ARLISS2022 development review report

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Judging comments	
Other words	

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CanSat class	Open class

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Chapter 1 Mission Statement

ARLISS is a harsh environment not seen anywhere else in Japan. We will create an aircraft that will reliably reach the goal in the ever-changing desert environment. Furthermore, when conducting an exploration using an unmanned vehicle in an area where human traffic is difficult, movement speed is a major factor in expanding the exploration range. On the other hand, in the desert, there are many factors such as car ruts and grass that can cause the CanSat to move in an unintended direction, and the faster the CanSat's speed, the greater the effect. This team aims to achieve the goal of traveling at high speed from the landing site in the shortest possible time, regardless of the actual production environment, by using high running performance through four-wheel drive, a sturdy aircraft, and a flexible program that adapts to the environment. In addition, a map of the driving section is created by logging sensor data while driving and combining it with the coordinates obtained from GPS.

The following factors can be considered as environmental factors in ARLISS.•Temperature: The temperature changes drastically throughout the day, from low temperatures in the morning to high temperatures in the afternoon. •Wind: CanSat is carried away by strong winds in the sky. •Atmospheric pressure: Due to the above effects, the atmospheric pressure may differ between the launch and landing points.•Rain Although it is a desert, it sometimes rains. Also, in that case, the ground becomes like mud.•Dust Dust is expected to occur due to the dry air and desert environment. In addition, charging is thought to affect electrical components such as circuit boards.

In addition, the following factors can be considered to make the level of difficulty higher when compared to domestic competitions.•Vibrations and shocks caused by rocket launches •Descent from high altitudes •Long-distance driving of several kilometers •Ground surfaces unsuitable for driving, such as ruts and grass

Regarding the above factors, we will develop an aircraft that takes into consideration the exterior reinforcement of the aircraft, high traversing performance in ruts through four-wheel drive, danger avoidance through programming, and fail-safe features, with the aim of achieving certain goals. Also, this time we will try a new approach: battery management. Power consumption is measured using voltage and current sensors installed inside the aircraft, and power consumption is adjusted based on the remaining battery level and distance to the goal. Even when standby times are long or the CanSat is blown away by the wind and needs to travel long distances, the goal is ensured by optimizing power consumption.

Movement speed is an important factor in conducting wide area exploration in a short period of time. If the movement speed is slow, it is necessary to carefully select the location to be explored from among multiple exploration points without actually going there, but if it is possible to move at high speed, it is necessary to carefully select the location to be explored from among multiple exploration points without actually going there. Conducting preliminary inspections will be of great help in carefully selecting research locations. In fact, for Mars exploration, preliminary surveys are being carried out using high-speed movement using drones, and the use of high-speed movement makes it useful to tour the planned exploration areas in advance. Unlike drones, CanSats that travel on the ground can measure the unevenness of the earth's surface, so we believe that they can provide data that will be useful for constructing routes for large exploration vehicles. It is also possible to drive on planets with no atmosphere.

It is possible. Based on the above, this team's aircraft aims to travel at high speed and reach the goal in the shortest distance. On the other hand, as the cansat travels on the ground at high speed, it is expected that the vibrations applied to the cansat will be large, and straight-line stability during high-speed travel may become an issue. As a solution, we prepared multiple tire shapes and measured the running stability of each to investigate the effect of wheel shape on high-speed running. We believe that it would be possible to map the terrain by patterning the acceleration and angular acceleration sensor values when the CanSat bounces due to the shape of the wheels when traveling in a specific shape in advance. In addition, by using data on acceleration and angular acceleration while driving to appropriately switch between forward and reverse rotation of the motor, we believe that the performance of four-wheel drive will be further improved, making it possible to drive over higher ruts and obstacles. Ta.

Log data while driving. Create a simple map by mapping the data obtained through logging to coordinates. The data to be acquired is as follows.

•GPS coordinates

•Atmospheric

pressure Altitude

•Temperature

Air temperature

•Acceleration

•Angular acceleration Vibration •Geomagnetism Magnetism In addition to data obtained using sensors such as atmospheric pressure and temperature, vibration of the aircraft is determined from acceleration and angular acceleration data obtained by driving on the ground. and evaluate the difficulty of driving on the ground. During actual operation, it will be possible to conduct wide-area exploration by taking advantage of its small size and high speed, and by using multiple units, it will be possible to conduct wide-area exploration in an even shorter time. We also believe that by sharing the driving difficulty level created by the aircraft, it will be possible to optimize the driving route, lowering the risk of getting stuck and making it possible to move faster.

Chapter 2 Success Criteria

Clarify the standards for each element of the comeback category and mission, and monitor the status of achievement.
To make it easier to understand, we have set success criteria for each.

The success criteria for evaluating achievement in the comeback category are set as follows:
do.

minimum success	Separate from parachute and start running
middle success	The aircraft performs controlled flight toward the goal.
full success	The aircraft issues a goal judgment and the aircraft stops.
advanced success	Achieve 0m goal

As an evaluation of the shortest distance traveled, (distance traveled)/(distance from landing point to goal) is directly calculated.
The evaluation value is the progress.

*Distance traveled is calculated using GPS log data.

minimum success	Achieve straightness of 3.0 or less
middle success	Achieve straightness of 2.0 or less (ACTS2021 record)
full success	Achieve straightness of 1.5 or less
advanced success	Achieve straightness of 1.1 or less

Regarding the evaluation of running speed, the value obtained by dividing the running distance by the running time is used as the evaluation value.
Evaluate the time it takes to recover from a stuck situation and the speed of correction to the target course when the course changes.
Ru. Since the driving distance will be longer than last year's ACTS2021, the average
Since it is expected that the speed will improve, ACTS's average speed of 6.92km/h was set as the standard. Evaluation indicators
is the average speed representing the travel time relative to the distance traveled, and the travel time relative to the distance from the separation point to the goal point.
Use absolute average speed to represent time.

minimum success	Achieve an average speed of 6.92km/h or higher (ACTS2021 record)
middle success	Achieve an average speed of 8.54 km/h or higher (ACTS2021 average speed during high speed driving) speed)
full success	Achieve an absolute average speed of 7km/h or more
advanced success	Achieve an absolute average speed of 8km/h or more

In this team's mission, the operation during the first launch is considered to be important as it questions environmental compatibility.

Therefore, the environmental compatibility of the aircraft will be evaluated using the following methods.

The driving distance was set to 500m using Google Lunar XPRIZE.

minimum success	Travel more than 500m after separating the parachute
middle success	Reach a goal during the tournament
full success	Reach the goal on the first launch
advanced success	Reach the goal on the morning of the first day of launch

Set the success criteria for utilizing logged data as follows. You can obtain data to create a travel trajectory.

minimum success	Control reports can also be created GPS log data (around 1Hz) Control log data (left and right motor output, target course, current course) Data logs can be obtained for other onboard sensors Acceleration
middle success	Angular acceleration Air pressure Geomagnetism Voltage, current From acceleration sensors The vibration
full success	data obtained from the aircraft can be used to indicate the severity of the unevenness of the ground.Using a
advanced success	barometric pressure sensor, data from the launch of the rocket to the goal can be plotted in three dimensions.

Chapter 3 Setting requirements

3.1 System requirements (requirements for ensuring safety and regulation)

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

We were able to confirm that the impact load upon landing on S11 did not cause damage to the aircraft or stop its operation. ing	

3.2 Mission requirements

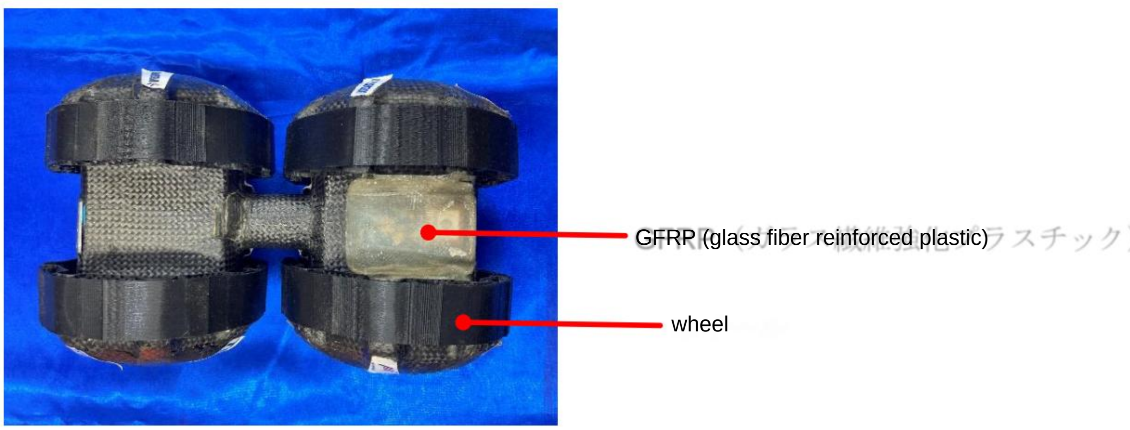
number	Mission requirements
M1	The driving time and driving speed are measured, and the normal driving distance and driving distance can be measured.
M2	The maximum speed of the aircraft on flat ground can be measured.
	This shows that the M3 aircraft has sufficient running performance in the desert.
	If you wish to participate in the Comeback Competition, please be sure to meet the following requirements:
	It has been confirmed that M4 performs autonomous control without human intervention during missions.
	After the M5 mission, submit the specified control history report to the management and examiners for logging and acquisition. It is possible to explain the data obtained.

Chapter 4 System Specifications 4.1

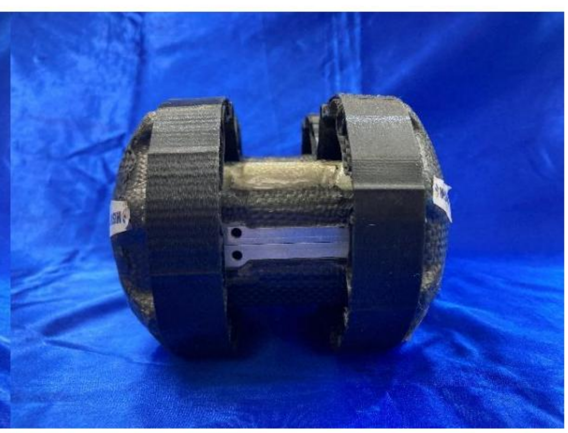
Aircraft Appearance

We developed a four-wheel drive aircraft with wheels that are larger than the body in order to ensure that we can reach the goal without getting stuck on rough desert roads. In order to prevent damage due to impact during launch or landing, it has a stress-stressed shell structure, and uses CFRP (carbon fiber reinforced plastic) for its wheels and body to disperse impact, making it lightweight and high-performance. Achieving strength.

Aircraft isometric drawing



Aircraft top view

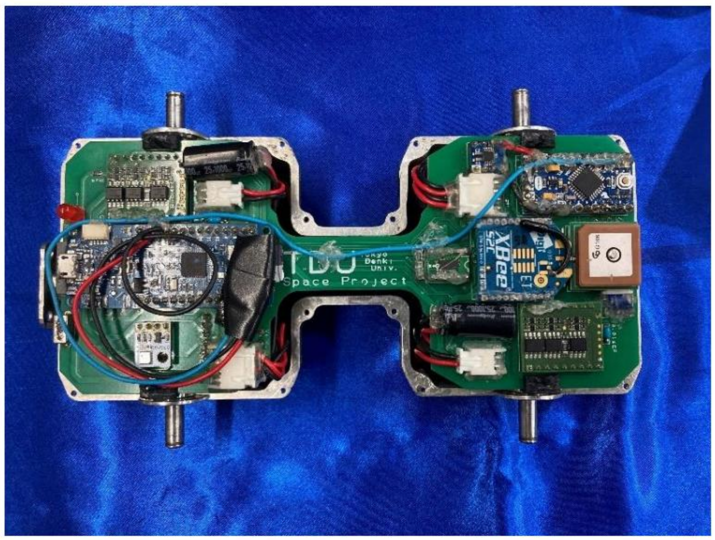


Aircraft side view Aircraft front view

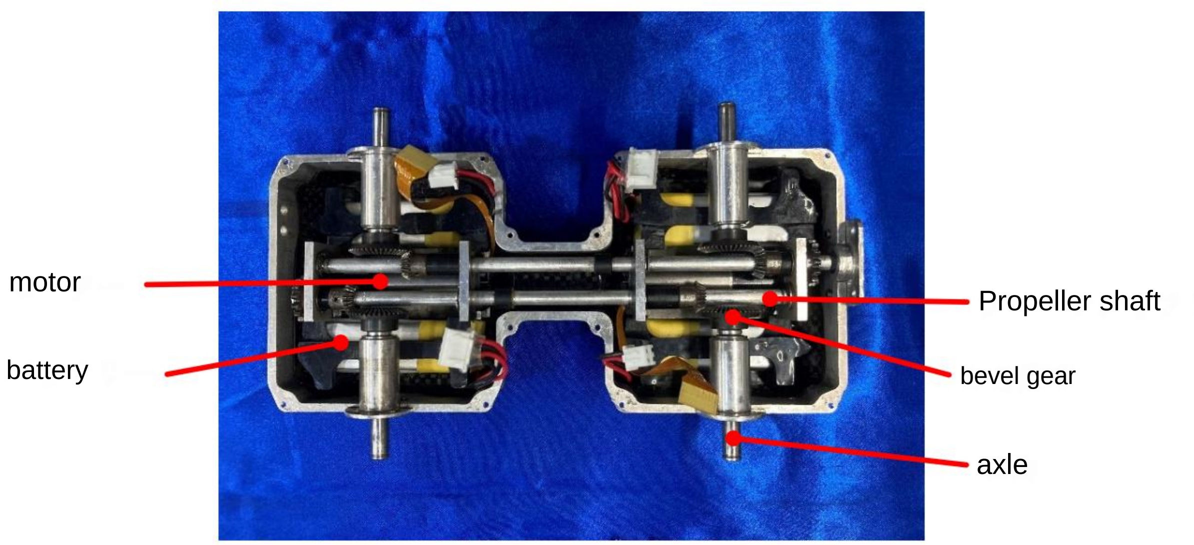
Since CFRP is difficult for radio waves to pass through, GFRP (glass fiber reinforced plastic) is used in areas where communication equipment such as GPS and wireless devices are present.

4.2 Aircraft interior/mechanism

To achieve four-wheel drive, power is transmitted from the motor to the wheels via bevel gears and a propeller shaft. Two motors control each wheel. Turning is performed by changing the rotation speed of the left and right wheels, which eliminates the need for a complex steering mechanism and improves reliability. The control board is fixed to the top of the mechanical parts using a 3D printed bracket. There is no distinction between the upper and lower sides of this machine, and it can run with either side on the top, but better communication can be obtained with the board on the top, so place heavy objects such as the motor and battery opposite the board. By placing it at the bottom of the side, it is configured so that the top and bottom are easily in a normal state.



Board configuration



Drive system configuration

Chapter 5 Test item settings

number	Verification item name	Corresponding self-examination items Request number(s)	Scheduled implementation date
V1	Mass test	S1	7/25
V2	Aircraft storage and release test	S2	7/25
V3	Quasi-static load test	S3	7/23
V4	Vibration test	S4	Under adjustment
V5	separation (parachute deployment) impact test	S5	7/25
V6	drop test	S6	8/1
V7	Lost countermeasure test	S7	7/30
V8	Wireless power ON/OFF test	S8	Survey only
V9	Communication frequency change test	S9	7/30
V10	End-to-end testing	S10	8/1~7
V11	Landing impact test	S11	8/1
V12	Controlled driving test	M4	7/15~24
V13	Control report creation test	M5	7/15~24
V14	Driving time measurement test	M1	7/15
V15	Maximum speed test	M2	7/15
V16	Running performance test	M3	7/15

Chapter 6 Contents of Implementation Test

V1. Mass Test ÿ Purpose

To show

that the mass of the aircraft and parachute satisfies the regulation (1050g) or less.

ÿ Exam content

1. Place the carrier on the electronic balance and reset the value to 0. 2. Place CanSat and parachute inside the carrier and measure. An unedited video showing the process from the start to the end of the

measurement. ÿ Results A video of the test is shown in the link below. https://youtu.be/bCexota0wsI

The mass of the aircraft obtained in the video is shown below.

From the video, the mass of the aircraft and parachute is 1,044g. ÿ

Discussion

According to the results, the mass of the aircraft and parachute is less than the regulation 1050g.

V2. Aircraft storage/release test ÿ Purpose To

demonstrate

that the aircraft and parachute can be stored in a carrier with a diameter of 146 mm and a height of 240 mm or less as specified by the regulations. It also shows that it is released from the carrier.

ÿ Exam content

1. Carriers owned by this team (ÿ 147mm x 270mm) with 0.5mm thick cardboard and measure the inner diameter and height from the bottom to the mouth.

2. Place the aircraft and parachute into the carrier and check that the diameter fits. 3. Measure the length from the aircraft to the opening of the carrier, and make sure the height of the aircraft is within the regulations. Make sure that This unedited video shows the series of steps from measuring the dimensions of the

carrier. ÿ

Results A video of the test is shown in the link below. https://youtu.be/Vpu2VjATfBM

The video shows that the aircraft can be stored in the carrier and released. The test results showed that there was a 50mm space between the opening of the carrier and the top of the fuselage.

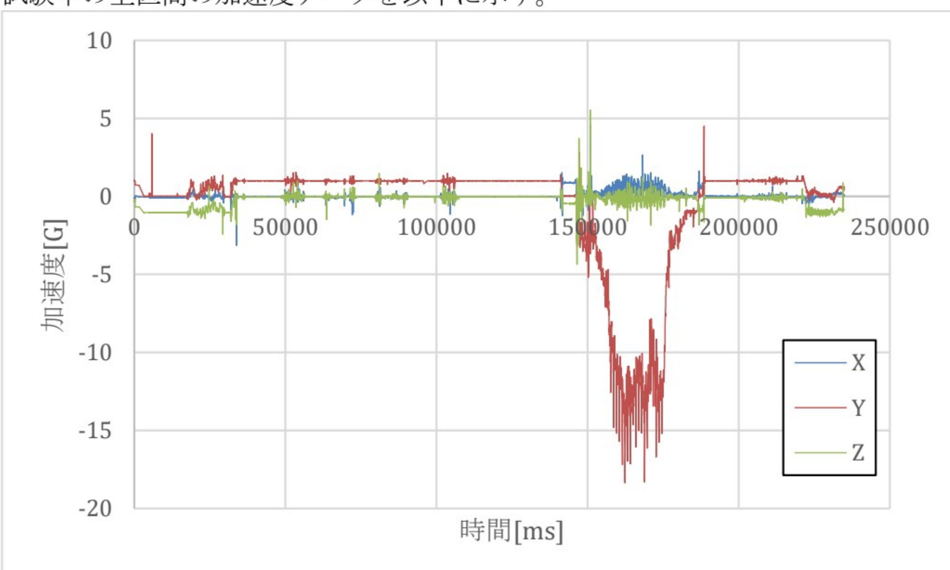
- 考察
  開口部から 50mm の空間があり、キャリアの高さが 270mm であるためレギュレーションの全長 240mm 以下を満たしている。また、内径 146mm のキャリアに収納し、スムーズに放出できたことから外形Φ146mm 以下であることを満たしている。

V3. 準静的荷重試験

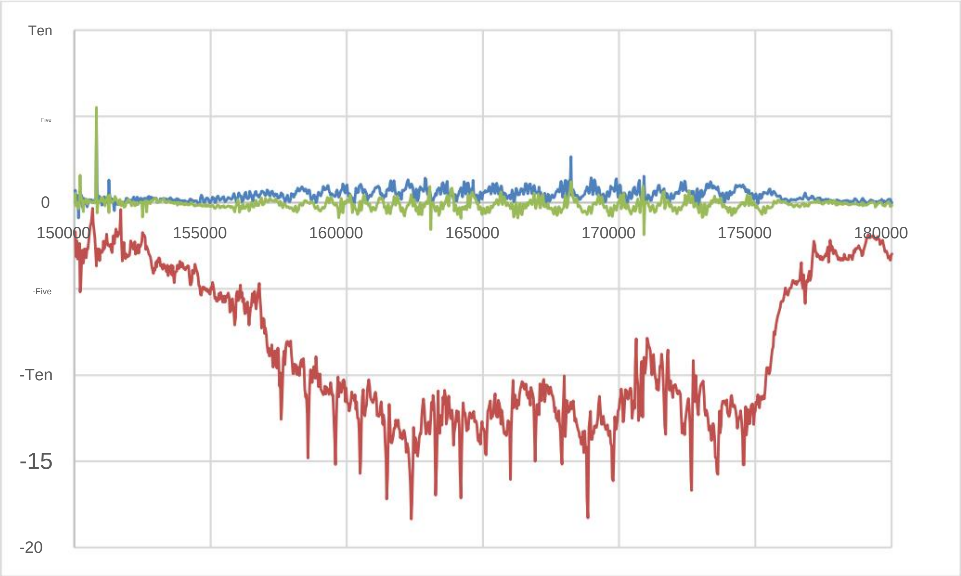
- 目的
  ロケット打ち上げ時の機体にかかる静荷重によって機体の機能が損なわれないことを示す。
- 試験内容
  レギュレーションより CanSat に対して垂直方向に 10G 以上を加えたのち機体が正常に動作することを確認する。
  1. ハンマー投げの要領でキャリアに入れた機体を回し、遠心力を利用して準静的荷重をかける。
  2. 回転が安定してから 10 秒間測定し、その間回転を続ける。
  3. キャリアより機体を取り出し、走行プログラムを書き込んで走行することを確認する。
  4. 機体に搭載されている加速度センサーのデータを無線モジュールで送信し、垂直方向に 10G 以上が加えられていることを確認する。

  試験の一連の工程を無編集の動画で示す。
- 結果
  試験の動画を以下に示す。
  https://youtu.be/Waomhomfnx0

  試験中の全区間の加速度データを以下に示す。



A cutout of the 150 second to 180 second interval from the entire area graph is shown below.



In the above acceleration data, it can be confirmed that 10G or more was applied for 10 seconds in the interval from 160 seconds to 170 seconds.

ÿ Discussion

The aircraft was shown to be able to withstand the static load applied during rocket launch.

V4. Vibration test ÿ Purpose To

demonstrate

that the random vibrations that occur from rocket launch to aircraft release do not affect the aircraft's operation.

ÿ Exam content

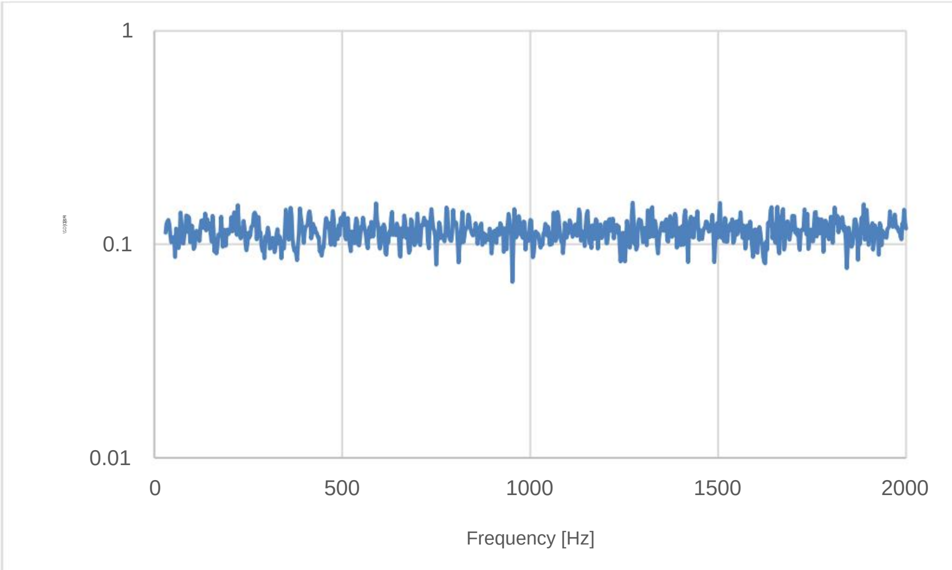
Apply random vibration equivalent to 15G at 30~2000Hz, referring to the regulations. 1. Store the cansat in the carrier and place it on the test machine. 2. Vibrate the carrier for 30 seconds using a testing machine. 3. Remove the cansat from the carrier and check that it is working properly. The above process is shown in an unedited video. Also, the vibration log data of the test machine is attached.

ÿ Results A

video of the test is shown below.

https://youtu.be/VIoRYQEq5_o

The vibration data of the vibration tester is shown below.



The execution acceleration [G] can be calculated from the power spectral density [G2 /Hz] using the following formula. Let the frequency value be ... and the power spectral density be 1 , 2 , 3.

$$= \frac{\log 10 \frac{\quad}{}^{+1}}{\log 10 \frac{\quad}{}^{+1}}$$

When ÿ ÿ1

$$= \frac{\quad^{+1} \quad^{+1} \quad^{+1})}{((+1)}$$

= ÿ1

$$= \log \frac{\quad^{+1}}{}$$

At this time, the effective value of acceleration

$$= ÿÿ$$

The effective value of acceleration was calculated using Excel from the acquired acceleration data. As a result of calculating all the data, the calculation could not be performed due to overflow, so we used the obtained data in skips of three values, which is the minimum value that can be calculated. The execution acceleration value at this time was 15.00897G. The files used for calculation ~~are shown below. https://tdu.box.com/s/0ifqfjcjs79fkdxic5ou5koj33mhq~~0n4

ÿ Discussion

Data from the vibration tester showed that 15G of vibration was applied between 30Hz and 2000Hz, indicating that there was no problem with vibration during rocket launch.

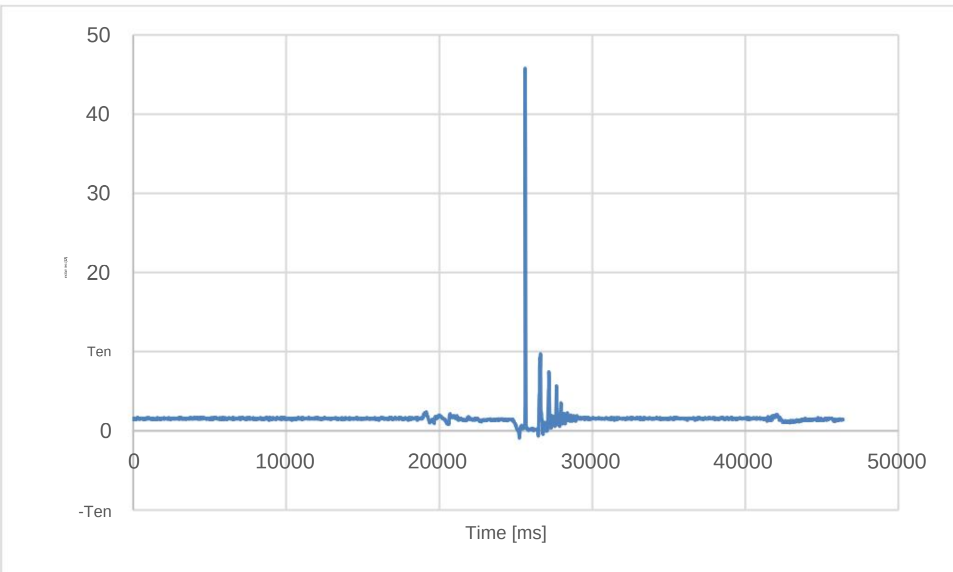
V5. Separation (parachute deployment) impact test ÿ Purpose To demonstrate
that the
functions of the aircraft body, such as the joints with the parachute and the ropes, are not impaired by the impact when the aircraft is released from the rocket and the parachute opens. It also indicates that a shock of 40G or more has been applied.

ÿ Test details 1.
Connect the parachute to the aircraft and tie the parachute umbrella with string.
2. Set the string at a height where the CanSat does not reach the ground, climb onto a stepladder, and lower the aircraft. 3.
Measure the acceleration using the sensor mounted on the aircraft and confirm that 40G or more is applied.
Ru.

In the preliminary examination, it was from the second floor, but as a result of the preliminary examination, it was found to be excessive for the test conditions of 40G, so the test was conducted using a stepladder.

ÿ Results
A video of the test is shown
below. https://youtu.be/FkgtaGOI1w4

The acceleration applied during the test is shown below.



The maximum acceleration during the test was 45.8G.

ÿ Discussion
The test results showed that an opening impact of 40G or more was applied to the parachute joint, and that there were no problems with its operation.

V6. Drop test ÿ Purpose To
demonstrate
that the deceleration mechanism (parachute) when the aircraft descends to the ground is functioning.

ÿ Exam content
Measure the terminal velocity of the parachute. 1.
Drop a CanSat from the 4th floor. 2.
Shoot video with a fixed camera during the drop. 3.
Analyze the captured video and determine the descent speed along with the drop height.

A comparison with the theoretically calculated descent speed without a deceleration mechanism shows that the parachute deceleration
is working. The falling speed during free fall without a parachute can be calculated using the following formula. In order to take air resistance into account, use Newton's law of drag below.

$$= \frac{1}{2} \quad ^2$$

D: Air resistance [N], CD: Drag coefficient, ÿ: Air resistance density, V: Falling speed [m/s], S: Representative area [m2]

The equation of motion of an object subject to air resistance can be expressed by the following equation.

= ÿ

Here, since = 0 at the terminal velocity, = . Substituting this into
Newton's law of resistance, we get

=ÿ2

Aircraft weight = 1.050 × 9.81 = 10.3 The
representative area is the cross-sectional area of the carrier, and S = 0.017.
The CD value is 0.9 assuming the aircraft is a cylinder. The
air resistance density ÿ is calculated using the following formula.

$$= \frac{}{(+ 273.15)}$$

Temperature = 30ÿ, atmospheric pressure = 10.3[hPa], and gas constant = 2.87.

$$= \frac{1013}{2.87(30 + 273.15)} = 1.16$$

= ÿ 2 × 10.3

0.9 × 1.16 × 0.017

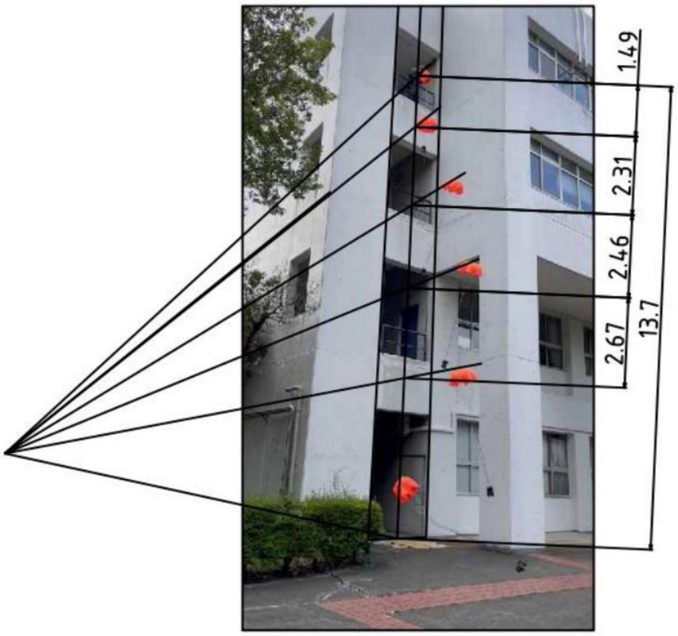
= 34.07[/]

At the preliminary screening stage, we had planned to use a drone to measure the parachute's descent speed, but the test took place in the middle of the night and we were unable to use a drone, so we conducted a drop test from the highest point possible. .

ÿ Results A
video of the test is shown below.
~~https://youtu.be/qcl2QIUBLwk The~~
height of the starting point from the ground is shown below.

How to show a composite of images taken every 15 frames.

Here, the frame rate of the video is 30fps, and the time between images is 500ms. Next, we show images where the height was determined from the position of the parachute in each image.



From the image above, the falling distance and speed from 0.5 seconds to 2 seconds are as follows.

Time	Falling distance	Falling speed [m/s]
0s~0.5s	[m]	2.98
0.5s~1.0s	1.49	4.62
1.0s~1.5s	2.31	4.92
1.5s~2.0s	2.46 2.67	5.34

ÿ Consideration

The results show that the measured drop value is sufficiently smaller than the theoretical free fall value.

This confirmed that the parachute was functioning adequately to reduce deceleration during a fall.

V7. Lost Countermeasures Testÿ Purpose

To show

that countermeasures have been taken to recover the aircraft and that they are effective.

ÿ Exam content

When searching for the aircraft, measure the visibility distance of the parachute, which serves as a landmark for the search, and the wireless communication distance to receive the aircraft's

coordinates. [1]. Parachute visibility distance measurement

Measure the distance at which the parachute can be seen near the Koshibe River embankment in Hatoyama Town, Saitama Prefecture, which has a good view. The critical distance is the point at which the parachute canopy is no longer visible, and each member performs one test at a time, and the average distance is determined as the critical parachute visibility distance. The parachute used should be of fluorescent color. [2]. Wireless

communication distance

measurement Measure the communication limit distance of the radio equipment installed on the aircraft. [1] Similar to the test, the test was conducted near Koshibe River, Hatoyama Town, Saitama Prefecture, to measure the distance at which a receiver connected to a PC can receive data from the transmitter installed on the aircraft. A person with a PC places the aircraft and measures the distance using a walking tape measure while walking. The aircraft sends a count-up signal every second, and at the point where it can no longer receive the signal, it stops moving and waits 10 seconds. If it returns within 10 seconds, it will move again, and the point where data could not be received for 10 seconds will be the limit point of communication distance. Perform the above process three times and take the average distance as the communicable distance. The test is shown in an unedited video.

Photo of test location

In addition, the method for creating an aircraft in the event of a problem with the wireless module is shown below.

The following are known as prerequisites from past competitions: 1. Our team's aircraft has a small parachute, so it falls quickly, and there is an extremely high possibility that it will land within 4km from the launch point.

2. The aircraft, nose cone, and rocket body fall in almost a straight line from upwind.

From past records, it is known that the falling speed is the following: aircraft body>nose cone>rocket body. It is also known that even if the landing order changes, the landing points will be almost in a straight line.

The person in the passenger seat searches in the direction of travel and on the right side, the person in the rear of the driver's seat searches on the left side in the direction of travel, and the driver searches in the direction of travel using binoculars.

ÿ Results The

parachute visibility distance results are shown below. At the preliminary screening, all members were present, but there was a change in the number of members after that, so there is only one record. In the test, we measured whether the parachute could be recognized every 50 m, and the distance before the parachute became unrecognizable was used as the result. As a result of the test, approximately 500m was the limit distance for parachute recognition.

A video of the communication distance measurement test is

shown below. Number of exams	Video link
1st time	https://youtu.be/rJikz2xA3dg https://youtu.be/
2nd time	zD28Xjq53ck https://youtu.be/QRoZgBk19xY
3rd time	

The communication distance measurement results from the video are as follows.

	Communication
Number	distance 250.1m
of times:	281.5m
1st time	270.4m

2nd time 3rd time The average communication distance is 267.3m.

ÿ Discussion

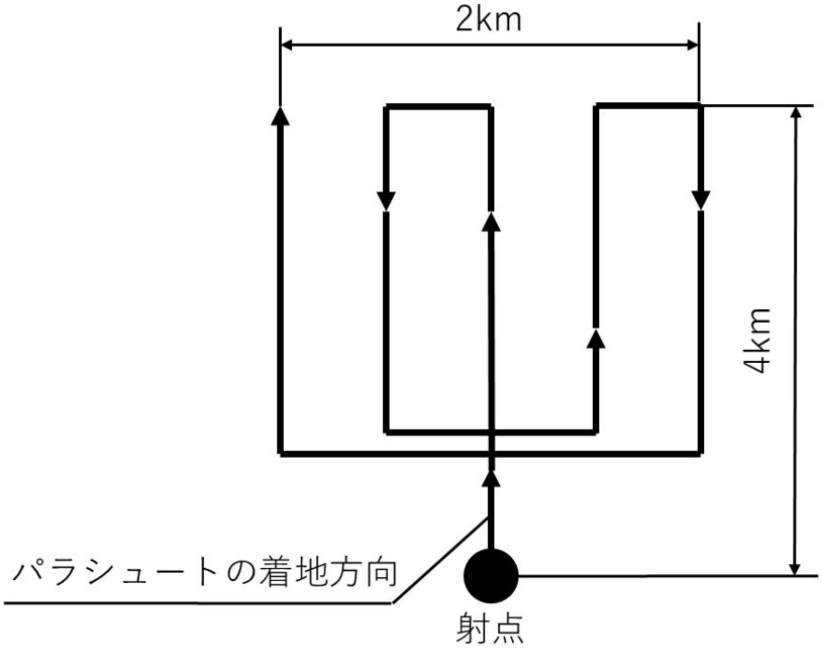
The search for the aircraft will be conducted through communication and parachute searches. Also, based on past search results, the aircraft, nose cone, and rocket body are found from upwind in that order, so if the position cannot be confirmed by radio, use the following search method to find the aircraft. As a means of extending the communication range and locating the aircraft from a distance, we are considering operation by visualizing on a map the coordinates of the aircraft when it descends, where communication is easier to pass.

How to search for the

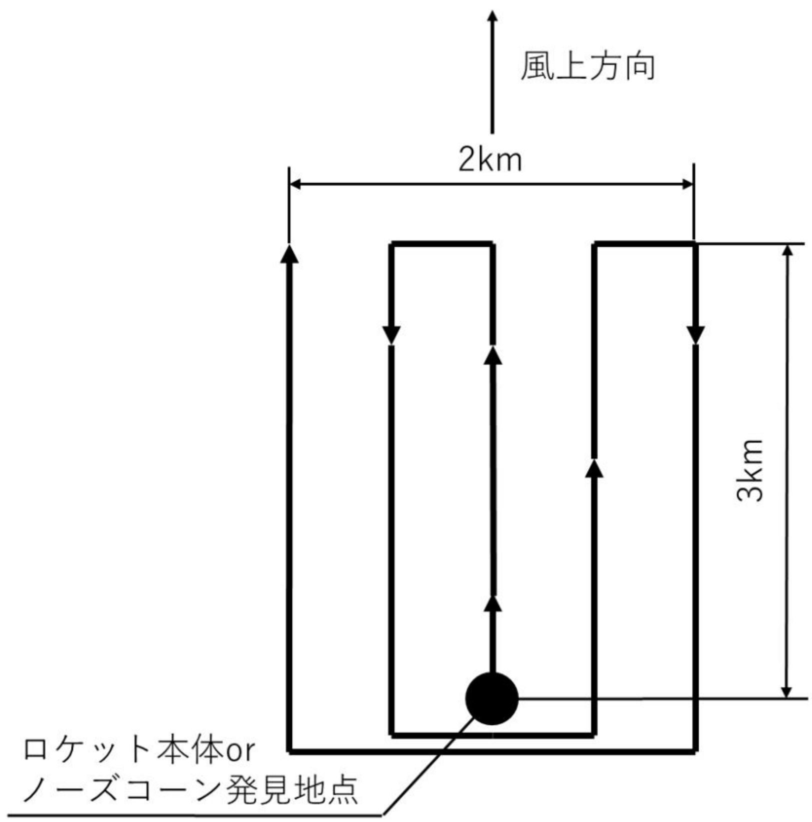
aircraft The following search method uses a GPS receiver to check the location information and flight trajectory.

Once the direction in which the parachute will land after launch is determined, the search shown in the diagram below will begin as soon as possible. If the aircraft, nose cone, or rocket body cannot be found during the search, check the wind direction again and search upwind in the same way. If the aircraft is found, the search ends; if the aircraft is not found and the nose cone or rocket body is found, the search proceeds to the next method.

Machine Translated by Google



After confirming the wind direction, search an area of 2km x 3km upwind as shown in the figure below. If it is still not found, the search area will be expanded to downwind or adjacent areas.



V8. Wireless power ON/OFF test ÿ Purpose To

confirm

that the regulations state that there is no need to turn off the power and that it is FCC certified and below 100mW ÿ Test

details To test

the XBee ZB S2C installed in the aircraft. Indicates FCC ID.

Also, check the output from the vendor's

specifications. ÿ Result The FCC ID of XBee ZB S2C is shown below.

FCCID is MCQ-S2CTH. The specifications

are shown below.

SPECIFICATIONS	Digi XBee® S2C Zigbee Standard | Programmable
性能	
トランシーバーチップセット	Silicon Labs EM357 SoC
データレート	RF 250 Kbps、シリアル最大1 Mbps
室内/都市部レンジ*	最大 60 m
屋外/RF見通しレンジ*	最大 1200 m
送信出力	3.1 mW (+5 dBm) / 6.3 mW (+8 dBm) ブーストモード
受信感度 (1% PER)	-100 dBm / -102 dBm ブーストモード

From the above, the maximum transmission output is

6.3mW. ÿ

Discussion The results show that the radio installed in the aircraft is FCC certified and has a power output of 100mW or less.

V9. Communication frequency change test ÿ Purpose

To

demonstrate that it is possible to change the frequency of the wireless module installed in the aircraft in order to prevent interference at the venue.

ÿ Test details

Connect the XBee installed in the aircraft to a PC and change the channel using X-CTU. The procedure is shown below.

1. Check that the XBee and PC are connected (characters sent from the XBee are displayed on the PC))
2. Change the channel of the receiver on the PC side to indicate that communication is not possible. (Indicates that the characters sent from the XBee are not displayed on the PC)
3. Change the XBee channel to show that communication is occurring again. The above steps are shown in an unedited video.

ÿ Results

A video of the test is shown below. https://youtu.be/NC46NURHZww

ÿ

Discussion We showed that it is possible to change the communication frequency of the wireless module installed in the aircraft by switching the channel used.

V10. End-to-End Test ÿ Purpose: To

demonstrate

that the aircraft can operate without damage during the entire sequence from mounting the rocket on the aircraft to separating the parachute, reaching the goal, and measuring the distance.

ÿ Exam content

1. Turn on the aircraft and wait until it acquires GPS and enters standby mode.
2. Make sure the carrier is empty and place the aircraft into the drop carrier. 3. Release the aircraft from the carrier and separate the parachute, causing the aircraft to begin operating upon impact. and control the progress to the goal. 4. Measure the distance to the aircraft's goal after the CanSat reaches the goal and stops.

This unedited video shows the process from dropping the cansat into the drop carrier to measuring the goal distance. ÿ The

result video

is shown below. Number

of	
times	Video https://youtu.be/
1st time	YYSPWKxW5gg https://
2nd time 3rd time	youtu.be/vhljvI3fZV8 https://youtu.be/HqewsIG7MpM

The goal distance according to the test is shown below.

Number of	Distance to goal [m]
tests 1st	4.1
time 2nd	0.87
time 3rd time	5.3

ÿ Discussion

We have shown that the series of processes from powering on the aircraft to reaching the goal is operational.

V11. Landing impact test

ÿ Purpose:

To demonstrate that the aircraft will not be affected by landing impact from above.

ÿ Test details The

test is performed in the following

steps: 1. Apply a shock of 40G using a vibration tester.

2. Take out CanSat and write the running program.

3. Verify that CanSat is working properly. The above process is

shown in an unedited video. At the time of the

preliminary review, it was planned to conduct the test using a drone, but since the performance of the vibration test made it possible

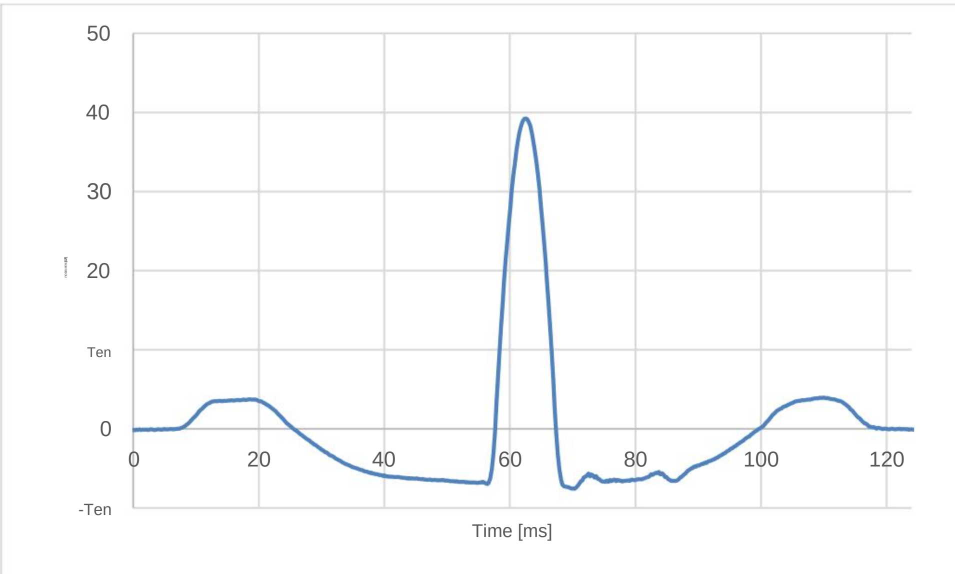
to perform the test, the impact test was changed to a shock test using

a vibration

tester. ÿ Results A video of the test

is shown below. https://youtu.be/XwZ5SEhWjVA

The acceleration data of the vibration tester is shown below.



The acceleration value measured by the test machine was 39.249G.

ÿ Discussion It

was shown that there was no problem with the aircraft's movement even when a shock of approximately 40G was applied.

V12. Controlled driving test

ÿ Purpose

Indicates that CanSat is making a controlled run towards the goal.

ÿ Exam content

The test is conducted in the following steps.

1. Place the CanSat at least 15m away from the goal, and check the location of the goal and the initial direction of the CanSat. direction.
2. Orient the CanSat so that its initial direction of travel is at least 90 degrees away from the goal.
3. Execute the CanSat running program and take a picture of the CanSat being controlled in the direction of the goal.
4. Perform the same experiment five times with different starting locations and run in the direction of the goal under control. shows.

Each test will be shown as an unedited video.

ÿ Results

A video of the test is shown below.

Number	movie
of times	https://youtu.be/_qIG5bzpIFc
1st time	https://youtu.be/sCqJwrL5_Yg
2nd time	https://youtu.be/A2vpU6LHLoA
3rd time	https://youtu.be/eFALvEpkCTo
4th time 5th time	https://youtu.be/scit0aLfj8I

ÿ Consideration

It showed that the CanSat was under control and was moving towards the goal.

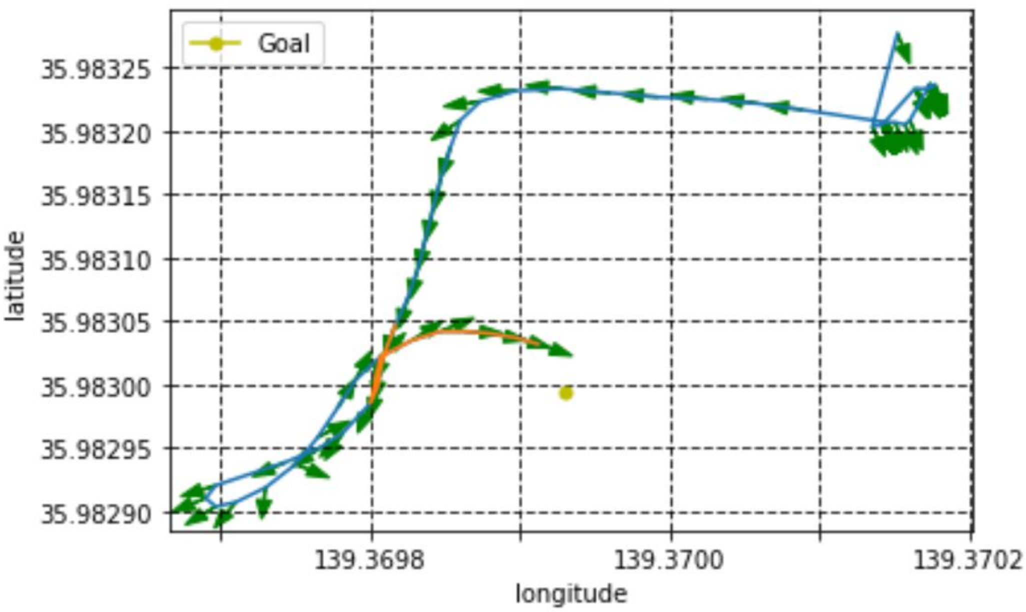
V13. Control report creation test ÿ Purpose To

demonstrate that a control report can be created using logs after the aircraft has stopped. ÿ Test

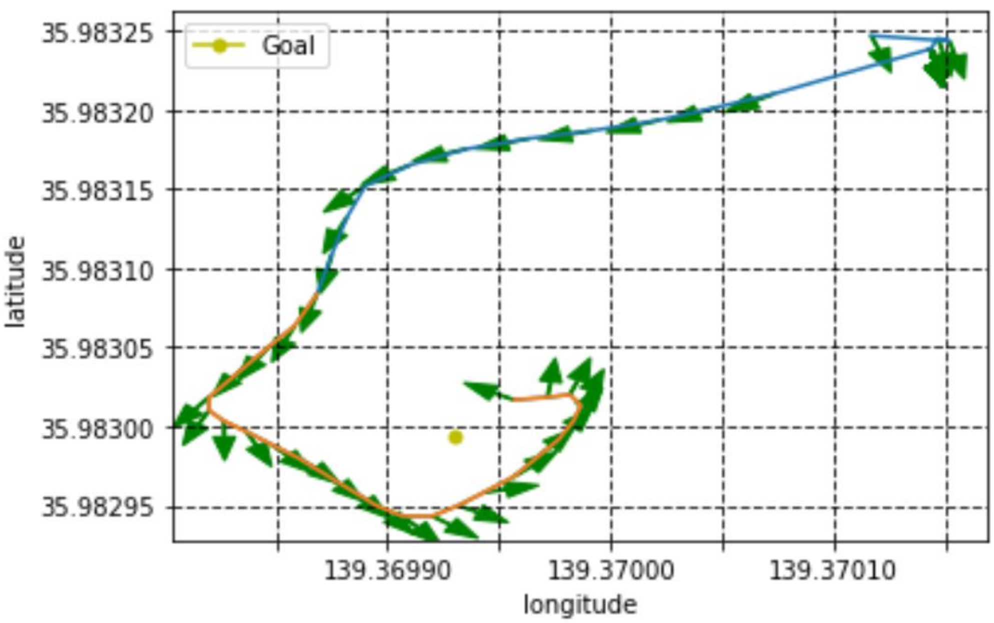
details Create a control report from the driving data during the ETE test. Attach the control history report you created.

ÿ Results The

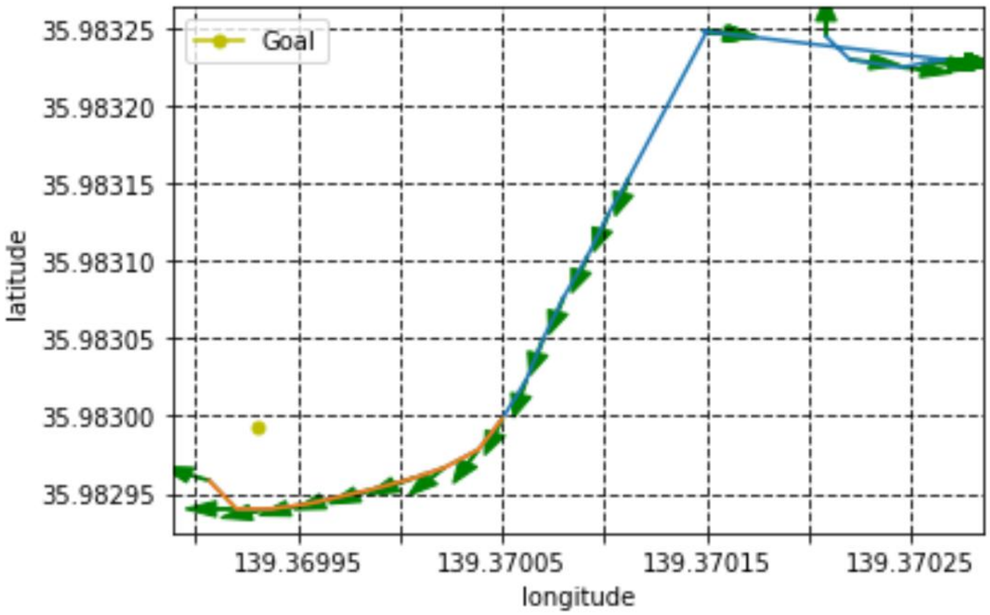
control report for the first end-to-end test is shown below.



The green arrow in the figure indicates the direction of travel recognized by the aircraft from GPS. Also, the blue line shows where the vehicle is running at high speed, and the orange line shows where the vehicle is running at low speed. How to present the control report for the second End-to-End test.



The control report for the third end-to-end test is shown below.



ÿ Discussion

The above figure shows that it is possible to create an image of the aircraft's travel log as a control report.

V14. Driving time measurement test ÿ Purpose To

measure

how long CanSat can run. Calculate CanSat's limit travel distance from the speed determined from the V15 maximum speed test

ÿ Test details 1.

Fully charge CanSat and measure the battery discharge capacity using a charger.

2. Run the CanSat running program and send the voltage and current values to the PC. 3. Calculate the power consumption from the transmitted voltage and current values, and calculate the driving time from the discharge capacity.

4. Calculate the possible travel distance from the speed obtained from the V15 test.

An unedited video showing how voltage and current values are sent to CanSat. Also, create and show a power consumption graph from the measured data.

ÿ Results A

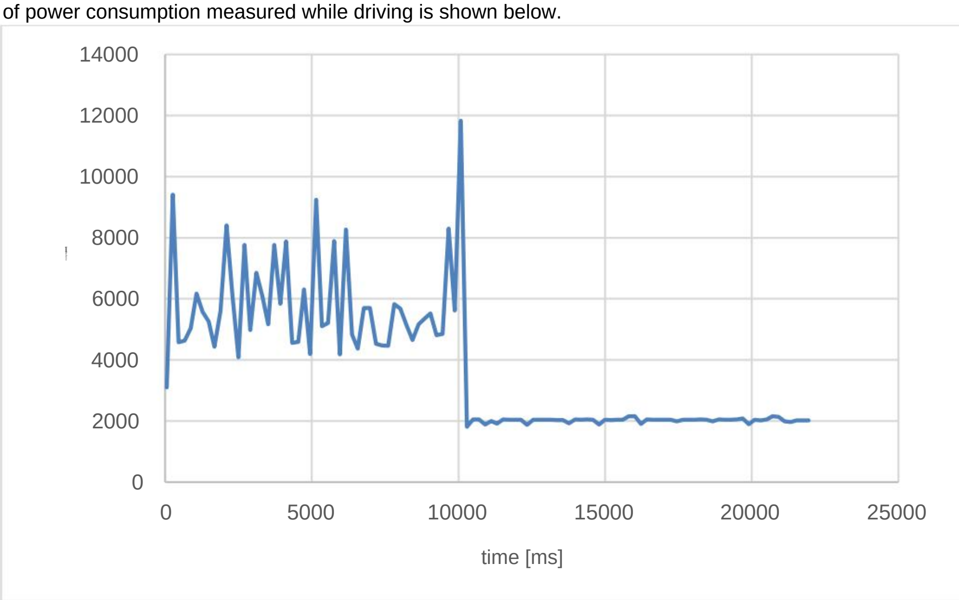
video of the test is shown below.

https://youtu.be/uTnTA4BXubM The

battery capacity at the end of charging is shown below.

From the image, the battery discharge capacity is 416mAh. A video

of power consumption measured while driving is shown below.



The recorded power consumption is shown

below. The average power consumption for up to 10 seconds while the motor

was running was 5.6W. Also, the average

voltage at that time was 12.3V. The possible running time

t[h] can be calculated using the following formula using power consumption P[W], battery capacity W[mAh], and rated voltage V[V].

$$= \frac{\quad}{1000} \times \frac{\quad}{\quad}$$

Substituting into the above formula,

$$= \frac{416}{1000} \times \frac{12.3}{5.6} = 0.913[ÿ] = 54.8[\quad]$$

Therefore, the possible running time is 54 minutes.

Based on the V15 driving speed test, if the driving speed is 11.3km/h, the possible driving distance is 10.3km.

ÿ Consideration

The distance that can be traveled is 10.3km, and in the past record, it has fallen within 4km, so it is difficult to reach the goal.

It is possible to run.

V15. Maximum speed measurement test

ÿ Purpose

Determine the maximum speed of CanSat and use it as a comparison material for on-site driving. It also achieved the design value of 10km/h.

Confirm that it is completed.

ÿ Exam content

Measure distance and time using a walking tape and stopwatch.

1. Rotate the left and right motors at 100% and start the stopwatch while driving.
2. Drive for about 15 seconds and record the time and distance traveled at that point.
3. Measure three times and use the average value as the maximum speed.

A video of the exam will be taken and an unedited version will be shown.

ÿ Results

A video of the test is shown below.

Number	movie
of times	https://youtu.be/NyaP2UtexUs
1st time	https://youtu.be/b9En4TfCRBQ
2nd time 3rd time	https://youtu.be/Oos5TO6dOzM

The running speed determined from the measurement time and running distance from the video is shown below.

Number	Running time [s]	Mileage [m] 49.7	Traveling speed [km/h]
of times	16.15		11.1
1st time	15.38	49.3	11.5
2nd time 3rd time	15.68	49.5	11.4
		average	11.3

ÿ Consideration

The results show that the running speed is 11.3km/h, which satisfies the design value of 10km/h.

V16. Running performance measurement test

ÿ Purpose

Indicates that the aircraft will not get stuck due to obstacles such as cracks, unevenness, or ruts on the ground surface at the venue.

vinegar.

ÿ Exam content

From past ARLISS measurement records, it is known that the height of the ruts is approximately 60mm.

We recreated a 60mm rut using sand and demonstrated that it is possible to place the aircraft in front of the rut and get over it without making a run-up.

confirm. The test will be conducted three times, and success will be achieved if the test is completed 3 out of 3 times. Also, in order to successfully overcome the rut,

Increase the height by 10 mm each time, and measure the maximum height of the rut that the aircraft can overcome.

The test will be videotaped and the unedited version will be shown in the results.

ÿ Results

A video of the test is shown below.

Rut height video	
60mm https://youtu.be/FaH7dFTakAA	
70mm https://youtu.be/LhnbP2VUKlU	
80mm https://youtu.be/2a_Tmf1PvDE	
90mm https://youtu.be/isDWrtH4LxQ	

The results of the running performance test are as follows from the video.

Rut	1st time 2nd time ÿ ÿ ÿ ÿ ÿ ÿ		Third time
height 60mm			ÿ
70mm			ÿ
80mm			ÿ
90mm	×		

ÿ Consideration

The results show that the aircraft has the ability to overcome 80mm ruts.

Chapter 7 Gantt chart (process control)

The schedule until around August 8th, which is the submission date of the second examination report, is shown below.

	July																									August										
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11
Tournament schedule	1st screening report																																2nd examination report			
End-to-End																																				
drop test																																				
Landing impact test																																				
Lost countermeasure test																																				
Communication frequency change test																																				
Mass test																																				
Storage/release test																																				
Separation impact test																																				
Quasi-static load test																																				
Maximum speed test																																				
Running performance test																																				
Control report creation test																																				
Controlled driving test																																				
Driving time measurement test																																				
Vibration test	Schedule being adjusted																																			
Wireless power ON/OFF test	Survey only																																			
Aircraft improvement period																																				

Chapter 8 Impressions of the responsible teacher

1.Responsible teacher's impressions

The aircraft participating this time follows the basic hardware design of the aircraft used when it participated in ARLISS last time, but has improved reliability and control. Our team has made every effort to maintain the quality and content of our activities as much as possible, even though our team has had a major change in our active members due to the effects of the coronavirus pandemic, making it difficult to pass on our skills. This time, one second-year student who has never participated in ARLISS is working hard. Thank you for your understanding.

Chapter 9 Tournament Results Report

(1)

Objective: Run to the goal in the fastest and shortest time possible.

(2) Results

1st launch Parachute

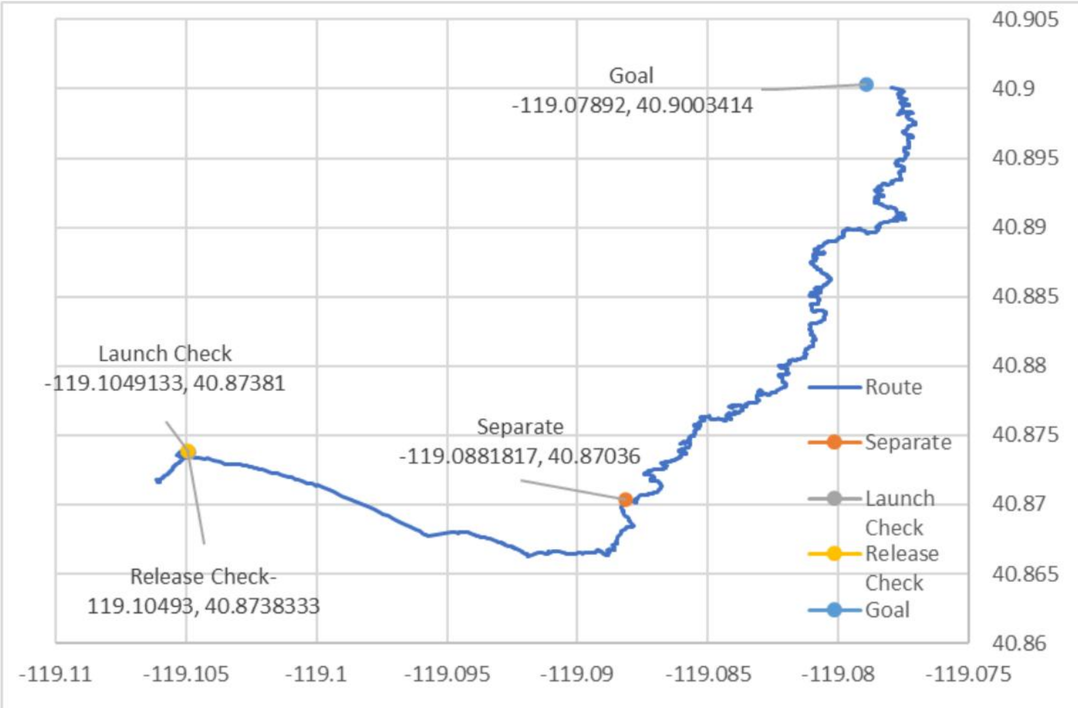
did not separate and retired

The first launch failed to separate the parachute and was retired. Since the aircraft control log could not be confirmed, the judgment was made based on the aircraft condition. When the aircraft was discovered, it was not moving and was not communicating. The power lamp indicating that the aircraft was powered on was on, so we waited for 15 minutes, the automatic separation time, after determining that the aircraft was descending, but it did not work, so we recovered it. When attempting to separate the parachute manually after recovery, it was possible to separate the parachute by rotating the parachute connection by hand, but it was not possible to separate the parachute by rotating the wheel. When the aircraft was inspected, it was found that there was a misalignment between the parachute connection shaft inside the aircraft and the mounting hole in the frame. Based on the above circumstances, the pilot attempted to separate the parachute, but determined that the motor torque was not enough to rotate the parachute separation mechanism, and the parachute separation could not be performed. For the second time, we corrected the hole positions in the frame using a router and applied lubricant to the threads, and after confirming that the parachute could be separated by rotating the motor, we conducted the second launch.

2nd launch

During the second launch, the separation was successful and the vehicle traveled 106m from the goal.

The driving log is shown below.



The driving data obtained from GPS was as follows.

Straight line distance from the falling point to the goal Travel	3,416 m
distance Travel	5,955 m
time (separation time to goal time) Operating time Average	3,850 seconds
travel speed	7,471s
Average travel speed	5.56km/h
as a ratio of straight line distance Straight	3.19km/h
line speed	174%

During the second launch, the separation operation was successful and CanSat traveled 106m from the goal.
Ta. The cause of the stop at 106 m was due to a drop in battery voltage. The driving time is approximately
After 1 hour, the results matched those from the previous test. I can't reach the goal within the GPS error.
Possible reasons for this are an increase in travel distance and a decrease in travel speed. Preliminary domestic test
The average speed was confirmed to be 10km/h, but the actual average speed was about half that. Also, go straight
The degree of travel was 174%, which is thought to be due to the increased travel distance due to the meandering motion of the CanSat.
It will be done. In addition, when we observed the driving situation on site, we found that the speed decreased significantly when turning.
there was. The average running speed decreased due to continuous turns at large angles accompanied by deceleration.
it is conceivable that.

(3) Discussion

The level of achievement of the success criteria is shown in the table below.

The degree of achievement is ÿ: Completely achieved, ÿ: Partially achieved, ×: Not achieved.

Comeback success criteria

Success Criteria		Level of achievement
Minimum	Contents Separate the parachute and start operating	ÿ
Middle	CanSat heads towards the goal	ÿ
full	CanSat finishes 0m	ÿ
extra	finishes	×

Straight line success criteria

Success Criteria		Level of achievement
Minimum	Contents Straightness:	ÿ
Middle	300% or less	ÿ
Full	Straightness: 200% or	×
Extra	less Straightness: 150% or less 0m Goal	×

Average speed success criteria

Success Criteria		Level of achievement
Minimum	Contents Average speed: 6.92 km/	×
Middle	h or more Average speed: 8.54 km/	×
full	h or more Average speed over straight line distance: 7 km/	×
extra	h or more Average speed over straight line distance: 8 km/h or more	×

Running performance success criteria

Success Criteria		Level of achievement
Minimum	Content: Move more than 500 m	ÿ
Middle	CanSat reaches the goal Reach	ÿ
full	the goal without getting stuck for more than 10	ÿ
extra	seconds Reach the goal without getting stuck at all	ÿ

Sensor data success criteria

Success Criteria		Level of achievement
Minimum	Contents Save the data necessary for	ÿ
Middle	the control log Save the sensor data	ÿ
Full	Determine the severity of the unevenness of the ground based on sensor data	×
Extra	Create a 3D map	×

The success criteria related to the CanSat goal is 106 m from the goal;
It is difficult to say that this has been completely achieved because it is far away from GPS measurement errors, so it is considered partially achieved. Additionally, it was not possible to determine the logging of sensor data because the range setting of the acceleration sensor was low and the acceleration data during driving was at the upper limit of the range. In setting the success criteria this time, it is necessary to understand what kind of state the ``goal'' refers to and to evaluate the communication aspect, which was an issue this time.

Chapter 10 Summary

(1) Points of improvement/

effort In terms of communication, the XBee frequency of 1575MHz and the Arduino Pro mini's CPU frequency of 16MHz were integer multiples, so we shielded the board with aluminum tape and Kapton tape. With this improvement, GPS acquisition, which had previously been unstable, was now able to be reliably acquired within 40 seconds, greatly stabilizing it. In terms of

control, we have added redundancy to all processes such as separation and turning operations. Compared to previous domestic competitions, ARLISS will have a large difference in startup time and each operation time (launch, landing, and running). As a result, considering the possibility that an error may occur between the initial value obtained at startup and the sensor location after time has elapsed, we have tripled the separation based on air pressure, acceleration, and time, and also doubled the gyro and time when turning. Reduced the risk of falling into an infinite loop.

(2) Issues -

Development of a program that simulates a launch

Before the first launch, the separation program was activated due to changes in air pressure when the rocket was loaded. In this case, it was not a serious problem because it occurred before launch, but if it occurred after launch, the parachute would separate in the sky, which would be extremely dangerous. Due to the structure of the rocket, it was not assumed that the internal pressure would increase after the nose cone was inserted. In addition to improving the assumed system, it is necessary to develop controls and aircraft that take into account local launch procedures.

•More reliable operation of the

separation mechanism The first launch was retired because the parachute did not separate. One possible cause is the parachute separation mechanism being locked. In our team's aircraft, the rotation of the wheels and the separation of the parachute are linked, so if the wheels rotate due to the impact upon landing, depending on the direction, the screws at the parachute joint may tighten, making it impossible to separate the parachute with the torque of the motor. did it. By using lubricant, we were able to separate without any problems on the second launch, but we felt that we needed a method that would ensure separation under any circumstances.

•Improved hardware maintainability During the

second launch, we reached 108m from the goal, but the average speed at that time was 5.57km/h, about half of the expected speed. One of the causes was that one of the wheels on the left side had misaligned while driving. In the current aircraft, adjusting the internal gear backlash requires disassembling the drive mechanism, and the aircraft also needs to be pumped up for confirmation, so adjustment takes time. It is necessary to develop a structure that eliminates the need for mechanical adjustments, or to develop an aircraft that allows adjustments to be made in a short time.

•Improvement of

control The current aircraft uses GPS for guidance, and there is no control to reach the 0m goal. However, it is difficult to imagine winning the Comeback category without a 0m goal, so it is necessary to establish a method to achieve a 0m goal. At the same time, it is necessary to improve the straight-line stability of the aircraft and establish a control method that allows it to travel shorter distances at higher speeds.

- Improving

communication The current aircraft communicates using a 2.4GHz XBee module, making it difficult to communicate over long distances. There is a need for a method to confirm the position of the aircraft during launch and landing using communication methods that enable long-distance communication such as LoRa and the 430MHz band.

(3) Future outlook We will

continue to develop the 0m goal in order to win the championship while maintaining the strength, which is the strong point of the current aircraft. In addition, improvements have been made in terms of communication, allowing for better communication during high-flying and long-distance landings. Allows the location of CanSat to be revealed.

Chapter 1 Summary of the results of the accident safety review 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	Due to quasi-static loading during launch, safety standards The functions required to satisfy the requirements are not impaired. This has been confirmed through testing.	ÿ	
S4	Vibration loads during launch cause safety standards to be exceeded. The functions necessary to satisfy the requirements are not impaired. has been confirmed by testing	ÿ	
S5	Collision during rocket separation (when parachute is deployed) Shock load is used to meet safety standards. Tests have confirmed that functionality is not impaired. coming	ÿ	
S6	To prevent falling at dangerous speeds near the ground. It has a speed reduction mechanism, and its performance can be confirmed by testing. ing	ÿ	
S7	Measures against S7 loss have been implemented, and their effectiveness has been tested. This has been confirmed by experiment.	ÿ	

	(Examples of countermeasures: location information transmission, beacons, fluorescent lamps) color paint, etc.)		
S8 Comply with regulations to turn off radio equipment during launch	We have confirmed that it is possible (FCC certification? Devices with a power output of 100mW or less do not need to be turned off. Also, when using a smartphone, the FCC certification and software or hardware (What you can turn off with a witch)	ÿ	
S9 Willing to adjust radio channel,	We have also confirmed that adjustments can actually be made. Ru	ÿ	
Loading the S10 rocket, starting the mission, and launching the rocket.	End-to-end simulation of the process from start-up to recovery We have been able to conduct tests, and we plan to make major design changes in the future. There is no further	ÿ	
	If you wish to participate in the Comeback Competition, please be sure to meet the following requirements:		
Autonomous control without human intervention during M3 missions	We have confirmed that it will be implemented.	ÿ	
Specified control history report after M4 mission	Submit the data to the management and judges and log/obtain data. be able to explain the data	ÿ	