

UAV, UGV AIMING AT THE MOON AND MARS AIMING FOR ATMOSPHERIC OBSERVATIONS ON MARS

1stWataru Okamoto
 Institute for Space-Earth Environmental
 Research, Nagoya University
 Mars Society of Japan Moon Mobius

2ndTatsuki Horii
 AeroFlex Tsukuba University

Abstract- In recent years, there has been a growing interest in space development all over the world. Nearby stars such as the Moon and Mars will have manned spaceflights in the near future. Robotic exploration and construction will take place before humans actually go. Many shafts have been found on the Moon and Mars, and the first bases and cities will be built underground. Demonstration experiments will be conducted on Earth for robots that are active on the Moon and Mars.

MDRS (MARS DESERT RESEARCH STATION)

MDRS is a Mars simulation facility built in the desert of Utah, USA. Scientists and engineers from all over the world gather and stay for two weeks. Experiments of each theme, and exploration of the desert by the rover are carried out.



MDRS (Mars Desert Research Station)

MDRS is located about 11 km northwest of the city of Hanksville in Utah, USA, and it takes about 3-4 hours by car from the Grand Junction airport through the desert. It's right there. It has been operated by the American NPO "Mars Society" since around 2006, and research teams from various countries come every two weeks. We are conducting experiments on the theme that is an extension of our usual research.

Saturday, July 15, 2023
 Indonesia UFO Festival

Okamoto and Venzha Christ, Director of the Indonesian Space Association, participated in the 2018 CREW191 Team Asia. Okamoto is conducting exploration by drone.

group with Japanese participants

Japanese have participated in MDRS several times in the past. Among them, Okamoto participated in CREW137 and CREW191. In CREW191, a film crew from the Japanese TV station NHK is also participating.

- 2014 "Team Nippon Crew 137"
- 2015 "Crew165"
- 2017 "Crew182"
- 2018 "Crew188"
- 2018 "Team Asia Crew191"



火星移住実験で過酷な生活 7人のリアルドキュメント

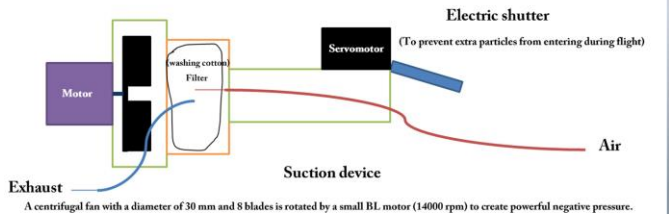
火星移住実験！クルー7人のリアルドキュメント

NHK 1.5チャンネル

Saturday, July 15, 2023
 Indonesia UFO Festival

COLLECTION OF AEROSOLS BY DRONE

Mars has an atmosphere. 0.7% of Earth's atmospheric pressure. Measuring atmospheric conditions is essential for working on Mars.



Drone-mounted aerosol collector

The air is aspirated with an aerosol and passed through a sealed and sterilized filter (medical cleaning cotton) to collect fine particles. At this time, a suction device that achieves a large flow rate so as not to lose to the airflow of the drone is important.

Motor, Washing cotton Filter, Servomotor, Electric shutter (To prevent extra particles from entering during flight), Air, Suction device, Exhaust

A centrifugal fan with a diameter of 30 mm and 8 blades is rotated by a small BL motor (14000 rpm) to create powerful negative pressure.

Saturday, July 15, 2023
 Indonesia UFO Festival

We used drones to collect aerosols. The collected aerosol was subjected to XAFS measurement at a synchrotron radiation facility (in this study, the Aichi Synchrotron Light Facility was used).



AeroFlex 先進的UAV研究事業 Aero Flex もっと空の近くに

AeroFlex 堀井樹代表とエアロゾル収集装置

AeroFlex公式ホームページ <https://horiiatsuki.wixsite.com/webside>

This collection device can remotely control the collection time of the aerosol. Aerosol collection was performed at the "field burning site" conducted on January 23, 2022, in the vicinity of the Kogai River (downstream of Yamato Bridge, Joso City, Ibaraki Prefecture).



Two collection heights, ``15-20 ft'' and ``300 ft'' above the ground, were selected, and the aerosol collection was performed for 3 minutes at these positions. A cotton puff was used as a collection filter to collect the aerosol.

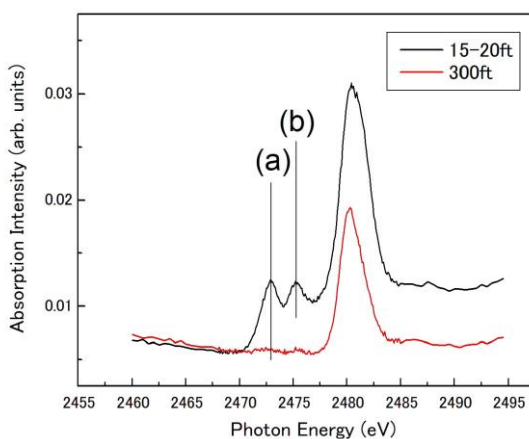
XAFS measurement @ Aichi SR_BL6N1 (He-path system)

Fluorescent X-ray
 Incident X-ray
 Measure the intensity of Fluorescent X-rays
 ↓
 Calculate absorption spectrum

- Attach up to 12 strip-shaped rubber samples
- Measured at atmospheric pressure with He path
- In-situ measurement by using a heating device

Capable of analyzing insulating samples and liquid samples:
 Capable of analyzing the chemical state of aerosols

Saturday, July 15, 2023
 Indonesia UFO Festival



MARS DRONE

On April 19, 2021, NASA successfully flew a drone on a planet other than Earth for the first time in human

history. Ingenuity is the drone that arrived on Mars in the Perseverance rover.

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website>
 Saturday, July 15, 2023
 Indonesia UFO Festival

At the University of Tsukuba venture company AeroFlex, we received an order from JAXA in Japan and produced a Mars drone. Equipped with 6 propellers, the middle propeller is placed upside down.

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website>
 Saturday, July 15, 2023
 Indonesia UFO Festival

CAVES ON THE MOON AND MARS

In recent years, many vertical holes have been discovered on the Moon and Mars. Drones and rovers will be deployed to explore these holes.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の遠くに

Shafts found on Mars Credit:

Vertical hole of Marius Hill- Vertical hole first discovered by KAGUYA (SELENE) -

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website> Saturday, July 15, 2023 Indonesia UFO Festival

Since the moon has no atmosphere, either a rover-only probe or a rocket-powered UAV is conceivable.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の遠くに

Trends in Mars Exploration

- Explore Mars and Moon shafts with UAVs and robots→ The world's first trial
- Mars exploration UAV researched by JAXA also aims to explore pits on Mars

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website> Saturday, July 15, 2023 Indonesia UFO Festival

Demonstration experiments are being conducted by actually operating drones and rovers in vertical holes in various parts of Japan.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の遠くに

Japan has many underground caves. We are exploring various caves for experimental purposes.

- 秋吉台国定公園 - UAV測量
- 大谷資料館 - UAV探査, UGV探査
- 石切山脈 - UAV測量
- 野島埴体塚 - UAV探査, UGV探査
- 千代ヶ崎砲台跡地 - UAV測量, UGV地下探査
- 片島魚雷発射跡地 - UAV測量

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website> Saturday, July 15, 2023 Indonesia UFO Festival

STATE OF EXPERIMENT IN A CAVE

UAV, UGV AIMING AT THE MOON AND MARS AIMING FOR ATMOSPHERIC OBSERVATIONS ON MARS
 Wataru Okamoto, Tatsuki Horii

We are conducting experiments using drones and rovers in various parts of Japan. We are testing both standalone and coordinated exploration.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の遠くに

Examples of UAVs and UGVs used in experiments

Ibis NEO
 Equipped with night vision camera

Cave Cat
 Small unmanned six-wheeled survey vehicle

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website> Saturday, July 15, 2023 Indonesia UFO Festival

The Nojima Bunker in Yokohama has been tested many times this year.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の遠くに

Joint UAV and UGV Exploration

- Exploration system that can "explore broadly and shallowly" at low cost is important
- Acquisition of topographical and surface environment data that cannot be obtained from the Mars Orbiter
- Mark the exploration location in advance

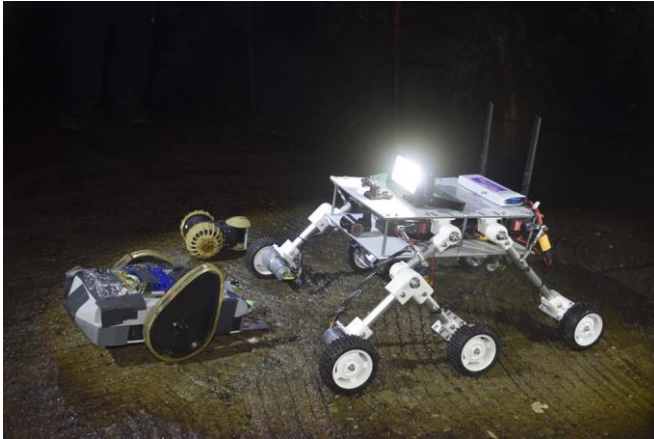
AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website> Saturday, July 15, 2023 Indonesia UFO Festival

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の遠くに

Cave exploration flying robot [Colibri]
 Output of each motor when approaching the wall.
 Back calculation from this data to find the force acting on the airframe

- A rotor guard is installed as a safety device preparation
- For the purpose of floodlighting and ensuring visibility in the cave. Equipped with white blue high-brightness LEDs on the front and rear
- In the next stage, in a non-GPS environment inside the cave it performs RTL (autonomous cave exploration flying robot dynamic return) and autopilot only with a vision sensor.

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website> Saturday, July 15, 2023 Indonesia UFO Festival



Rover Daimon Yaoki, which is participating in the experiment, will be launched this month. It will be Japan's first rover to go to the moon.

LANDING GEAR ON MARS

Here, we introduce a new landing gear that AeroFlex is developing.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の近くに

Extensive swarms by small exploration probes (RWD)exploration

- Acquisition of terrain and surface environment data using a small exploration probe
- Based on the data obtained by the probe Send a large spacecraft for detailed exploration

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website>
 Saturday, July 15, 2023 Indonesia UFO Festival

Until now, landers have generally used parachutes.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の近くに

Exploration probe that descends while moving due to autorotation

Probe using Rotary Wing Decelerator (RWD)

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website>
 Saturday, July 15, 2023 Indonesia UFO Festival

Horii is developing a landing gear that applies the principle of helicopter autorotation.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の近くに

Rotary Wing Decelerator (RWD)

◆ Deceleration method using Autorotation, which is also used for safe landing when the helicopter loses power

◆ Upward drag and rotational torque are generated by the lift and drag generated by the flow received from below, it slows down

Normal Operation
Powered Level Forward Flight

Autorotation
Unpowered Steady Glide

url: <https://ardupilot.org/copter/docs/traditional-helicopter-autorotation-mode.html>

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website>
 Saturday, July 15, 2023 Indonesia UFO Festival

It is easy to control the speed and position of the landing point.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の近くに

Theoretical study in RWD | Assumed conditions (Drop environment) Rotary Wing Decelerator (RWD)

- ◆ Assuming a ride-sharing with a large probe
- ◆ After the first stage of deceleration in the parachute
- Altitude about 4 km
- Drop speed about 89 m/s Detach from the spacecraft at and decelerate on its own assume that

Entry, Descent, and Landing Metric

url: https://www.jpl.nasa.gov/news/press_kits/mars_2020/download/mars_2020_landing_press_kit.pdf

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website>
 Saturday, July 15, 2023 Indonesia UFO Festival

In addition, there are scenes where the deceleration effect is more than the parachute.

AeroFlex 先進的UAV研究事業 Aero Flex
 もっと空の近くに

Theoretical study in RWD | Calculation results

Calculation results with airframe mass of 1.8 kg and rotor diameter of 1.2 m (same conditions as Ingenuity)

time vs Altitude

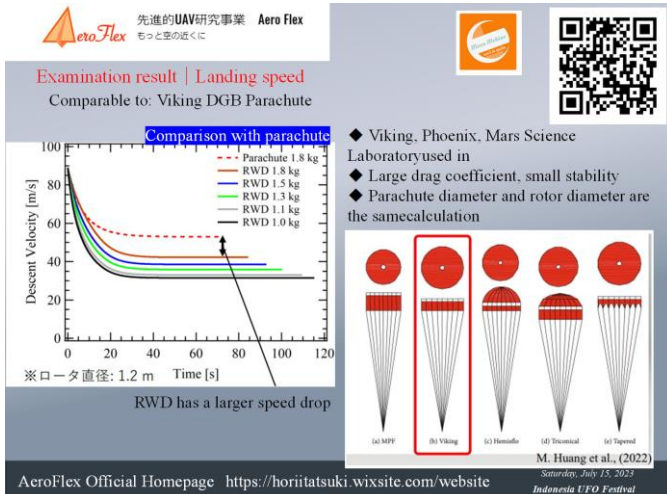
time vs F_lift

time vs velocity

time vs Rotation

- ◆ Falling speed, number of rotations, and drag are constant terminal velocity is reached→The same is true for all conditions.make sure
- ◆ Rotation speed is about 1680 rpm.The wing tip does not exceed the speed of sound→The same is true for all conditions.make sure

AeroFlex Official Homepage <https://horitatsuki.wixsite.com/website>
 Saturday, July 15, 2023 Indonesia UFO Festival



On Earth, we are thinking of applying it to a probe that is dropped into a typhoon.

ACKNOWLEDGMENTS

We received a lot of support from JAXA and other universities and research institutes in Japan, as well as from the Indonesian Space Association. Thank you for your continued support. Let's go to space together.

REFERENCE

“Inspection for the purpose of grasping the current situation of the Nojima Bunker, examination of measurement exploration experiments, and continuous observation programs”

Hiroki Manabe , Satoshi Mohri , Itsuki Horii , Kan Hama , Kiyoo Oyama , Wataru Okamoto , Fujio Yura , Hideki Kuma , Yasuyuki Okazaki

National Institute of Technology, Sasebo College Research Report No.59, pp86 - 95, published 2023-01-31

<http://id.nii.ac.jp/1416/00000913/>

"Vertical hole-cavity-like terrain and environment multi-stage simulated exploration experiment program for the UZUME project"

Hiroki Manabe, Hideki Kuma, Naohiro Inagawa, Seiki Yoshimori, Wataru Okamoto, Satoshi Mohri, Tetsuya Uedera, Takanobu Maeda, Kiyoshi Horie, Ryuji Oura, Danishi Ai, Itsuki Horii

National Institute of Technology, Sasebo College Research Report No.59, pp114 - 121,

Issued 2023-01-31

<http://id.nii.ac.jp/1416/00000916/>

"Interdisciplinary Fusion Teaching Materials for Cultivating Glocal Literacy -Vertical Holes-Earth Analog Topography of Underground Cavities and Underground Cultural Heritage-"

Hiroki Manabe, Kiyoshi Horie, Ryuji Oura, Takanobu Maeda, Satoshi Mohri, Hideki Kuma, Wataru Okamoto,

Wataru Matsuhiro, Danishi Ai, Itsuki Horii

National Institute of Technology, Sasebo College Research Report No.59, pp122 - 131, Published 2023-01-31

<http://id.nii.ac.jp/1416/00000917/>

Space Science and Technology Union 66 Program:

<https://branch.jsass.or.jp/ukaren66/wp-content/uploads/sites/38/2022/11/ba04dd2f4d8a81221932c4ddf0edfad8.pdf>

page 23

The practice of drone and 3D modeling courses aiming to cultivate "glocal literacy"

<

<https://researchmap.jp/ky40509691/presentations/41266095>

Kiyoshi Horie, Hiroki Manabe, Ryuji Oura, Hideki Kuma, Tatsuki Horii, Wataru Okamoto 28th Technical College Symposium in Yonago January 28, 2023

3D Modeling of the Hario Transmitting Station and Katashima Torpedo Test Site Ruins and Utilization as Tourism Resources

<

<https://researchmap.jp/ky40509691/presentations/41802643>

Wataru Inaoka, Hikaru Fujisawa, Kiyoshi Horie, Wataru Okamoto, Itsuki Horii

Hosted by the Former Naval Port City Japan Heritage Utilization Promotion Council

Former Naval Port Four Cities Naval Base Japan Heritage Symposium in Sasebo (Sasebo Civic Cultural Hall) March 20, 2023

• AGU 2022 iPoster

Air pollution collection and XAFS analysis by drone

Wataru Okamoto, Shinya Yagi 1), Tatsuki Horii 2)

1) Nagoya University 2) AeroFlex

<https://agu2022fallmeeting-agu.ipostersessions.com/default.aspx?s=38-15-5A-B8-A9-F5-23-94-01-AB-2A-F8-BA-82-CF-E7>