrier storage (jig storage), 14:15 Start fixing the jig, 15:00 Sensor operation preliminary check, 33:33 Vibration condition setting, 41:45 Vibration start 44:30 Vibration continued (7s), 48:10 Separation shock Shock wave condition setting, 53:18 Shock wave starts 56:56 Jig removed, 58:22 Sensor operation check, 1:02:30 CanSat removal 1:05:13 Parachute separation operation + motor drive confirmation 1:05:37 Aircraft damage location check, 1:07:55 Camera operation check 1:08:57 (Test completed) Acceleration sensor removed, 1:10:44 Facility photography)

Also share vibration data with the drive Vibration test data: https:// drive.google.com/drive/folders/1WfYcEoprKB3MbaULERZaVwiM9W5cBHNP?us p=sharing

- Consideration Vibration tests confirmed that CanSat can withstand vibrations during rocket launch. We also submitted vibration data based on experiments from the provided data.

v5. Separation impact test • Purpose: Confirm

by impact

test whether the CanSat can withstand the impact when it is released from the rocket. Also, confirm that the joints can withstand the impact from the rocket when the parachute opens, and that there is no damage to the parachute or the aircraft.

• Test content

The magnitude of the instantaneous separation impact when the CanSat vehicle is ejected from the rocket and the parachute opens was determined from data from three ARLISS2019 launches. The separation impacts at ARLISS2019 were approximately 23.48 [G] for the first separation , approximately 25.41 [G] for the second separation , and approximately 21.67 [G] for the third separation . Since the three separation impacts were less than 30[G], we assumed that the separation impact would be equivalent to a maximum of 30[G], taking into account errors, and conducted an evaluation test. The acceleration data during release of ARLISS2019 is shown in Fig. 6-5-1 for the first separation impact, Fig. 6-5-2 for the second separation impact, and Fig. 6-5-3 for the third separation impact.

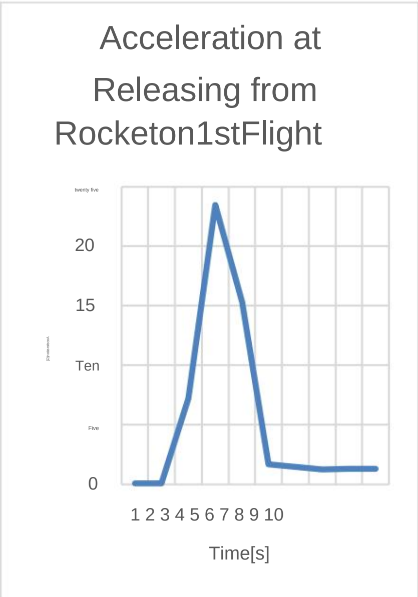


Fig.6-5-1 Separation impact 1st time

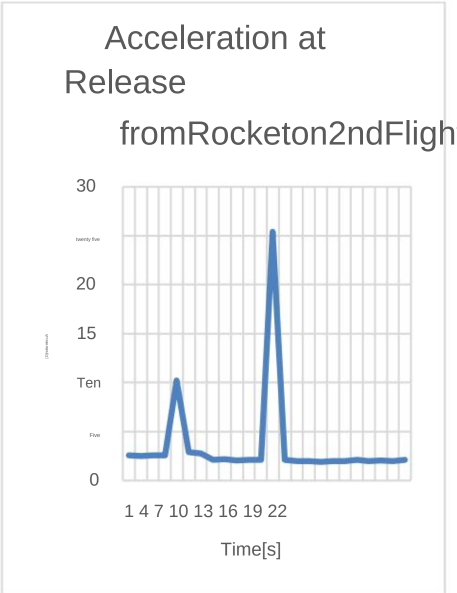


Fig.6-5-2 Separation impact second time

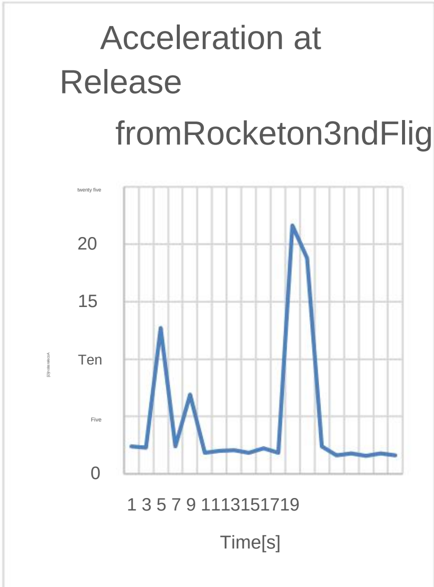


Fig.6-5-3 Third separation impact

Using an acceleration of 30G as a reference value, the CanSat was allowed to fall freely from a high position while holding the parachute in its hand, and when an impact exceeding 30G was observed using the CanSat's acceleration sensor, an acceleration of 30G was observed. Evaluate whether there are any abnormalities in the state of CanSat when the

Using an acceleration of 30G as a reference value, the CanSat was allowed to fall freely from a high position while holding the parachute in its hand, and when an impact exceeding 30G was observed using the CanSat's acceleration sensor, an acceleration of 30G was observed. Evaluate whether there are any abnormalities in the state of CanSat when the

A diagram of the actual experimental method is shown in Fig.6-5-4.

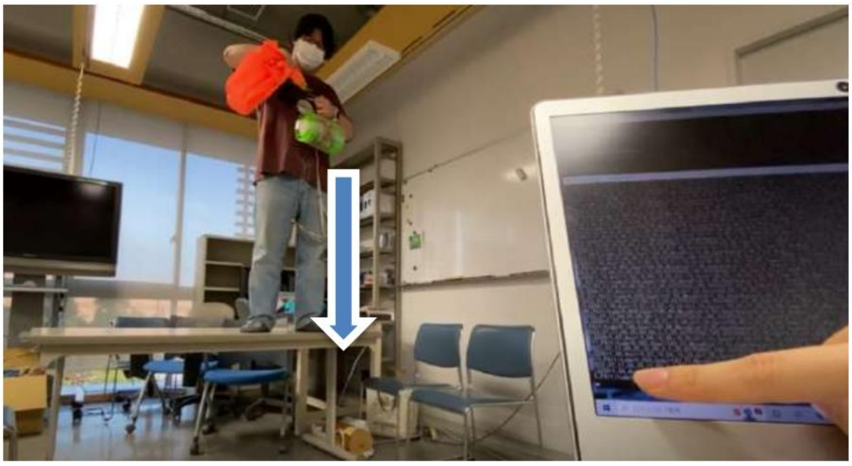


Fig.6-5-4 Image of experiment

• Results

Separation shock was applied several times, and an acceleration of approximately 30G was applied. The log data of the actual acceleration is shown in Fig.7-5-5. The parts where values of 30G or higher are observed are the parts that are subject to separation shock.

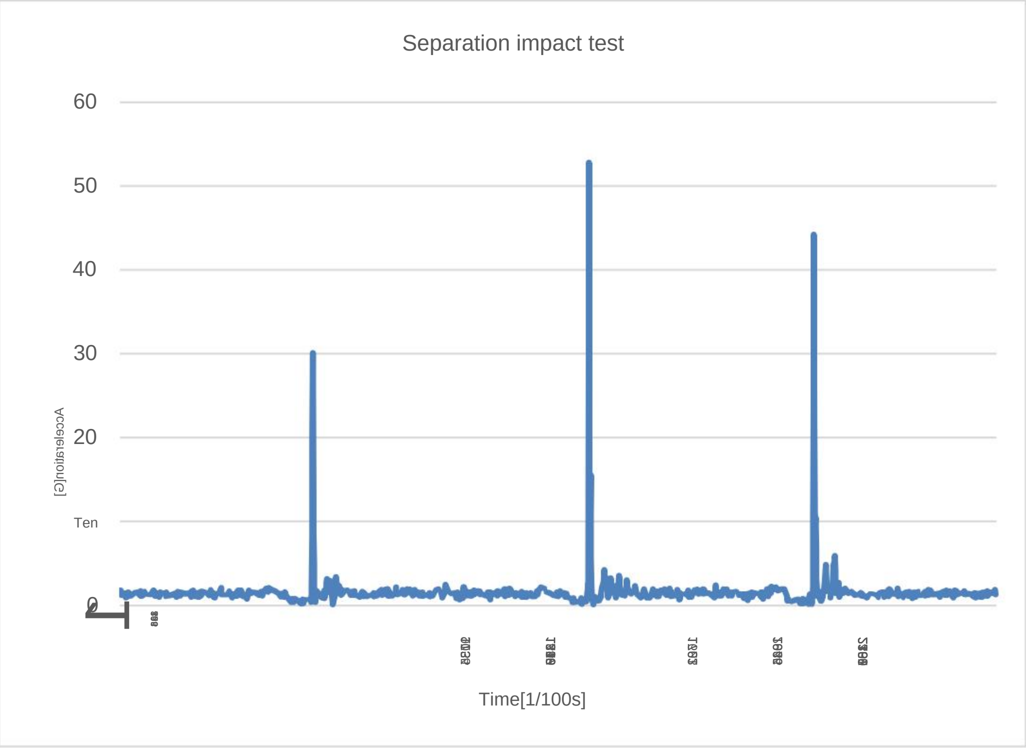


Fig.7-5-5 Separation impact values (vertical axis is applied acceleration [G], horizontal axis is time [1s])

As shown in Fig. 7-5-5, separation shocks of 30G or more were applied three times: 30.1G, 52.80G, and 44.26G . After three or more impacts of 30G or more, no damage was observed at the joints of the parachute or the joints with the CanSat protective cover. There was no damage to the aircraft, sensors, etc., and the parachute burnout mechanism and motor drive functioned normally. It was confirmed that there were no problems with the values of the sensors installed in CanSat or with its running.

The test was videotaped and records were made to check for any abnormalities, and no abnormalities were found in the aircraft. (See URL below)

ÿ Separation impact test video URL: https://youtu.be/DW30i7LR9Nk

(00:00 Experiment explanation~, 00:20 Separation shock 3 times~, 00:50 Circuit operation sensor confirmation~, 02:55 Parachute detachment operation + motor drive check~, 03:30 Aircraft damage location confirmed~)

•

Considerations From the test results, there was no evidence of damage to electronic components such as sensors, the fuselage, or the motor, so the joints with the parachute, the parachute, and the fuselage withstood the impact when the parachute was released from the rocket and opened. I decided that it would be possible.

v6. Drop test

• Purpose

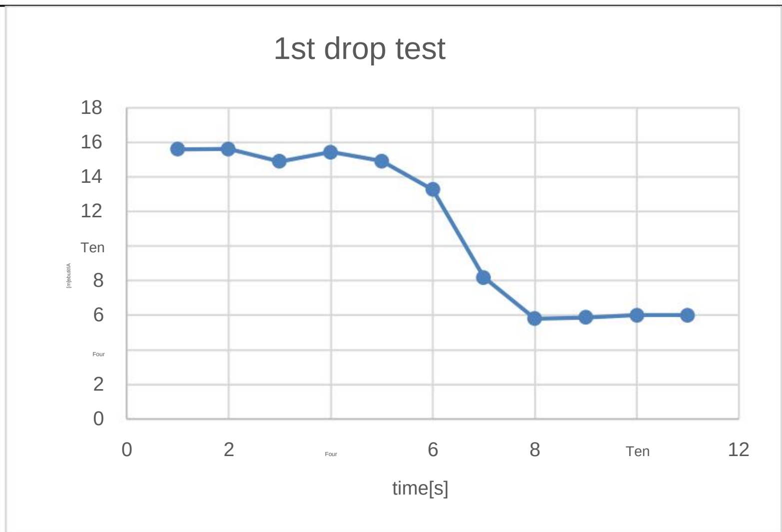
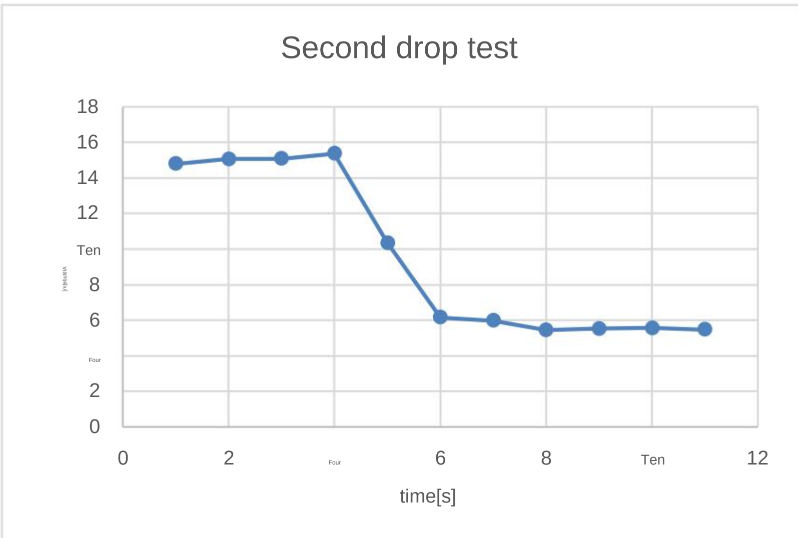
Confirm that the parachute can be opened and decelerated, and that the terminal speed is approximately 5 m/s. Ru.

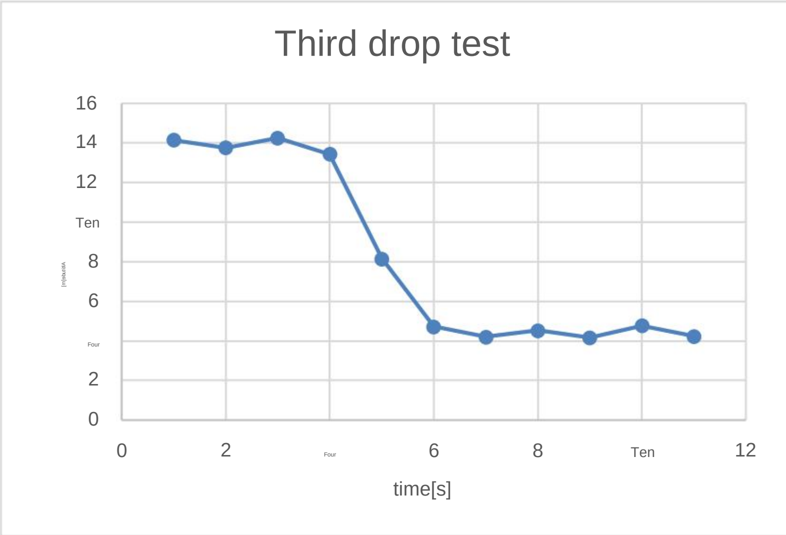
• Test content

A parachute with a CanSat attached was dropped, and the acceleration measured during the fall decreased by about 5 m/s. I checked to see if it reached the terminal velocity.

• Results

The experimental results are summarized in Table.6.

times number	termination speed	5m/s Is that all? •or×	Experimental data graph	Video URL
1 times eye	5.089 [m/s]	•		https://youtu.be/xtlTvwk6RMk
2 times eye	5.014 [m/s]	•		https://youtu.be/YYK8LJwjvgM

3 times eye	5.30 [m/s]	•		https://youtu.be/dArfhvVE2Uk

[First time] In the graph, between 13.272m at 6s and 8.183m at 7s, the falling height during 1s is 5.089m, 5.089m/1sÿ5.089m/s.

[Second time] In the graph, between 15.364m at 4s and 10.35m at 5s, the falling height during 1s is 5.014 m. 5.014 m/1sÿ5.014m/s.

ÿThird timeÿ

In the graph, between 13.444m at 4s and 8.144m at 5s, the falling height during 1s is 5.30m.

5.30m/1s = 5.30m/s ,

and it was confirmed that the terminal velocity was 5m/s or more three times.

• Consideration

It was confirmed that the terminal velocity after deceleration by the parachute was approximately 5 [m/s].

v7. GPS data downlink test • Purpose: To confirm that long-distance

communication is possible and is effective as a countermeasure against lost CanSat.

• Test details

Interplun IM920 (frequency used: 920MHz band) is used to receive wireless signals over long distances. We confirmed whether it is possible to identify the direction in which CanSat is located.

It will be considered a success if the radio waves from the Interplun IM920c (transmitter) can be received by the Interplun IM920 (receiver), the received data can be sent to the connected PC, and displayed on Teraterm. In this experiment, the transmitted data is the elapsed time, but in the real world, position coordinates are transmitted as a countermeasure against lost data.

The experiment aimed at communication over a distance of 4km. As a basis for the target value of 4 km, the maximum reception distance of IM920 is set to 7 km according to the standard, but the launch altitude is 4 km, and the parachute color of the own organization is orange, so the CanSat direction after release can be visually observed in the air. After tracking it, we aimed to track it at the launch altitude of 4 km, with the aim of searching from there. Additionally, when conducting experiments, the geographical limit of nearby locations that can be seen is 4 km.

Fig.6-7-1 is a photo of the Interplun IM920 receiver used in the experiment, Fig.6-7-2 is a photo of the CanSat equipped with the Interplun IM920c transmitter, and the transmitter and receiver actually used are on the PC. A photo of the connected state is shown in Fig.6-7-3.

Fig.6-7-1 Receiver Interplun IM920

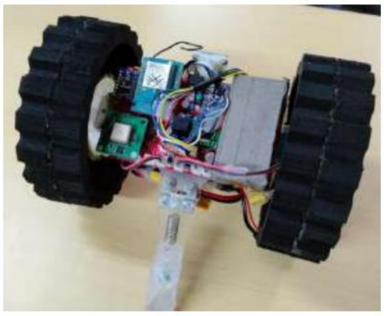


Fig.6-7-2 CanSat equipped with transmitter Interplun IM920c

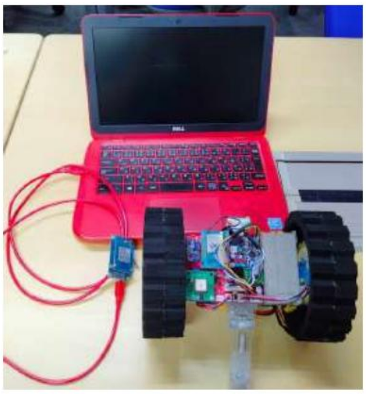


Fig.6-7-3 Receiver (left) and transmitter (right) actually used

It also shows the coordinates of the position where the distance was actually measured.

Distance specified location: Approximately 4.0km [Latitude 34.79416666 Longitude 137.13055555] ~ [Latitude 34.76916666 Longitude 137.16861111] Distance

• Results

4km wireless reception

When we tried wireless communication by placing the transmitter incorporating CanSat at [latitude 34.79416666 longitude 137.13055555] and the receiver at [latitude 34.76888888 longitude 137.16861111], wireless communication was successful.

The transmitter position photo is Fig.6-7-11, the latitude and longitude of the transmitter position is Fig.6-7-12, and the receiver position photo is Fig.6-7-13. The latitude and longitude of the receiver position is shown in Fig.6-7-14, the Google MAP of the receiving and transmitting positions is shown in Fig.6-7-15, and the data actually acquired is shown in Fig.6-7-16.

Fig.6-7-11 Photo of transmitter position

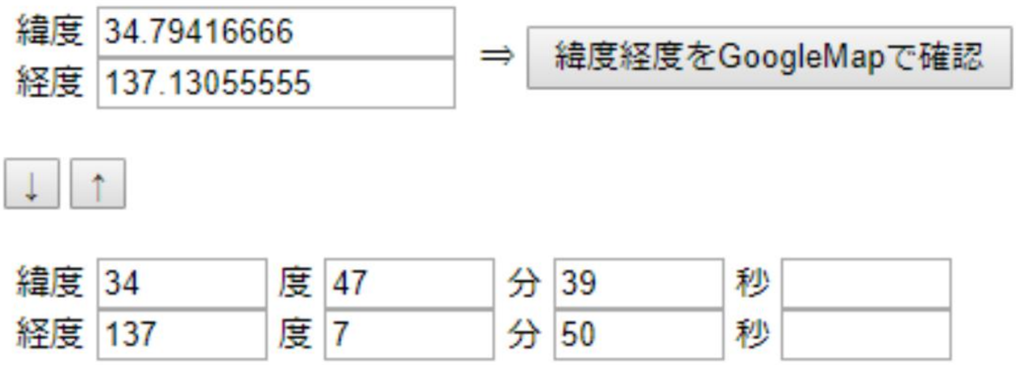


Fig.6-7-12 Latitude/longitude conversion of transmitter position (conversion from GPS logger hours, minutes, and seconds in Fig.6-7-11)

Fig.6-7-13 Photo of receiver position

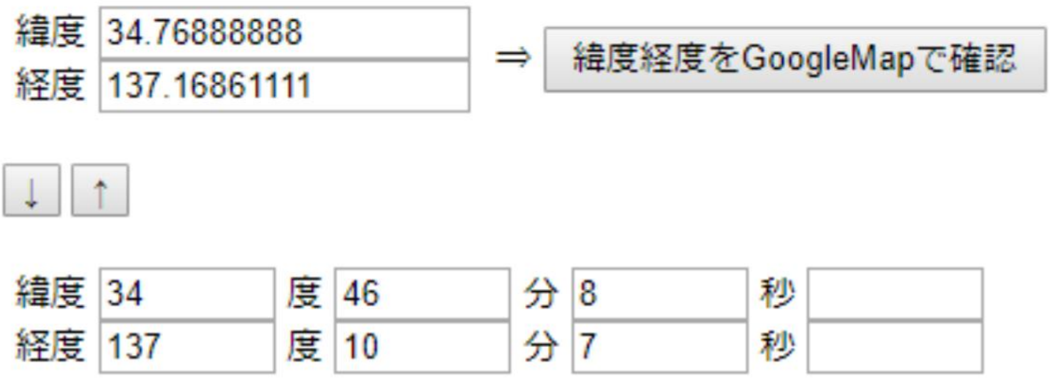


Fig.6-7-14 Latitude and longitude conversion of receiver position (conversion from GPS logger hours, minutes and seconds in Fig.6-7-12)

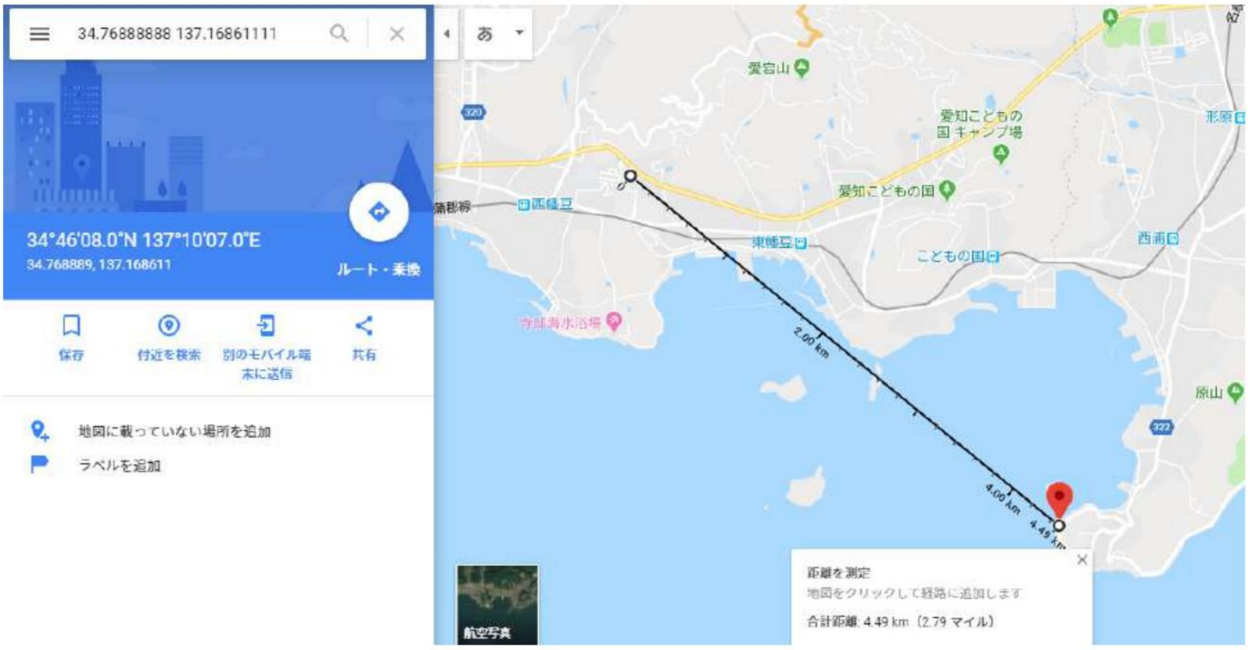


Fig.6-7-15 Distance measurement on Google Map between 4km

A video was taken showing the GPS data received from the transmitter displayed in real time.

•Long distance communication test: https://youtu.be/yN6jo3j9JEs

As a result of experiments, it was confirmed that long-distance communication of approximately 4 km is possible.

• Consideration

Even when the IM920 was mounted on a CanSat, it was possible to receive data from a distance of 4 km. Using the data obtained, we confirmed that CanSat's location could be determined and the location of CanSat could be determined.

v8.Communication device power OFF/ON test • The radio waves of the target

communication

device are OFF during launch and ON when CanSat is released from the rocket.

Make sure that it becomes true.

• Test details The

communication device used this time, Interplan IM920, has a radio field strength below the default, but since it is not FCC certified, we decided to use the altitude value obtained from the barometric pressure sensor value to cut off the power supply to the communication device. 20 seconds after turning on

CanSat according to the program, it goes into sleep mode (DSRX) and communication radio waves are turned off while it detects a small altitude, and when it detects a large altitude for several seconds, it detects that a rocket has launched. After that, when CanSat detects the altitude at the time the power was turned on for a few seconds, it determines that it has been ejected from the rocket and has landed, and when the change in the gyro sensor value becomes small, it determines that it has fallen to the ground and has stopped (ENRX). I created a program.

In the experiment, it is impossible to observe the rocket altitude of about 4000m, so the Aichi The experiment was conducted in an environment where the height of the building No. 7 of the University of Technology was assumed to be the height of the rocket. Using the university elevator, when the CanSat power is turned on, detect the altitude on the 1st floor, confirm that the communication radio waves are OFF, and then ascend to the 9th floor. Assuming that the rocket is ascending, the altitude value is set to the initial value. After detecting for 10 seconds that the altitude has risen to 15m or more from the value, it descends to 1F, and after detecting that the altitude is 15m or less for 10 seconds as a value close to the initial value, when the change in the gyro sensor becomes small, it will fall to the ground. We determined that it was stopped and confirmed that the communication radio waves were turned on.

In addition, the procedures for communication conditions are shown in ÿÿÿ below.

ÿ When CanSat is powered on, communication radio waves are turned on for 20 seconds, then radio waves are turned off. ÿ If an altitude of 15m or higher is detected for 10 seconds, communication radio waves are turned off in sleep mode (DSRX).

condition

ÿ After continuously detecting the altitude within 15m for 10 seconds, move on to program ÿ. ÿ When the change in the gyro sensor becomes small, it is determined that the robot has fallen to the ground and stopped.

Wireless ON state in communication mode (ENRX)

In addition, as experimental equipment, we displayed the wireless log on a PC and the real-time log of the program when connected to CanSat by wire in parallel, and also measured radio waves with a spectrum analyzer as a radio wave observation device and turned the radio waves on and off. I made it possible to check visually. The actual experimental equipment is shown in Fig.6-8-1.

Fig.6-8-1 Experimental equipment for visually checking radio wave ON/OFF

• Results

The actual results are summarized as (1) whether the communication device was turned off, (2) whether the set high altitude was observed, and (3) whether the communication device was turned on after falling from the high altitude.

ÿ CanSat power is turned on on the 1st floor of the building, and 20 seconds later, the wireless communication log stops and the spectrum The analyzer stopped observing radio waves in the 920Mz band, and wireless communication was turned off. Figure 6-8-2 shows the wireless log on the PC during the actual experiment, the real-time log of the program when connected to CanSat by wire, and the display photo of the spectrum analyzer.

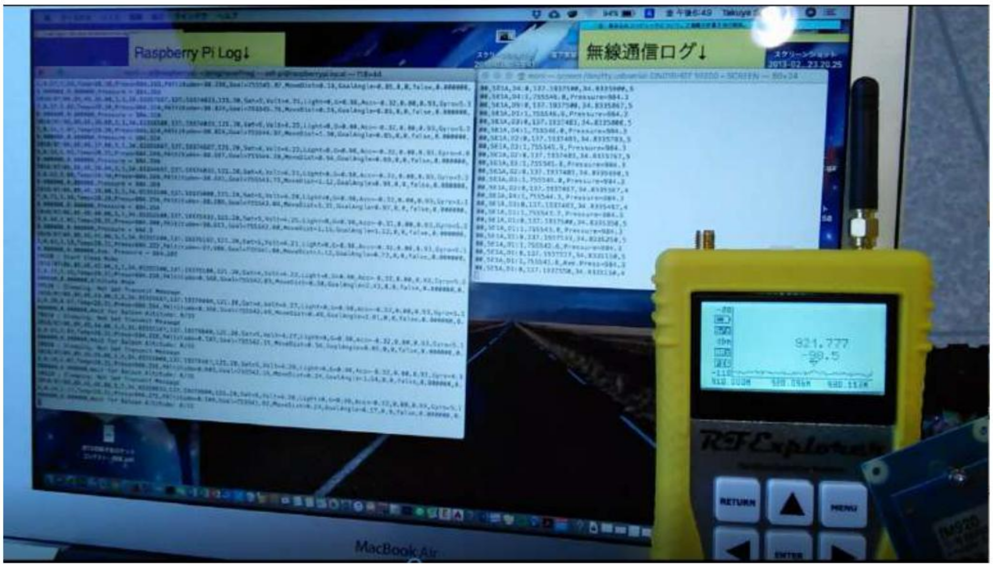


Fig.6-8-2 Power OFF confirmation photo

ÿ After ascending to the 9th floor of the building, an altitude of 31m was observed using the Raspberry Pi Log, indicating that the robot had ascended. Observed. A

photo of the actual altitude observation real-time log is shown in Fig.6-8-3.

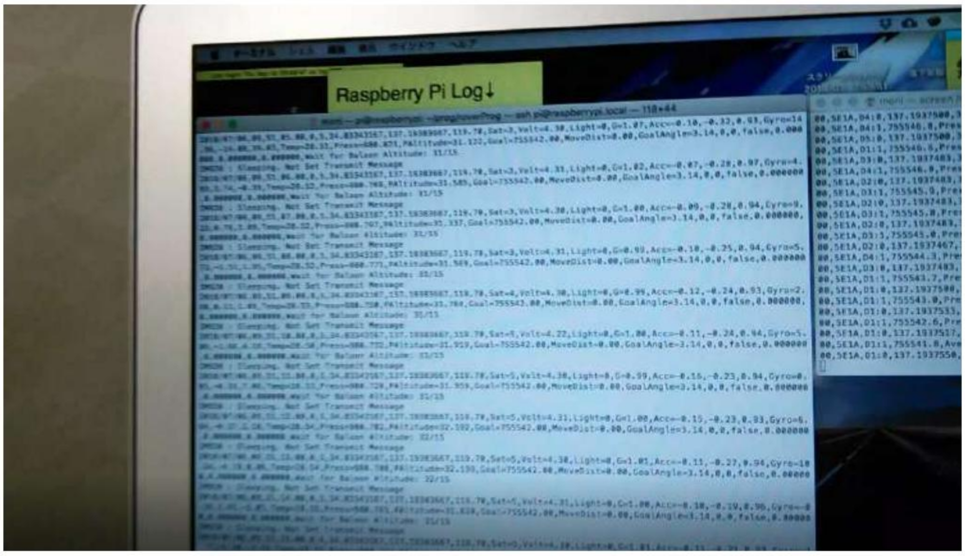


Fig.6-8-3 High altitude observation

ÿ Descend to 1F, place CanSat on the ground, stop it, observe the drop in altitude, and Since the change in the gyro sensor value became smaller, it was determined that the aircraft had landed on the ground, and the radio waves were turned on. In the actual experiment, I connected the wireless log to the PC and CanSat via wire.

Fig.6-8-4 shows the real-time program log and the spectrum analyzer display photo.

Fig.6-8-4 Radio ON confirmation photo after altitude descent

We have also put together a video of the test. (Refer to the URL below) ÿ Communication device power ON/OFF test video URL: https://youtu.be/i2LnoMklAzI

Through the test, we were able to confirm that the radio waves of the communication device were turned off when the rocket was retracted, and turned on when the CanSat was released from the rocket.

• Consideration

As a result, the test confirmed that the regulations for turning off radio waves during launch could be complied with.

v9.Communication frequency ch change test •

Purpose

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

• Test content

We took steps to program the radio we planned to use (interplan IM920) to switch the communication device to be used depending on the situation. Channel conversion is performed on the program and data is received after inputting [stch (number of channels)] on Tera Term. Confirm that you can change the wireless channel using these functions.

• Results

Describe the results of the experiment by describing the wireless setting program actually used as ÿ and changing the channel of that program as ÿ.

ÿ On the Raspberry Pi zero W main program connected to M920

Change the number in parentheses of [sc16is750.setChannel();] to the number of channels and compile.

The channel can be changed by pressing the button.

In the experiment, the settings were changed from 5 channels to 7 channels. The actual program is shown in Fig.6-9-1.

Fig.6-9-1 Channel change program

ÿ If you compile [STCH 07] on TeraTerm on the PC connected to IM920, the chat will start.

channel becomes 7. The actual data log is shown in Fig.6-9-2.

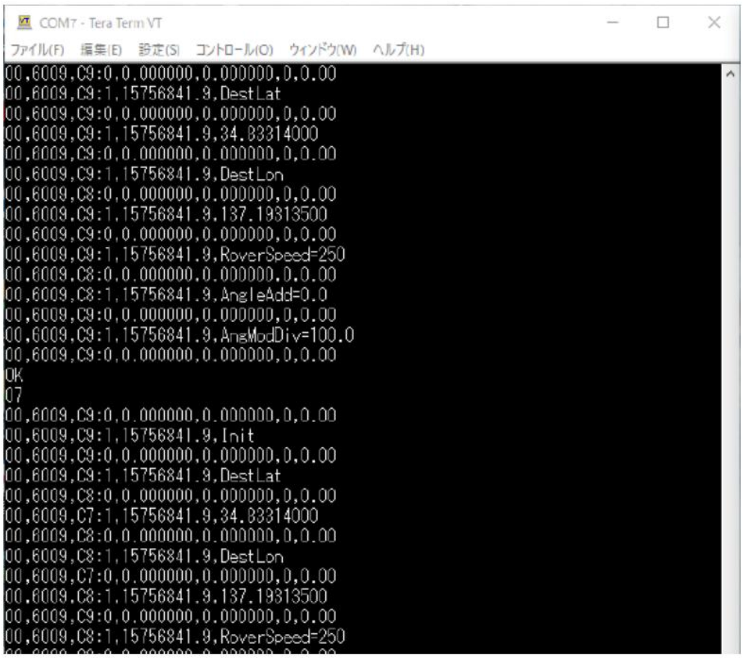


Fig.6-9-2 Data log after channel change during experiment

Regarding changing the wireless channel (interplan IM920), we confirmed that we could actually communicate by changing the channel using a

program. We have also put together a video of the test. (See URL below)

ÿ Communication frequency change test video URL: https://youtu.be/Kq6UdYgvaNI

• Consideration

It was confirmed that wireless channel adjustment was possible.

v10. End to End Exam •

Objective

Perform CanSat operation using the same procedure as the actual operation. Submit a video that confirms that each sequence can be performed autonomously.

• Test content

1 CanSat is released from the carrier under its own weight 2 Landing impact 3 Detachment from parachute 4 Autonomous travel to destination using GPS location information 5 Deep Learning Object Detection Goal approach & judgment 6 Check if it is possible through the series of steps up to log data retrieval.

• Results The experimental results are shown in Table.15.

Table.15 End to End results

Number of times	success Or failure	detail	URL
1 times	success	[Carrier release ~ Running with GPS] After the carrier was released, the sun sensor value determined that the carrier was released from inside the carrier to the outside, then it separated from the parachute and ran close to the goal based on GPS information. [Goal detection with Object Detection - Log retrieval] Goal detection with Object Detection started from around 5m from the goal, circled until the goal was reflected on the camera, and then the goal was determined after approaching 0m. Then Object Detection Run the program that extracts the log image and outputs the travel trajectory. I was able to retrieve EndtoEnd's driving miracle log data.	https://youtu.be/NTiNaNUbnBk 00:24 Carrier storage 01:28 Release 01:37 Landing impact 02:40 Parachute release operation 03:00 GPS travel start 03:30 Object Detection start 04:14 Goal judgment 05:12 Log extraction travel trajectory 06:11 Object Detection Image Log https://
Second time	success	[Carrier release ~ Driving with GPS] After the carrier was released, the sun sensor value determined that the carrier was released from inside the carrier, and then it separated from the parachute and ran close to the goal based on GPS information. [Goal detection with Object Detection - Log retrieval] Goal detection with Object Detection started from around 5m from the goal, circled until the goal was reflected on the camera, and the goal was determined after approaching 0m. Then Object Detection Run the program that extracts the log image and outputs the travel trajectory. I was able to retrieve EndtoEnd's driving miracle log data.	youtu.be/pubwN5vwaWI 00:24 Carrier storage 01:01 Release 01:18 Landing impact 02:26 Parachute release operation 02:38 GPS start running 03:32 Object Detection Start 03:49 Goal Judgment 04:51 Log Extraction Travel Trajectory 05:33 Object Detection Image Log

In addition, the control history was recorded in the V11 control history report test.

• Consideration

The end-to-end test confirmed that there were no problems with the flow of the competition. We will conduct repeated tests to improve accuracy before the actual production.

v11. Control history report test • Purpose End to End

Created

from the test data and controlled using the competition report on the day of the experiment and after the competition. Confirm that you can submit your history.

• Test content

The point where the program was started is the starting point, and the data from the starting point to the goal point is saved as a file on the microcontroller's SD card. After the experiment, data files such as GPS and control values were read from the SD card, and the raw text data was summarized in an Excel file and displayed in an easy-to-read format. As for the Excel data, submit the files acquired at each sampling time of 1s and the data acquired at each sampling time of 0.01s. Additionally, the driving trajectory was visualized and displayed in changing colors to make it easier to see.

• Results

A control history was created using the data actually performed with V15End to End.

[Travel trajectory]

The colored and arrowed travel trajectory diagrams created for control history submission are shown in Fig. 16-1 for the first end to end and in Fig. 16-2 for the second end to end.
In the driving trajectory diagram, the driving trajectory is shown in color from latitude and longitude, with the maximum steering value for right turns being 0.20 (yellow) and the maximum steering value for left turns being -0.20 (purple). Also, indicate the start point, target point, and stop point with arrows, and Indicates latitude and longitude.

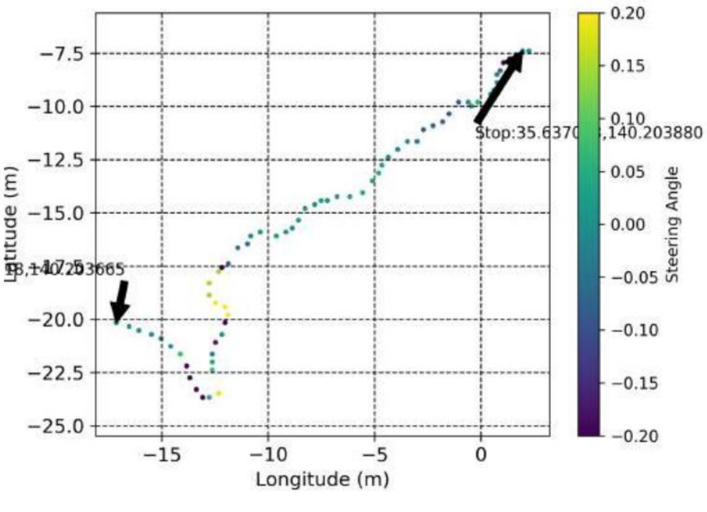


Fig.16-1 1st End to End travel trajectory

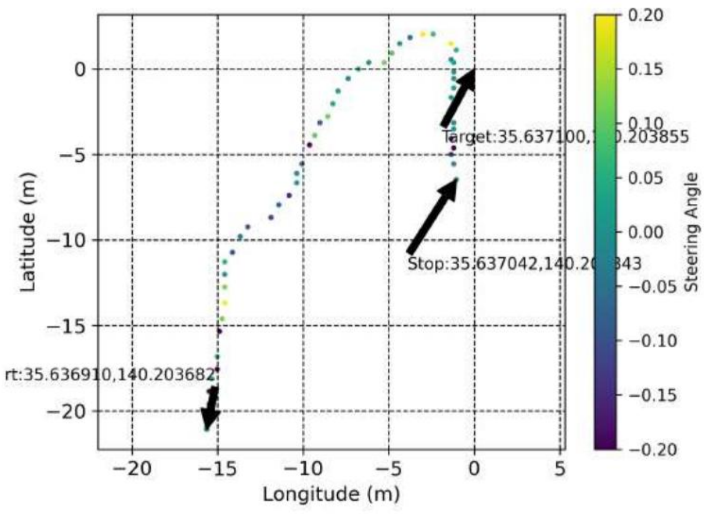


Fig.16-2 Second End to End travel trajectory

[Control history
explanation] Control history text The raw data is summarized in an Excel file
for easy viewing. You can check basic control output system data. The Excel file can be checked from
the drive URL after 5p.

Control items are

Time series data: columns A to D

A	B	C	D	E	F
Year	Month	Day	Hour	Minute	Second
2019	8	15	7	22	10
2019	8	15	7	22	11
2019	8	15	7	22	12
2019	8	15	7	22	13

Control output data: AF to AS columns

AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
Goal Angle	Drive Speed	Speed Division	Steering Modify	Steering Angle	Steering Modify Angle	Actual Steering Angle	Target Motor Rev R	Target Motor Rev L	Actual Motor Rev R	Actual Motor Rev L
-1.58	0	9	FALSE	0	0	0	110	66	111	76
-1.58	250	5	TRUE	-0.504014	-0.00504	-0.127263	0	0	44	36
-1.59	250	5	TRUE	-0.505619	-0.010096	-0.128929	122	106	132	115
0	250	5	TRUE	0	-0.010096	-0.002524	122	106	127	108
-0.88	250	5	TRUE	-0.279795	-0.012894	-0.073172	122	122	124	113
-0.39	250	5	TRUE	-0.125159	-0.014146	-0.034826	122	113	114	119
-0.69	250	5	TRUE	-0.218401	-0.01633	-0.058683	122	118	144	93

GPS location information value: I, J columns

I	J
Latitude	Longitude
40.14226333	139.9874683
40.14226333	139.98747
40.14226333	139.9874733
40.14226333	139.9874733

It is written in

In addition, the algorithm for the control method using GPS is shown in Fig.16-3.

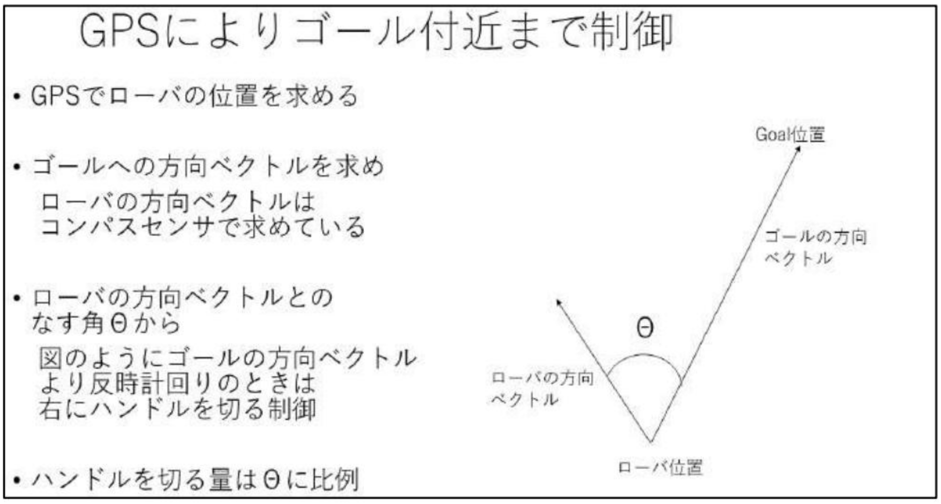


Fig.16-3 Control method using GPS

An explanation of the control output data items is shown below.

•AH column Angle between CanSat traveling direction and goal [rad]: From 1 second ago and current CanSat
The angle between the CanSat's direction of travel and the goal is determined in radians and reflected in the control.

•AI row motor output speed (-255~+255): The output applied to the motor is given as -255~+255 (right to left).

•AJ row speed resolution: GPS is controlled every second, but as a noise countermeasure when changing to a new speed, the motor output is converted by a linear change over a specified time (0.1 seconds). (Countermeasures against noise by making small changes in voltage)

•AL row steering correction (TRUE or FALSE): Determines whether or not to apply steering correction to CanSat from the control value, and represents it as TRUE or FALSE.

•AC row steering angle (-1 to +1) (-1: left, +1: right): -1 to +1 represents the steering angle, with maximum left turning -1 and right turning maximum +1. I am.

•AM row correction rudder (steering I control): In consideration of motor damage, when one steering angle is extremely large, I control is applied to increase the other steering angle.

•AN row actual steering angle (-1 to +1): This represents the steering angle that is actually output to the motor by adapting the AC row steering angle to the AD row correction rudder.

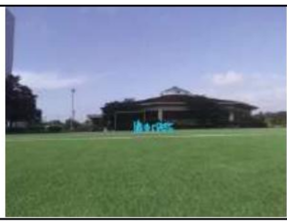
- AO row right motor target rotation speed (-255 to 255): Right motor steering target rotation speed using rotation speed control.

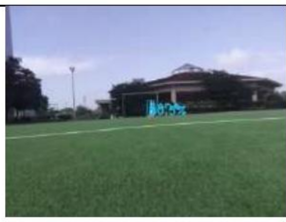
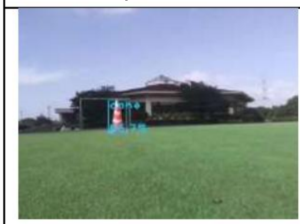
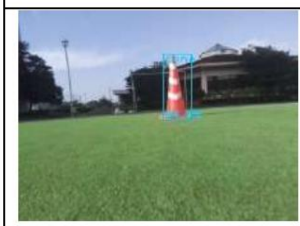
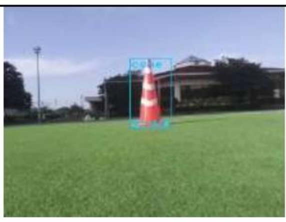
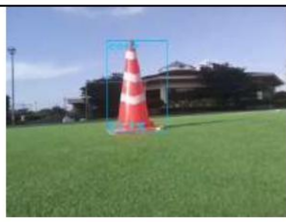
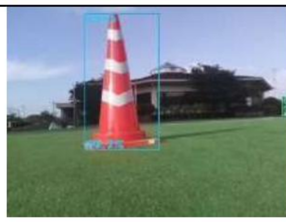
•AP row left motor target rotation speed (-255 to 255): The rotation speed of the left motor steering actual measurement result using rotation speed control.
•AQ row right motor target rotation speed (-255 to 255): Right motor steering target rotation speed using rotation speed control.

•AR row left motor target rotation speed (-255 to 255): The rotation speed of the left motor steering actual measurement result using rotation speed control.

[Object Detection Image Log] Table
16-1 shows the first image log of End to End Object Detection, and the second image log is shown in Table 16-1.
is shown in Table 16-2.

Table 16-1 End to End 1st Object Detection

Image log & details up to 0m goal with Object Detection				
16 turns until finding the goal (pic1-16)				
 pic1	 pic2	 pic3	 pic4	 pic5
 pic6	 pic7	 pic8	 pic9	 pic10
 pic11	 pic12	 pic13	 pic14	 pic15
 pic16				
After discovery, the goal was determined by turning 42 times and going straight (pic17-59)				
 pic17	 pic18	 pic19	 pic20	 pic21
				

pic22	pic23	pic24	pic25	pic26
 pic27	 pic28	 pic29	 pic30	 pic31
 pic32	 pic33	 pic34	 pic35	 pic36
 pic37	 pic38	 pic39	 pic40	 pic41
 pic42	 pic43	 pic44	 pic45	 pic46
 pic47	 pic48	 pic49	 pic50	 pic51
 pic52	 pic53	 pic54	 pic55	 pic56

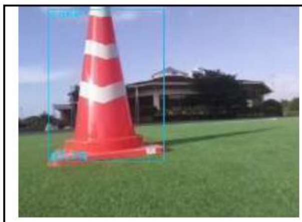
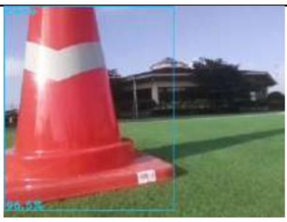
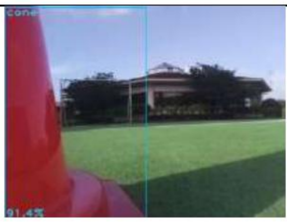
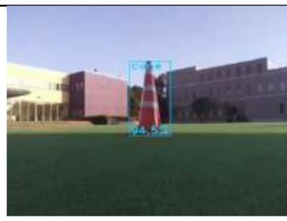
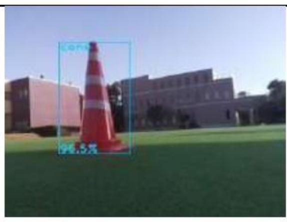
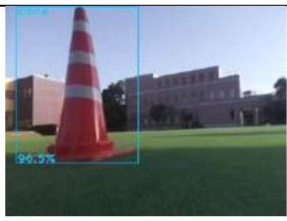
 pic57	 pic58	 pic59		

Table 16-2 End to End 2nd Object Detection

Image log & details up to 0m goal with Object Detection				
42 turns until finding the goal (pic1-42)				
				
pic1	pic2	pic3	pic4	pic5
				
pic6	pic7	pic8	pic9	pic10
				
pic11	pic12	pic13	pic14	pic15
				
pic16	pic17	pic18	pic19	pic20
				
pic21	pic22	pic23	pic24	pic25
				
pic26	pic27	pic28	pic29	pic30
				

pic31	pic32	pic33	pic34	pic35
				
pic36	pic37	pic38	pic39	pic40
				
pic41	pic42			
After discovery, the goal was determined by turning 10 times and going straight (pic43-57)				
				
pic43	pic44	pic45	pic46	pic47
				
pic48	pic49	pic50	pic51	pic52
				
pic53	pic54	pic55	pic56	pic57

In addition, the URL that summarizes the actual control log data is shown below.

ÿEnd to End Control history text Raw data, Excel file, travel trajectory, goal image:
https://drive.google.com/drive/folders/172xsRolKTe2KOWx2SyQnNpZD7ojEGBYi?us
p=sharing

• Consideration

Detailed data from when CanSat autonomously travels to its destination, determines the goal, and then stops.

We confirmed that it is possible to create a control history report and submit a control history report to the operator.

v12. Landing impact test • Check whether

the aircraft

can withstand the impact that occurs when landing at the destination .

• Test content

[Simulation_Test content]

We simulated the load when CanSat falls and lands. In ARLISS2019, there were three launches, the first one was about 56.11[G], the second one was about 25.72[G], and the third one was about 61.19[G]. The third landing impact, which is the maximum value of approximately 61.19[G], is treated as the maximum landing impact value.

ARLISS2019 1st acceleration graph is shown in Fig.6-12-1, ARLISS2019 2nd acceleration graph is shown in Fig.6-12-2, and ARLISS2019 3rd acceleration graph is shown in Fig.6-12-3.

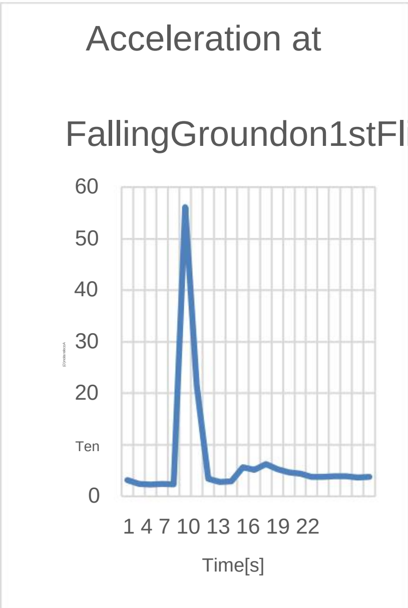


Fig.6-12-1 First landing impact

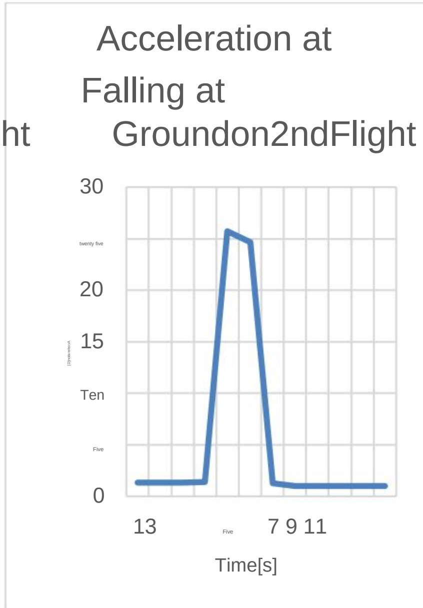


Fig.6-12-2 Second landing impact

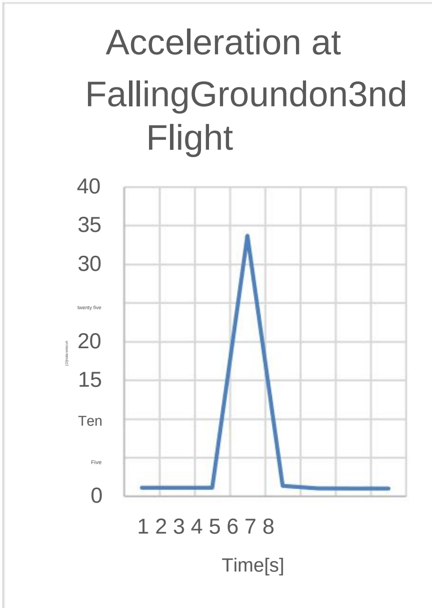


Fig.6-12-3 Third landing impact

CanSat has a mass of 0.850kg (see V1 mass test), and was observed during landing impact at ARLISS2019. The total load was calculated using the maximum load of approximately 61.19G as the reference value.

The aircraft lands from the tires on the side of the aircraft, and the loads of the board, motor, and battery are applied to the tires, so the simulation is performed using the weight of the aircraft minus the mass of the tires.

[Actual measurement_test content]

Find the height at which the impact is the same as when free falling from the terminal velocity of the parachute,
Check to see if there is any malfunction in CanSat when it is allowed to fall freely from that height.
The free fall height was calculated from the terminal velocity as follows.
(v2 = parachute terminal velocity 5m/s) (a = gravitational acceleration 9.8g)

Terminal velocity (see parachute drop test) = $\frac{2ÿ\ ^{2}_{0}}{2} = \frac{52ÿ\ 0}{2*9.8} = 1.275[\ ]$

CanSat is allowed to fall freely from a height of 1.275[m] or more, and then the electronic circuit's GPS and sensor
Check that the value of the class is not above or above, that the motor is not above or above, and that the CanSat is not damaged.
I did.

• Results

[Simulation_Results] As a
result of measuring the mass of one tire, the mass of the tire is 0.062 kg.
Therefore, the mass of two tires is 0.124 kg, and the total mass of the aircraft is 0.850 kg (see mass test).
The mass to which the load is applied becomes 0.711 kg. Adding 61.19 G to the mass of 0.711 kg
The total load is 44.42 kgf. The calculation formula is shown in 6.12.1 below.

0.850 – (0.062×2) = 0.726
0.726 × 61.19 = 44.42 ...6.12.1

When the total load of 76.0 kgf is distributed to the tire and motor binding parts, 22.21 kgf is added to each part. The calculation formula is shown in 7.8.2 below.

44.42 / 2 = 22.21 ...6.12.2

A diagram that clearly shows the above simulation results is shown in Fig. 6-12-4.
In addition, the photo that serves as the basis for measuring the mass of the 0.118 kg tire shown in formula 6.12.1 is shown below.
It is shown in Fig.6-12-5.

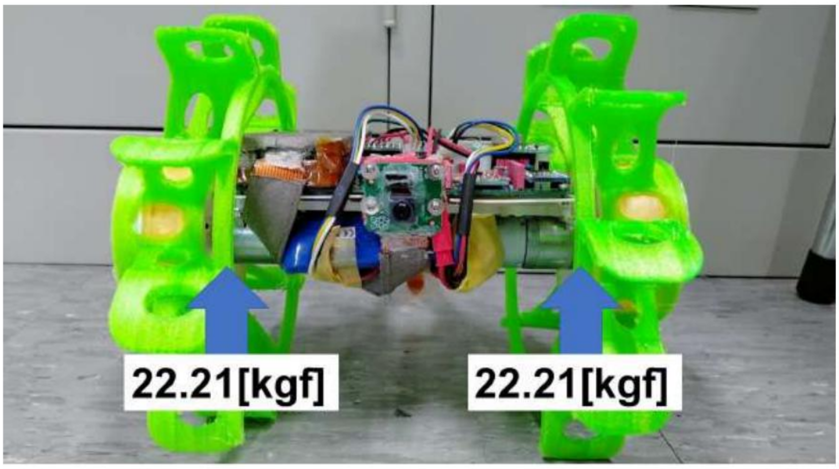


Fig.6-12-4 Simulation results

Fig.6-12-5 Tire weight

[Actual measurement result]

The landing impact was applied three times. The log data of the actual acceleration is shown in Fig.6-12-6.

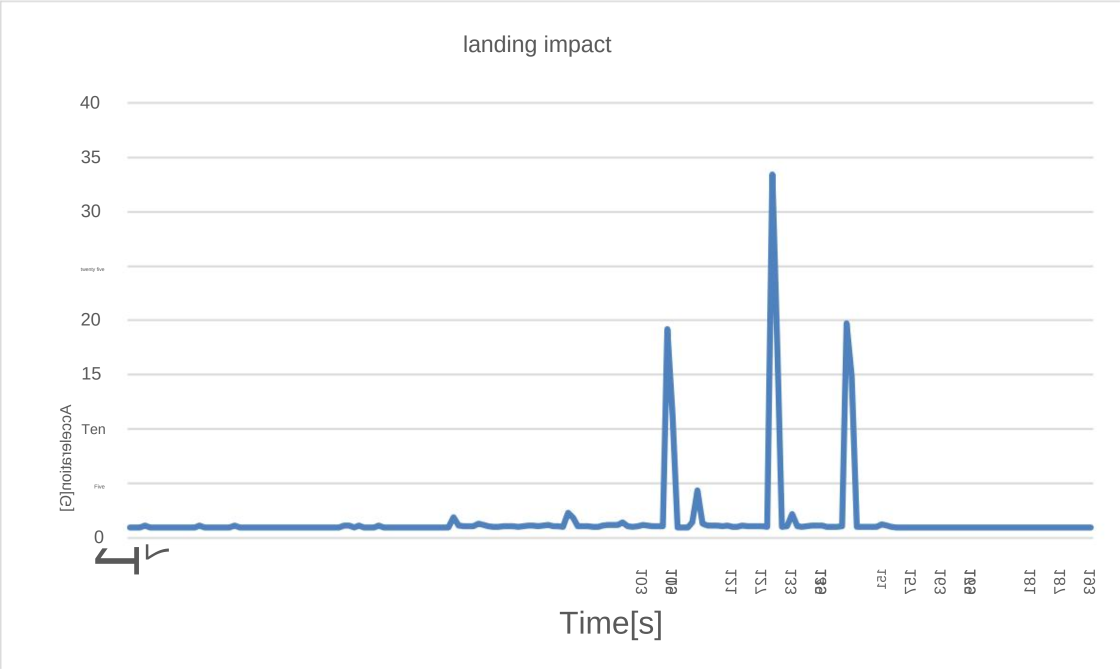


Fig.6-12-6 Numerical graph of landing impact (vertical axis is applied acceleration [G], horizontal axis is time [1s])

The landing impact observed from Fig.6-12-6 was 19.23[G] for the first time, 33.42[G] for the second time, and 19.74[G] for the third time. It was

Due to the change in tire design (see 3.2. Interior view and mechanism of the aircraft), the impact absorption mechanism of the tires worked, and it was confirmed that the landing impact value was smaller than the conventional tires of ARLISS2019.

Also, check for abnormalities in the electronic circuit GPS and sensor values, parachute release mechanism, and motor. We checked to see if the CanSat aircraft was damaged and confirmed that there was no breakdown and no problems with the CanSat.

A video of the landing impact test was taken and can be viewed on Youtube. Below is a look at the actual exam. It is shown in the URL below. (See URL below)

•Video URL of landing impact test : https://youtu.be/LO44Cxv_eVY

(0:33 Preliminary confirmation of circuit sensor operation, 2:12 1st drop impact, 2:32 2nd drop impact, 2:49 3rd drop impact, 3:05 Check circuit sensor operation, 4:40 Parachute release mechanism operation) Confirmed, 4:53 Motor operation confirmed (straight running), 4:13 Aircraft damage confirmed)

• Consideration

We confirmed that CanSat withstood the landing impact and operated without problems. We have confirmed that tires can absorb shock, and we will continue to experiment with various tire structures to improve shock absorption.

v13.Driving Performance Confirmation Test • Purpose To

confirm that

the vehicle can be driven without problems on the actual field.

• Test content A field

with large grass obstacles, similar to the large grass conditions at the Noshiro Space Event.

We ran the CanSat in a field and confirmed that it would not get stuck.

In the past, I have experienced many competitions in the Noshiro space event where the stems got stuck in large, thick grass, making it impossible to run. Therefore, we drove the CanSat on land with large grass similar to a competition field, and our mission was to change the shape of the tires to make it difficult for the grass to get stuck. We confirmed that it is possible to leave even if An example of an image of a large grass with thick stems in the experiment is shown in Fig. 6-13-1.

Fig.6-13-1 Image diagram of the experiment

We also conducted tests to see if the vehicle could drive through the ruts of ARLISS, by digging holes in the ground and reproducing the ruts. An example of an image of the track in the experiment is shown in Fig.6-13-2.

Fig.6-13-2 Image diagram of rut running experiment

• Results

Table 13-1 shows the results of the running performance confirmation test. CanSat is about 12cm long and thick grass,

We ran through grass that was approximately 34cm long and narrow, and grass that was approximately 38cm long and narrow.

Table 13-1 Running performance confirmation test results

Number of experiments completed		Grass condition Result details Length approx. 12cm thick		Video URL
1st time •			Approximately 12cm long and thick I ran through the grass.	
2nd time ÿ		Length approx. 34cm narrow 	Approximately 34cm long thin I ran through the rushes.	https://youtu.be/cPIhGK1oQ1s
3rd time ÿ		Length approx. 38cm narrow 	Approximately 38cm long thin I ran through the rushes.	

We also conducted an experiment by digging a hole in the rut to see if the rut could be overcome. The diameter of the CanSat's expanded tires is 17 cm, and according to the theory of the maximum level difference that can be overcome, it should be able to overcome a level difference with a radius of 8.5 cm. First, we checked to see if we could get over 5cm ruts, which is less than 8.5cm deep, and then we checked to see if we could run through 8.5cm ruts.

Table 13-2 Running performance confirmation test Overcoming ruts

Number of experiments completed		size of rut	result details	movie URL
1st time •		Depth 5cm Size 30cm Overcome while driving  	I overcame a rut that was 5cm deep and 30cm wide while driving.	https://youtu.be/HKwebfefbkw
2nd time ÿ		Depth 5cm Size 30cm Climb over while driving (first time from the opposite direction)  	Overcame a rut that was 5 cm deep and 30 cm in size while driving (from the opposite direction to the first time)	https://youtu.be/fl319fFGzD4
3rd time ÿ		Depth 5cm Size 30cm Overcoming the rut  	Climbed over a rut that was 5cm deep and 30cm wide.	https://youtu.be/ppsG0ew83eE
4th time ÿ		Depth 5cm Size 30cm Overcoming from the rut (3rd time from the opposite direction)  	I got over a rut that was 5cm deep and 30cm wide (from the opposite direction from the first time).	

5th time ÿ		Depth 8.5cm Size 33cm Climb over while driving  	Overcame a rut with a depth of 8.5 cm and a size of 33 cm while driving.	https://youtu.be/Rr4SXES8bZg
6th time ÿ		Depth 8.5cm Size 33cm Climb over while driving (5th time from the opposite direction)  	Overcame a rut with a depth of 8.5 cm and a size of 33 cm while driving (from the opposite direction for the 5th time).	
7th time ÿ		Depth 8.5cm Size 33cm Overcoming the ruts  	Climbed over a rut that was 8.5cm deep and 33cm wide.	https://youtu.be/42zvByzdf3I
8th time ÿ		Depth 8.5cm Size 33cm Overcoming the rut (7th time from the opposite direction)  	Climbed over a rut that was 8.5cm deep and 33cm wide (from the opposite direction for the 7th time).	

- Considerations It was confirmed that the vehicle can run on grassy ground and ruts. We will continue to consider the grip area, size, and shape of the tire to prevent stuck tires.

v14.Goal Detection Test • Check if you can make

a 0m goal

using the objective mission of Deep Learning Object Detection.

• Test content

From a point approximately 10m or more away from the target position, use GPS to get within a few meters, then approach the target color cone using image recognition using Object Detection and complete the 0m goal. Object below We will explain the details of the Detection specifications.

[0m goal speeding up using Object Detection] Object

Detection can detect multiple objects from a single image and determine where they are in the image. In addition to the goal, people and balloons can also be detected in a single image, and the location of each object can also be determined using coordinate information.

The Image Classfication I was using last year was converted from Tensorflow to Tensorflow Lite so that it could be recognized in the shortest possible time on the Raspberry Pi Zero W, and it took about 12 seconds to recognize the goal once. Therefore, calculation accelerator for Deep Learning

I connected Coral USB Accelerator to Raspberry Pi Zero W to speed it up. As a result, one goal recognition can be done in about 0.3 seconds instead of about 12 seconds.

[Object Detection usage details] ÿModel:

SSD MobileNet V1 ÿInput size:

300×300pixel, RGB3 channels ÿLearning method: Trained

model with coco 90 objects and about 5000 goal images cone, person, parachute, balloon, blue Transfer learning was performed using data annotated into five types of cone. Learning was performed for 1500 steps.

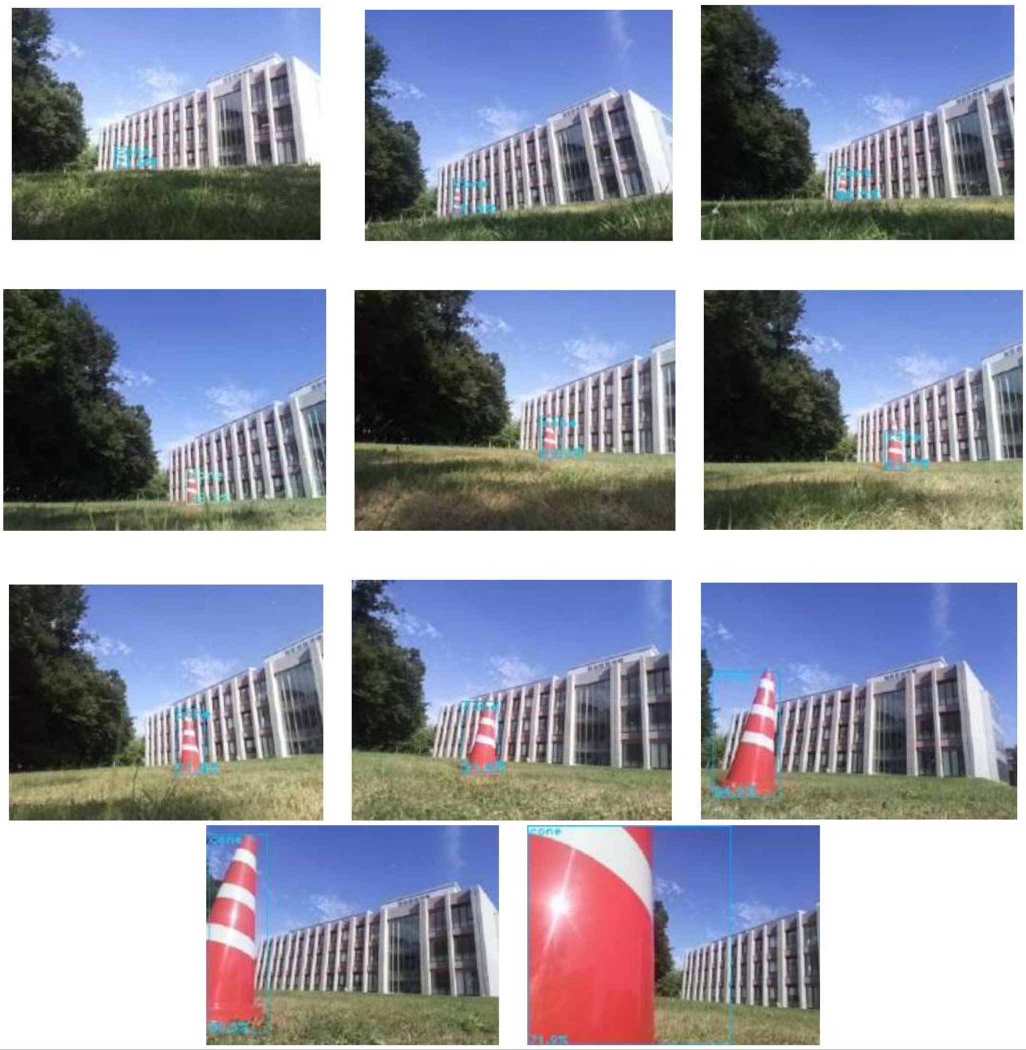
An example of actual annotation is shown in Fig.14-1.

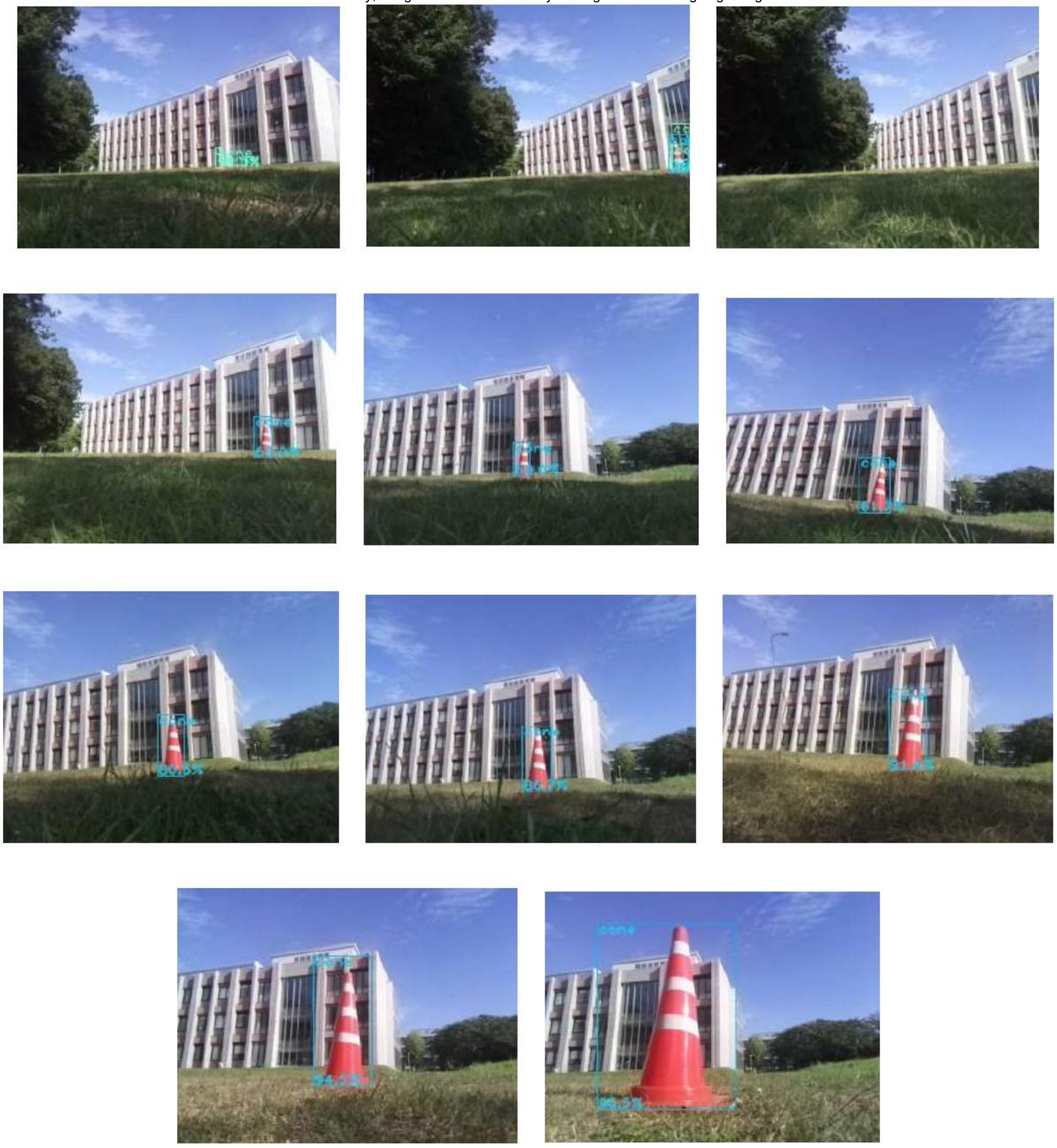
Fig.14-1 Annotations example

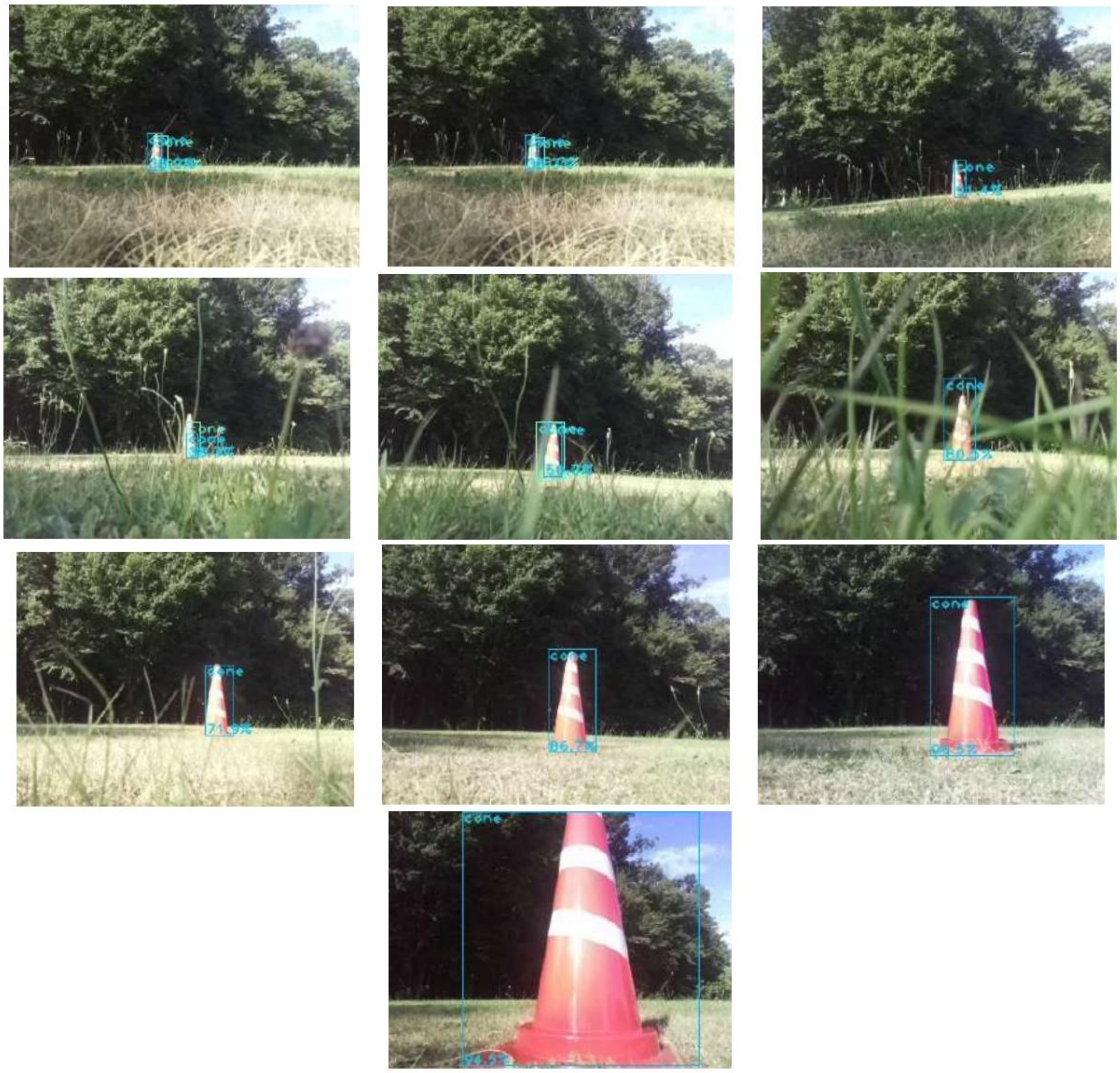
• Results

Table 10 shows the results of the goal detection test. In the image log, when a goal is discovered using Object Detection, it is shown as an image in a light blue rectangular frame. The images show the recognized log images up to the 0m goal from top to bottom and from left to right.

Table 10 Goal detection test results

Number of experiments	0m goal	Actual photos & details	movie URL
1st time	•	Turn twice to find the goal  After discovery, go straight and turn 11 times to determine the goal 	https://youtu.be/ZBeBAcegj2g
2nd time	•	Turn twice to find the goal	

<table>
<tr><td rowspan="2"></td><td rowspan="2"></td><td></td><td rowspan="2">https://youtu.be/MLe-Vh_op34</td></tr>
<tr><td>After discovery, the goal was determined by turning 11 times and going straight.
</td></tr>
</table>

3rd time •		After discovery, the goal is determined by turning 10 times and going straight. 	https://youtu.be/y-N-4gqOk7c

In addition, the URL that summarizes the images and control logs is shown below. In the control log, you can check the recognition rate (Score) of the recognition result by Object Detection and the control status (distance) of the distance to the goal indicated by 4-0 in the text log. (Control status 4: Longest distance, 3: Longest distance, 2: Shortest distance, 1: Shortest distance, 0: Goal judgment distance)

ÿ Goal detection test image log, control log: https://drive.google.com/drive/folders/1jSap_Q-lAs683BYEWPg5Tb6G30LakVej?usp=sharing

• We confirmed that the 0m goal in Deep Learning in the study mission could be achieved without any problems.

v15. Driving state estimation test • Confirm

that the

driving state can be estimated, which is the objective mission.

• Test details : The

vehicle was driven alternately on flat ground and on ground with large grass, and the running conditions were visually checked to see if the steering parameters had changed.After the test, the appropriate changes were recorded in the log after the experiment. I checked to see if it was correct.

• Results

[FFT data of driving vibration state] In

order to estimate the driving state of the mission and perform control appropriate to that state, FFT image data is generated from the x, y, and z values of each acceleration data during driving, and the image data is Through machine learning, the vehicle estimates the driving condition and performs control appropriate to that driving condition.

FFT data was generated for ACTS2020 when it was running on the ground and when it was stuck. The FFT data for 10 seconds during the Noshiro space event ground run is shown in Fig. 15-1, and the FFT data for 10 seconds in the stuck state is shown in Fig. 15-2. Each driving condition is represented by a different color.

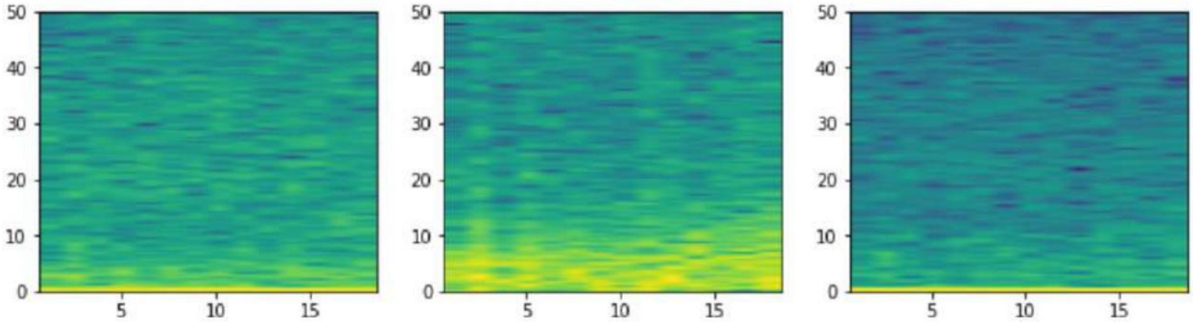


Fig.15-1 FFT data of acceleration x, y, z while driving with GPS at ACTS2020 (10s)

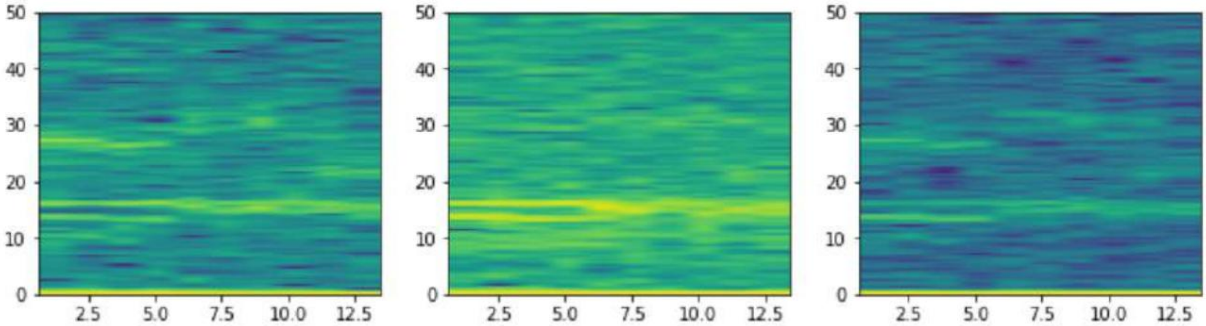


Fig.15-2 FFT data of acceleration x, y, z in a stuck state at ACTS2020 (10s)

In addition, we have completed a real-time FFT image generation system that will be used in actual production.

Describe the details. ACTS2021 The size of the second acceleration data x,y,z! # + # + #to

We performed an FFT simulation. The flow of the competition is measured by measuring the acceleration when being lifted by the balloon, when falling, when making a parachute release motion, when running, and when judging the goal. It was confirmed that the difference in FFT was largely reflected in the images.

Fig.15-3 is an FFT image of the balloon rising. In this image, the vertical axis shows the magnitude of the acceleration frequency component from 0 to 50 Hz, and the horizontal axis shows the number of seconds. Sampling is approximately 100Hz, and on the far left of the bottom frame is the time [1/100s], on the right is the date and time, and on the right is the distance to the goal and the distance traveled in 1s [m]. , and the control sequence is written to the right. The FFT image expresses the strength of the frequency component using color, and the H component of HSV is displayed by the magnitude of the frequency component, with blue at 0 and red at maximum. For example, when CanSat is completely stopped, the color is blue, and when there is a large acceleration such as a landing impact, the color becomes red. The intermediate color is green, and it becomes green when driving. The text information below is the information for the 0s point. Also, although the seconds range from 0 to 19, the numbers on the horizontal axis represent the FFT results for the time after 0s. For example, the horizontal axis 5s displays the FFT results after 5s. It can be seen that when the balloon is rising, approximately 10Hz is displayed in green.

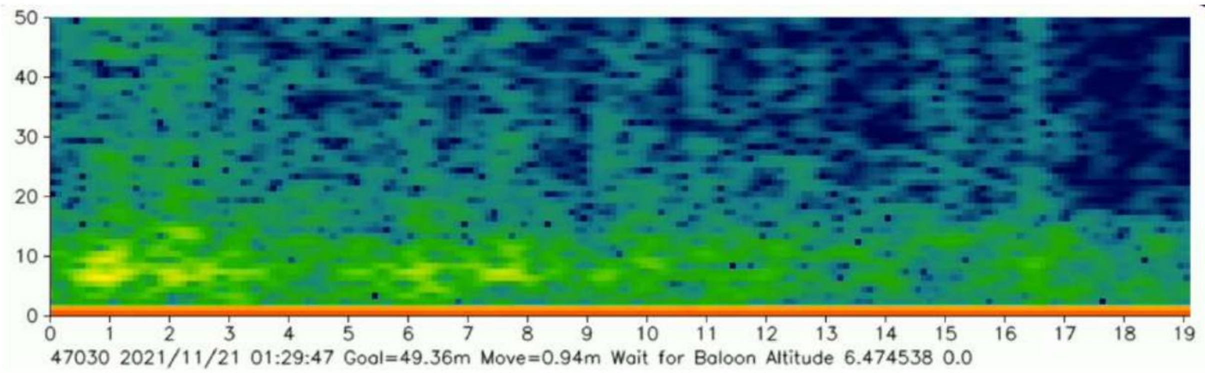


Fig.15-3 ÿ Wait for Balloon Altitude_In the video 8s

In addition, the FFT image at the time of landing impact is shown in Fig.15-4. It can be seen that red is displayed from about 0 to 40Hz at 12s on the horizontal axis, and then it becomes blue because it has landed and is stationary.

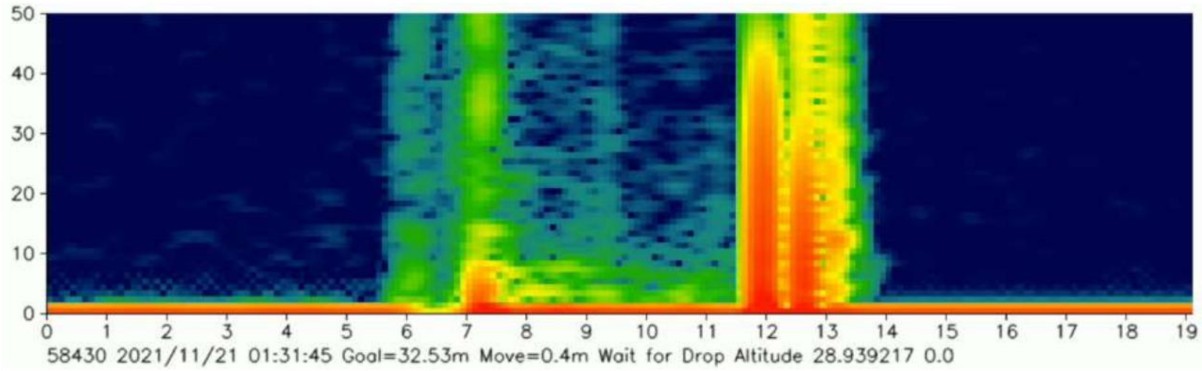


Fig.15-4 ÿAt landing impact_Wait for Drop Altitude_Video 56s

Figure 15-5 shows the FFT image during parachute separation. It can be seen at point 9s in the image that the CanSat separated from the parachute case and moved slightly from its stationary state after landing.

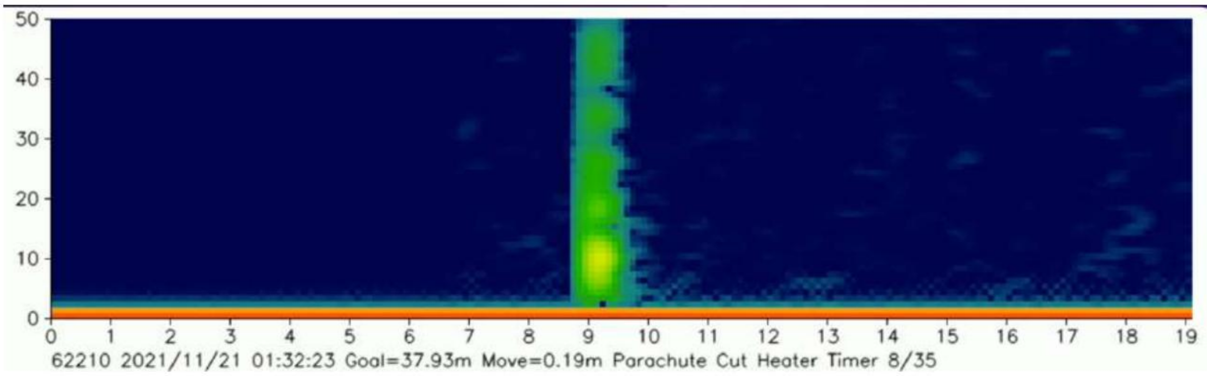


Fig.15-5 ÿ During parachute separation operation_Parachute Cut Heater Timer_In the video 1m12s

Fig.15-6 shows the FFT image at the start of running. It can be seen that after the parachute is separated, the vehicle starts running from a stationary state at the 5s point in the image, and the 0-50Hz range is green overall.

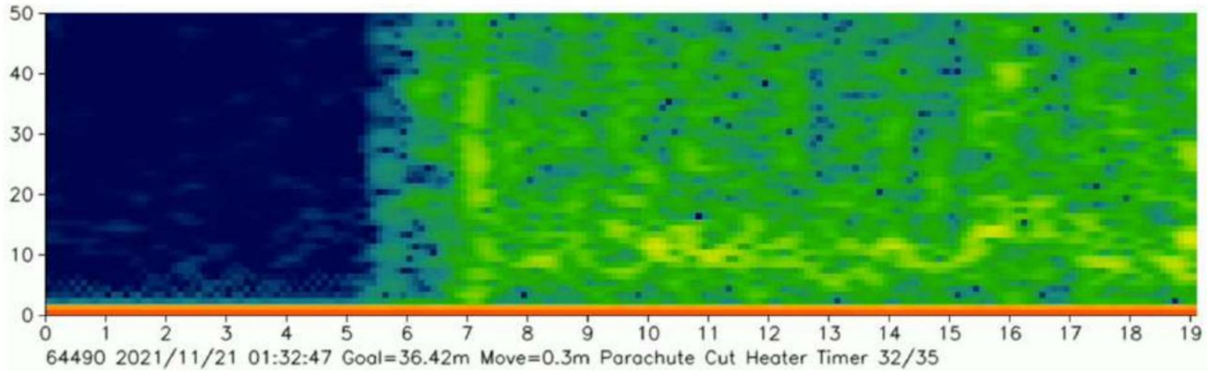


Fig.15-6 ÿ At the start of driving_Rover Drive Start_in the video 1m21s

Fig.15-7 shows the FFT image during goal judgment. It can be confirmed from point 4s on the horizontal axis that the CanSat is stationary at the end of the run and the goal judgment.

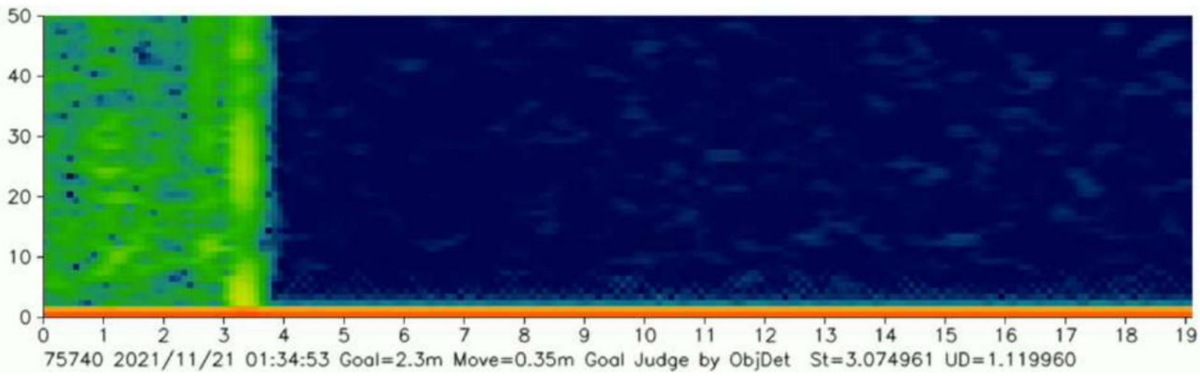


Fig.15-7 ÿGoal Judge by Object_Video 2m8s

In this way, it was confirmed that the images were completely different during each control sequence. Collect data while driving and use it for deep learning image recognition.

Travel estimation is performed using

We also compiled real-time FFT images from ACTS2021 into a video.

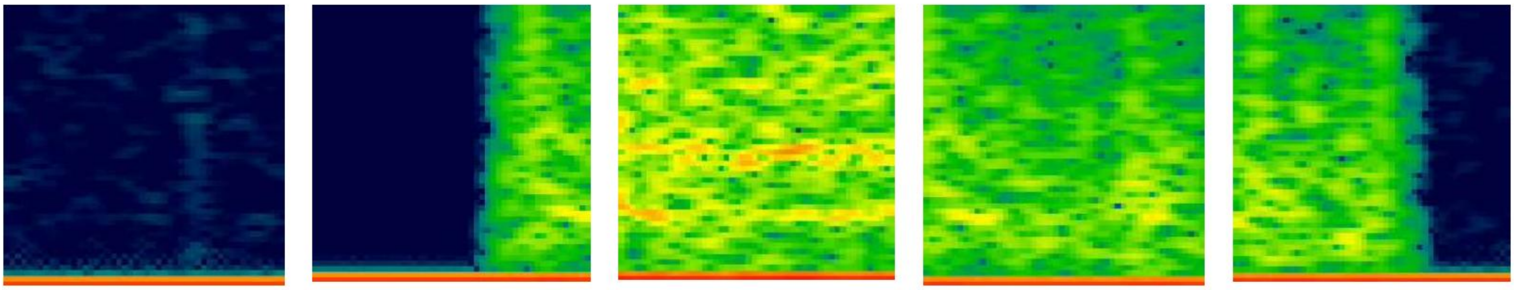
•ACTS2021FFT Video URL: https://youtu.be/M2HXDaGmhr4

[Driving test]

The driving conditions in the FFT image are classified into 5 patterns. The five classifications are shown in ÿ-ÿ below.

ÿ A state in which the FFT image in which CanSat is completely stopped is bright blue is determined to be halt.
ÿ When CanSat starts running, when the FFT image changes from bright blue to the FFT image of the running state,
It is judged as start of running.
ÿ When CanSat is running on hard, flat ground, it is judged as hard. ÿ When CanSat is running on uneven ground with grass, it is determined to be grass. ÿ When CanSat stops moving and changes from the FFT image of the running state to the deep blue image of the stopped state,
It is judged as stop running.

An example of the driving state of an actual FFT image is shown in Fig.15-8.



ÿ halt (when stopped) ÿ start of running ÿ hard (flat ground) ÿ grass (uneven grassland) ÿ stop running

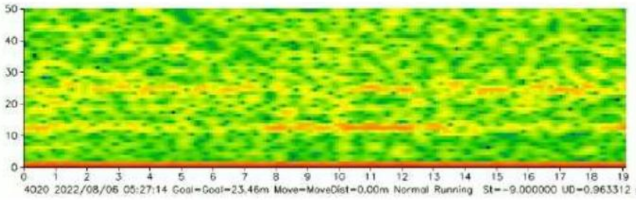
Fig.15-8 Example of FFT image of vibration in each state

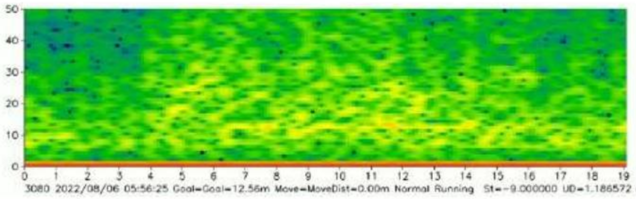
By classifying FFT images of running conditions, CanSat is classified as “hard” when actually running on flat ground.
We conducted a driving test to see if it could be detected as ``grass'' on uneven grassland.
We also conducted a running test to confirm whether the vehicle was judged as "halt," "start of running," or "stop running" when stopping, starting running, or stopping running.

Table 15 shows the judgment results for the running condition.

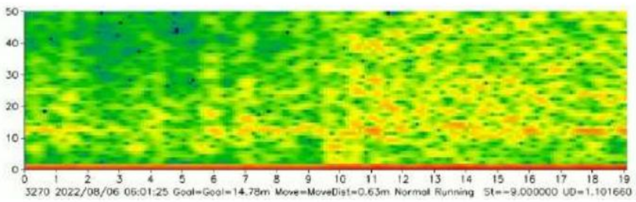
Machine Translated by Google

Table 15 Driving state estimation test results

<table>
<tr><th>times
number</th><th>judgment
fixed</th><th>ground condition</th><th>result details</th><th>Video URL</th></tr>
<tr><td>1
times
eye</td><td>•</td><td>flat ground (hard)
</td><td>Determined flat ground (hard) (actual
FFT image)
</td><td>ÿ Driving test video
https://youtu.
be/ZlBfezloHBs

ÿ FFT image
https://youtu.b
e/H1FxHRHDZrE</td></tr>
<tr><td>2
times
eye</td><td>ÿ</td><td>Grass ground (glass)
</td><td>Grass ground (grass) determined (actual
FFT image)
</td><td>ÿ Driving test video
https://youtu.
be/Fgpxu5hlvo8

ÿ FFT image
https://youtu.
be/YKXuVpJRw2U</td></tr>
<tr><td>3
times
eye</td><td>ÿ</td><td>Grassland ground(glass)&

flat ground (hard)
</td><td>Grass ground (grass) & flat ground (hard) determined
(actual FFT image)
Grass ÿ hard switches at 9-10 in the center of the horizontal axis in the figure.
</td><td>ÿDriving test video
https://youtu.
be/_D17GAHibtQ

ÿ FFT image
https://youtu.
be/ESJMHUW_GvE</td></tr>
</table>

• Consideration

Generate FFT data and use machine learning of FFT data to estimate driving conditions based on differences in images.

We confirmed that it can be set.

Chapter 7 Gantt chart (process control)

Overall, holidays and Saturdays and Sundays are treated as holidays, and the schedule is designed to be about twice as long as it would normally take. Since there are not multiple members, there are no exam schedules for each subject, and because it is a graduate school. New function idea, prototype creation and testing in May, mission & End to End related tests in June, End to End and mission related examination in July, NSE participation and recovery in August, and September Perform ARLISS preparation and recovery. The Gantt chart is shown in Fig.7.

ÿMayÿ

In May, we will devise new mission functions for CanSat, create prototypes, test and improve them. Weeks 1 and 2 will be used to devise new functions to be

installed on CanSat and conduct preliminary research. Weeks 3 and 4 will be about on-board parts. We received orders for materials and materials, and began developing mission functions. Starting from the 5th week, we will build a CanSat prototype model, test it, and make improvements.

ÿJuneÿ

In June, the CanSat prototype stage tests will be completed, and all tests other than mission and end-to-end related tests will be completed.In the first and second weeks, the CanSat prototype model will be manufactured, tested, and improved. The 3rd week is a mass test, carrier stowage test, and landing impact test (2 tests each for 1 week) The 4th week is a parachute drop test and opening impact test The 5th week is a quasi-static load test and separation impact test (NSE preliminary examination submission)

[July] All

tests will be completed in July and the final examination will be submitted. (2 tests for 1 week each) In the first week, the separation impact test was continued. The second week was a mission goal detection test and driving performance confirmation test. (Submit ARLISS preliminary examination report) In the third week, vibration tests, End to End, and control history tests will be conducted. In the fourth week, we will create the NSE actual aircraft and circuit. (Submitted for NSE main examination)

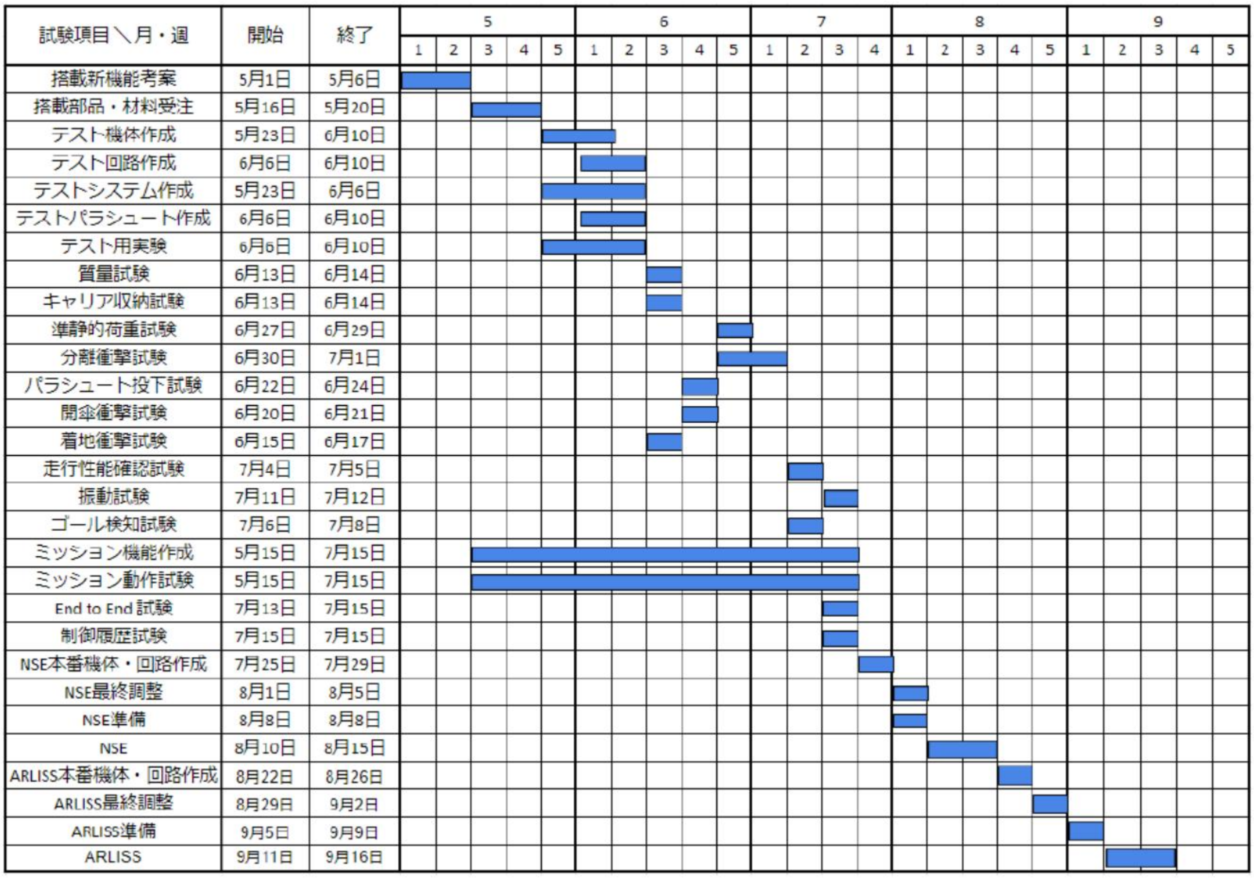
[August]

In August, we will make final adjustments to End-to-End and the actual production, leaving enough time in the schedule to enable overall recovery.

Ru

Week 1 NSE Final adjustments and preparations. (Submit ARLISS main review form) Participate in the Noshiro Space Event in the 2nd-3rd week and perform End to End. In the fourth week, based on the results of the NSE test, a CanSat for production use and a spare will be manufactured. In the 5th week, students will recover for the exam and make final adjustments and preparations for ARLISS.

[September] In September, final adjustments and preparations will be made for ARLISS.The 1st and 2nd weeks will be spent making final adjustments and preparations for ARLISS. Participate in ARLISS from the 3rd week.



試験項目＼月・週	開始	終了
搭載新機能考案	5月1日	5月6日
搭載部品・材料受注	5月16日	5月20日
テスト機体作成	5月23日	6月10日
テスト回路作成	6月6日	6月10日
テストシステム作成	5月23日	6月6日
テストパラシュート作成	6月6日	6月10日
テスト用実験	6月6日	6月10日
質量試験	6月13日	6月14日
キャリア収納試験	6月13日	6月14日
準静的荷重試験	6月27日	6月29日
分離衝撃試験	6月30日	7月1日
パラシュート投下試験	6月22日	6月24日
開傘衝撃試験	6月20日	6月21日
着地衝撃試験	6月15日	6月17日
走行性能確認試験	7月4日	7月5日
振動試験	7月11日	7月12日
ゴール検知試験	7月6日	7月8日
ミッション機能作成	5月15日	7月15日
ミッション動作試験	5月15日	7月15日
End to End 試験	7月13日	7月15日
制御履歴試験	7月15日	7月15日
NSE本番機体・回路作成	7月25日	7月29日
NSE最終調整	8月1日	8月5日
NSE準備	8月8日	8月8日
NSE	8月10日	8月15日
ARLISS本番機体・回路作成	8月22日	8月26日
ARLISS最終調整	8月29日	9月2日
ARLISS準備	9月5日	9月9日
ARLISS	9月11日	9月16日

Fig.7 Gantt chart

Also, the spreadsheet of the Gantt chart is shown below.

Gantt chart spreadsheet https://docs.google.com/spreadsheets/d/1WlLsO7sXlhtfopsxtKhZwL3XZM_a291au392DwweIrU/edit?usp=sharing

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

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

•If you do not want to participate in the comeback competition, please delete M3 and M4.

1.Safety standards review

request number	Self-examination items	Self-examination results	Comments from the responsible teacher (if there are any noteworthy items)
	ARLISS2022 Safety Standards		
S1	The mass of the aircraft to be dropped meets the standardsÿ		
S2	volume meets carrier standards	ÿ	
S3	Tests have confirmed that the quasi-static loads during launch do not impair the functionality required to meet safety standards.	ÿ	
S4	Tests have confirmed that the vibration load during launch does not impair the functionality required to meet safety standards.	ÿ	
	Tests have confirmed that the functions required to meet safety standards are not impaired by the shock load during S5 rocket separation (when the parachute is deployed).	ÿ	
S6	Has a deceleration mechanism to prevent it from falling at dangerous speeds near the ground, and its performance has been confirmed through testing.	ÿ	
	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.)	ÿ	
S8	It has been confirmed that it is possible to comply with the regulations for turning off the power of radio equipment at the time of launch (devices that are FCC certified and have a power output of 100mW or less do not need to be turned off. Also, when using a smartphone, it has been confirmed that it is possible to comply with the regulations for turning off the power of radio equipment at the time of launch. (Can be turned off with switch)	ÿ	

S9	Willing to adjust radio channel, We have also confirmed that adjustments can actually be made.	ÿ	
	We have been able to conduct an end-to-end test that simulates loading the S10 rocket, starting the mission, and recovering it after launch, and there will be no major design changes in the future.	ÿ	
	If you wish to participate in the Comeback Competition, please be sure to meet the following requirements:		
	It has been confirmed that autonomous control without human intervention is carried out during M3 missions.	ÿ	
	After the M4 mission, it will be possible to submit the specified control history report to the management and examiners and explain the logs and acquired data.	ÿ	

1.Responsible teacher's impressions

This time, we are taking on a new mission: performing FFT on vibration acceleration data, generating image data, and using it to estimate the state of CanSat using deep learning image recognition. Currently, we have succeeded in estimating five types of states, and we plan to add more states in the future, and have obtained interesting results. I would appreciate it if you could give me permission to participate.

Chapter 9 Tournament Results Report

(i) Purpose

The CanSat learns the 3-axis acceleration of vibrations while running, uses machine learning to estimate whether the ground is flat or uneven, and uses Object Detection to recognize the goal in real time and aim for the 0m goal.

(ii) Results

[First launch result]

ÿ4.5km Run from the drop point to the goal, 20cm goal Figure 9-1 shows a photo of the first launch result.

Fig.9-1 1st result

During the first launch, the aircraft withstood the impact of launch, rocket separation, and fall, and fell 4.5 km from the goal. After parachuting, we drove for about 2 and a half hours to the goal using GPS location information. While driving, ARLISS has various types of ground, including flat areas and smooth, soft areas, and the mission was able to successfully estimate the driving condition using FFT images at each point in determining the driving surface. The first running trajectory is shown in Fig.9-2.

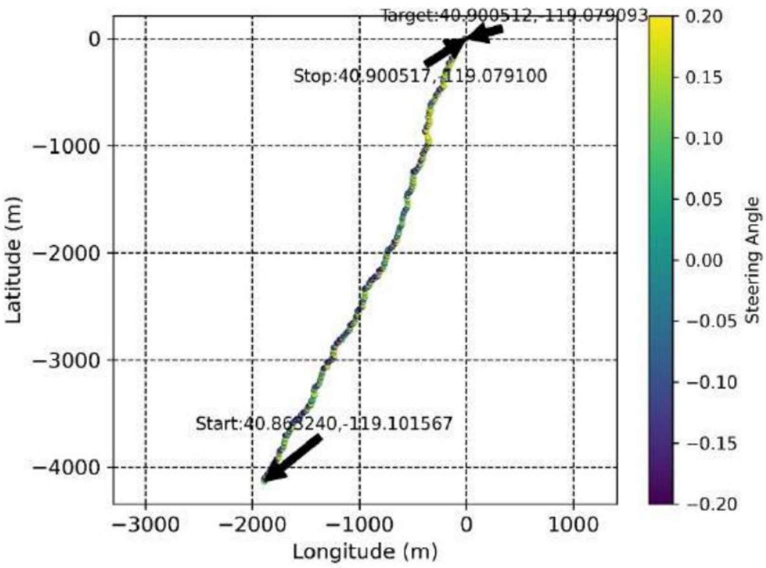


Fig.9-2 First run trajectory

Near the goal, we performed 0m goal guidance control using Object Detection, and at the goal at 20cm. It stopped. In the experiment, the size of the judgment image was controlled to stop after 3 times, but as the aircraft often collided with the goal and overturned, the control was changed to 2 times just before launch, which resulted in the image being smaller than the target. The train stopped 20cm short of the stop. The GIF image log from actual Object Detection is shown in Fig.9-3.

Fig.9-3 Image log in Object Detection

In addition, the motor battery consumes more than half of its capacity, and the computer battery is almost empty. Therefore, it will be necessary to expand the capacity of computer power supplies in the future.

[Second launch results]

ÿThe aircraft was deformed by the rocket impact, and one wheel did not move, making it impossible to drive.

Figure 9-4 shows a photo of the second result.

Fig.9-4 Second launch result

During the second launch, the communication from IM920's radio waves became garbled during the fall after separation from the rocket. After the CanSat landed and separated from the parachute, one wheel did not move and rotated, making it inoperable. When we

checked after the competition, we found that one of the motor mounting parts was deformed in the same way as when it was free falling, indicating that the motor had malfunctioned due to the large impact. The characters on IM920 were garbled, the parachute was burnt, and the CanSat was released at an altitude of 2000m, suggesting that it may have malfunctioned due to some sort of rocket impact. In the future, it will be necessary to design the aircraft to be stronger than the specified impact. Fig.9-5 shows a photograph of an actual scorched parachute.

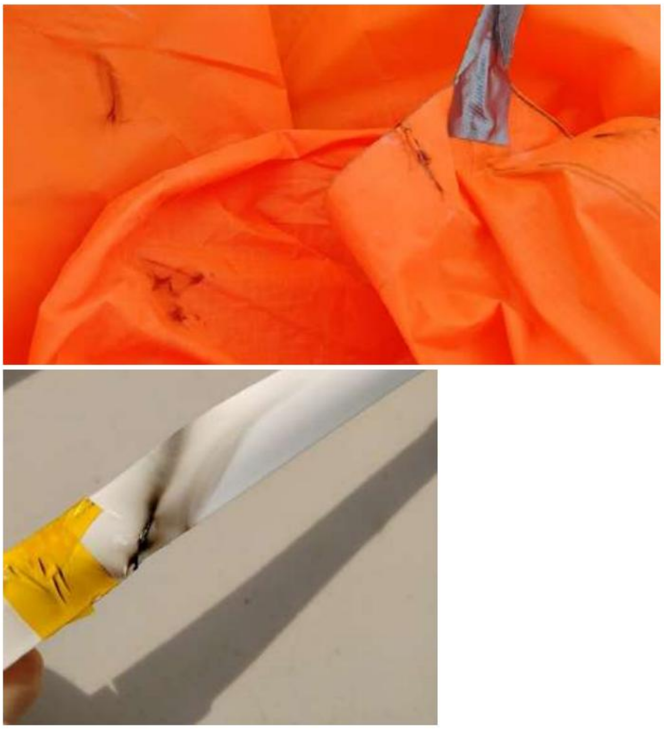


Fig.9-5 Burnt parachute

[Third launch results]

ÿ3.5km Driving from the fall point to the goal, but the camera did not function and the goal was not judged.

Since the third launch was an unrecorded launch, a video recording function was added to the launch. went. However, in the end, the camera did not function properly with this video recording function, making it

impossible to reach the goal. After separating from the rocket, the CanSat touched down 3.5 km from the goal and traveled for approximately 2 hours to within a few meters of the goal using GPS positioning information. After shooting a video, a bug in the program prevented the camera from taking images, making it impossible to reach the goal. The traveling trajectory is shown in Fig.9-6.

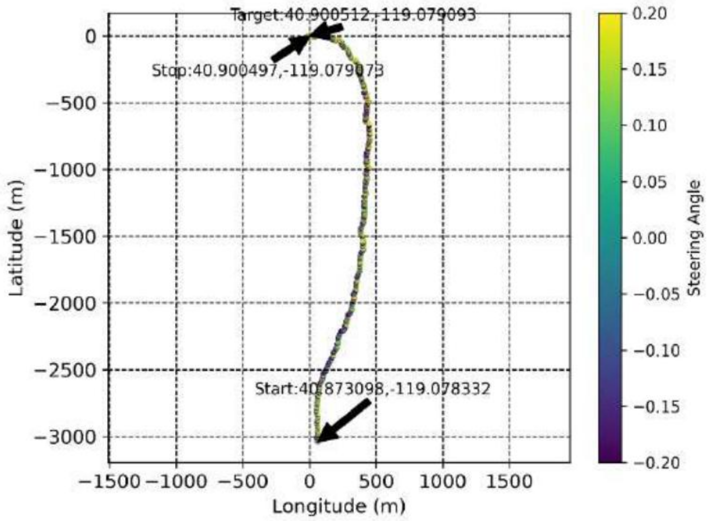


Fig.9-6 Third running trajectory

Although we used Raspberry pi Zero 2 this time, we have changed the system considering the operation with conventional Raspberry Pi Zero. The system was set not to perform parallel processing of Object Detection and video shooting. Since the load is heavy during Object Detection operation, we set it not to record video. In addition, the setting was such that object detection was not performed when the video recording flag was set. If the video recording flag was set for both, video recording and object detection processing were not performed. Figure 9-7 shows a photo of the train circling around the goal because it was not possible to take a photo near the goal.

Fig.9-7 3rd result

Additionally, in the third experiment, we conducted an experiment to see if it was possible to determine the CanSat's status using FFT images, in addition to determining the flight of the mission, the impact of the rocket and the impact upon landing. We detected types of impacts ÿ-ÿ in FFT images and succeeded in image classification using deep learning. A GIF image of the judgment result based on the actual FFT image is shown in Fig.9-8.

ÿ Rocket Launch ÿ Rocket Rising ÿ Release
from Rocket ÿ Descending with Parachute ÿ
Landing ÿ Open Cover (Parachute separation)
Parachute separation) ÿ Start of Running ÿ Running
ARLISS (ARLISS
running ground)

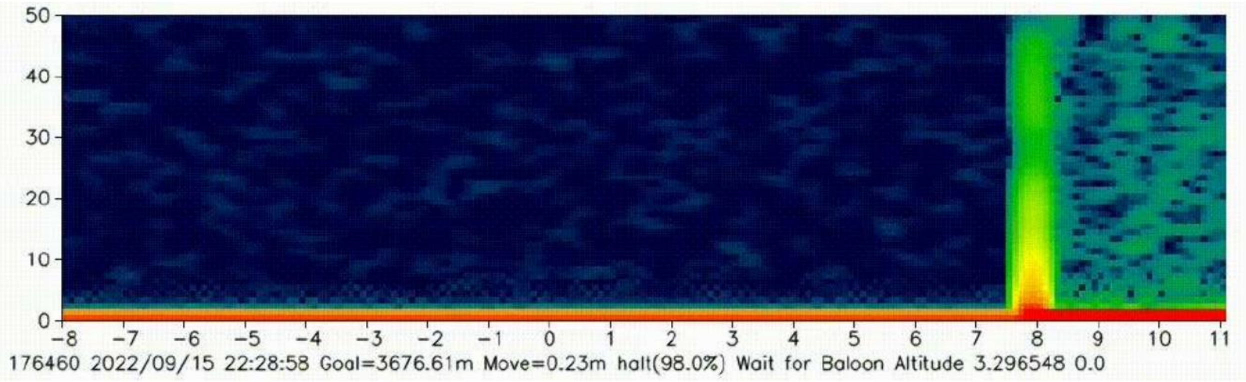


Fig.9-8 Impact of the entire 3rd ARLISS competition during launch Deep Learning classification results using FFT images

(iii) Discussion

[Success Criteria]

Minimum success is running at least 10m and reaching the goal on the first and third launches.
We were able to achieve this.

Middle success performed guidance control until 0m after starting Object Detection on the first launch.
However, it stopped at a point 20 cm from the front, so it was not completely achieved, but it was partially achieved.

Full Success succeeded in determining the ground condition on the first and third attempts, and on the third attempt, the rocket
We succeeded in determining the impact. However, the 0m goal was not achieved in the first and third attempts.
Therefore, this was partially achieved.

Advanced Success is the content of Full Success with stack judgment added, but this year's ARLISS
In this case, the ground was flat and there were no ruts that caused stacks, so it was partially achieved.
became.

minimum success	After the CanSat was released and fell, it landed without damage, separated from the parachute, and It travels over 10m by controlling the motor rotation speed based on position information.	ÿ
Middle success	After CanSat reaches near the goal, Object Detection reaches the goal 0m	ÿ 0.2m
full success	When CanSat travels on the ground, it determines whether the ground is flat or uneven and changes the state accordingly. Control the speed and steering wheel accordingly, and use Object Detection to detect the 0m goal. To do so.	ÿ 0.2m
advanced success	When CanSat travels on the ground, it determines whether it is flat, uneven, or stuck. Then, it performs travel control according to the situation, and uses Object Detection to detect the 0m goal. file.	ÿ 0.2m

[Cause analysis]

ÿ First launch Stop at 20cm point

In the first attempt, CanSat stopped at a point 20cm before reaching the 0m goal. In the pre-adjustment, the CanSat overturned when it collided with the goal and was unable to complete the 0m goal, so just before launch, the goal judgment conditions were changed from a control that uses Object Detection to stop the goal distance three times the size of the goal. I changed the settings so that it stops after two attempts. Additionally, the tire width was narrowed so that it would return to its original state even if it rolled over, making it more likely to roll over when it collided with the goal. In addition, the motor battery capacity was greatly reduced by traveling from 4.5 km, and because the speed was previously set to a slow speed that reliably guided the vehicle, there was insufficient power at the slow speed and the vehicle could not travel as far as before. It stopped.

Changes in goal judgment settings at the last minute, design of tires that are prone to overturning, and low battery power for motors. Due to the change in running distance, the train stopped short of the 0m goal.

In the future, we will completely review the goal determination control to make it more reliable to stop at 0m, review the design of tires that are prone to rollover, and improve the ability to take into account the motor battery to prevent the running speed from becoming too slow. There is a need to continue to.

ÿ Second launch Aircraft failure due to rocket impact

The second time, the motor connection part of the aircraft failed, but the rocket impact may have been stronger than expected, as the parachute was scorched and the IM920 radio was garbled when it fell. Considering that the impact is greater than expected, it is necessary to design an aircraft that can withstand impacts greater than the recommended test values.

ÿ 3rd launch Camera malfunction due to video recording

The third time, as a result of adding video recording to the system, the camera malfunctioned and the object Detection is no longer possible and goals cannot be achieved. The settings that will be incorporated into the actual production must be tested in advance, and it is important to avoid last-minute changes to the specifications as much as possible. Also, starting next year, it will be necessary to list in advance the changes to the specifications that will be made for data acquisition, and to conduct tests to ensure that they will work properly.

ÿ Management aspect

From a management perspective, it was necessary to have some leeway in the schedule. Regarding the schedule, multiple schedules were added after the Gantt chart was created, making it difficult to develop according to the planned schedule. In order to be able to develop with sufficient time even if other plans are added in the future, it is necessary to make the initial response earlier and provide a longer recovery period.

In addition, due to the current shortage of semiconductors, it has become difficult to obtain parts. It is necessary to consider the design of small parts.

Also, since the itinerary schedule was too busy, we decided to participate on a schedule such as arriving the day before. It is necessary.

Chapter 10 Summary

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

[Hardware]

Improvements were made mainly to the chassis, tires, and stabilizer. The chassis was conventionally made using PETG resin from a 3D printer, but it broke when subjected to impact during experiments, so we created the chassis, which is the mounting part for the motor, using a 3 mm polycarbonate plate. A new modeling machine, monoFab SRM-20, was introduced and the policy was created by cutting. The structure of

the tire has been changed from the conventional arc shape to a vertical angle, which provides more grip when driving on hard sand in the desert, and when stuck in a rut, the grip part bites into the corner of the sand, making it easier to break away. In addition, in order to prevent the aircraft from rotating sideways and becoming unable to travel in the event of a rollover, we designed the sides of the tires at an angle, and installed anti-rollover parts on the wheels to prevent the center from becoming flat.

In addition, the stabilizer uses a polycarbonate plate that uses a spring to fold up when the carrier is stored, but since it cannot be stored at a certain length, the block parts are lined up and have a structure that only becomes straight when traveling. It was designed to be foldable when stored. The actual CanSat aircraft is shown in Fig.10-1.

Fig.10-1 CanSat aircraft

ÿsoftÿ

As a novel mission, we determined the state of CanSat using its vibrations. The acceleration data was converted into an FFT image, and the driving condition was determined using deep learning image classification. We classified two patterns of driving ground: hard, flat ground and uneven, soft ground such as grass, but we conducted trial and error to find out which kind of ground would bring out the characteristics of the driving condition by comparing various factors such as color changes. We discovered the difference in the running conditions of these two patterns. For images in which the color changes for each frequency component of the FFT image, the FFT image changes greatly depending on the color change method and the range of samples, but in the end Using deep learning, we succeeded in determining the driving road surface within the range where image classification can be performed with high accuracy. In addition, since vibration changes greatly depending on driving speed and tire shape, we learned from various patterns to improve accuracy.

In addition, acceleration data, gyro data, x, y, and z directions are each converted into three FFT images or We conducted tests under various conditions to determine which method yields the highest accuracy for image classification using FFT images, depending on whether FFT images are created using one size.

ÿmanagementÿ

This year, the group carried out development and experiments between Kanagawa and Chiba prefectures, and carefully planned the preparation of parts and aircraft according to the experiment date and location. We calculated backwards when it would be needed and started developing and experimenting as early as possible. Additionally, due to the coronavirus pandemic when entering and leaving the United States, we carefully researched border

measures. Also, this year, there were many sudden additions to various plans other than the Gantt chart, but The end date was set and executed so that the necessary work would be completed as early as possible than scheduled.

(ii) Issues

ÿ Improved goal judgment control

A comprehensive review of the control that stopped at the 20cm point instead of the 0m goal during the first ARLISS launch. We will review and design a new mechanism for goal determination.

ÿ Strengthen aircraft design

Since the aircraft broke down during the second ARLISS launch, the structure was designed to be more resistant to impact.

ÿ Improvement of camera malfunction

On the third ARLISS launch, we were unable to determine the goal due to camera malfunction, so we will first modify the program and review it to see if there are any other bugs. Also, test all operations that may be performed during the actual performance, such as video shooting, to ensure that settings will not be changed during the actual performance.

ÿ Leave some time in your schedule Take into

account that even if you make a plan, other plans may come in, so finish the plan as early as possible. Schedule accordingly.

(iii) Future outlook

(ii) Make improvements to the items that need to be addressed. From CanSat vibration (acceleration data) during the mission In the image classification of the running ground using FFT images, we were able to determine the running ground and the condition even in vibrations such as rocket impact, so we incorporated the overall FFT image judgment, including parachute separation operations, into the control. Conduct a mission to see if you can perform reliable CanSat control.