

Tohoku University

Windnauts

(Human-Powered Airplane)

February 16, 2023



Department of Mechanical and Aerospace Engineering

Ryosuke Kano

About us

- ✓ Our club Tohoku Univ. “Windnauts” has been designing, producing, and flying human-powered aircrafts (HPA) since 1993.
- ✓ We’ve been competing for flight distance in the TV program “Birdman Rally”, and we have a record of five championships in the past.



The process to the competition

Workers



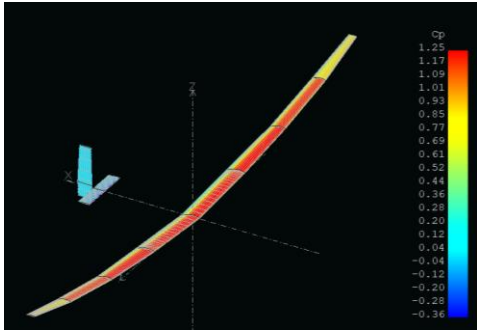
Testing

Competition

Production



Design



The process to the competition

Pilot

Physical training



Flight simulator



RC airplane



Test flight (TF)



@Campus Ground



@Kakuda Glider Field

Competition



“Wait for me, Platform!”

Influence of pandemic

Due to the pandemic, our activities at the university were restricted.

- ✓ We didn't have enough time to complete our aircraft.
 - We decided to **divert** 2020's HPA "Sun".
 - We diverted many **wing frames**, **cockpit frame**, **drive system**...
- ✓ We were losing traditional production **skills** and **technology**.
 - Thanks to the help of our alumni, we were able to take over the technology.



Test flight (Sun)



Production of a spar joint

Design

Concept

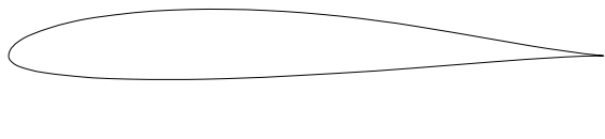
“Get the best out of Pilot’s physical strength and skills”

Specification

- ✓ Reduced power requirement
- ✓ Suitable controllability and stability
- ✓ Large flight envelope

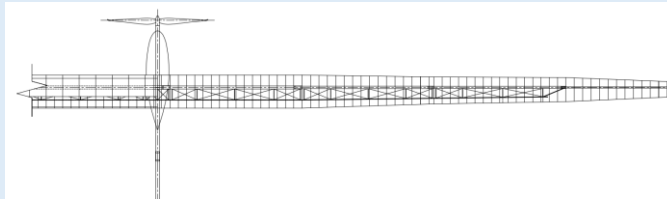
Design

Adoption of a new airfoil



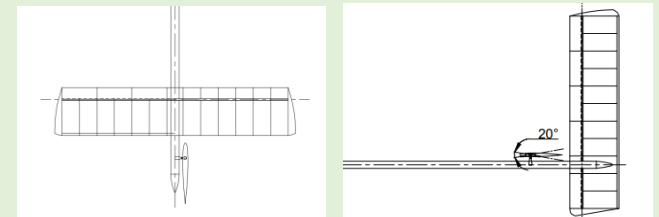
DAE-41 camber modified

High aspect ratio



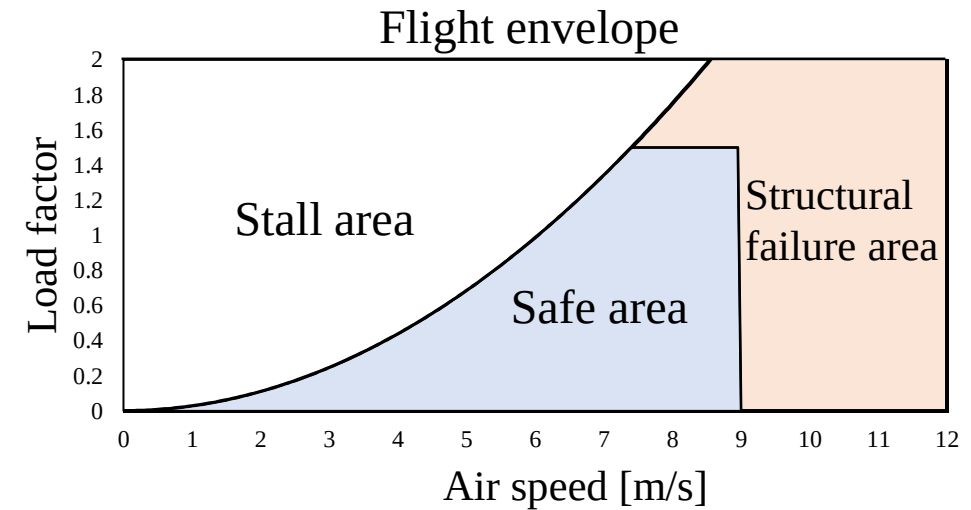
Aspect ratio : 37.7

Large tail volume



horizontal stabilizer : 0.415

Vertical stabilizer : 0.0145



Production

Propeller

Spar : CFRP
Rib & Plank : Balsa



↑ Spar & Rib

Drive system



↑ Above gear box

Wing

Spar : CFRP
Rib & Plank : Styrofoam



↑ Spar & Rib

Faring

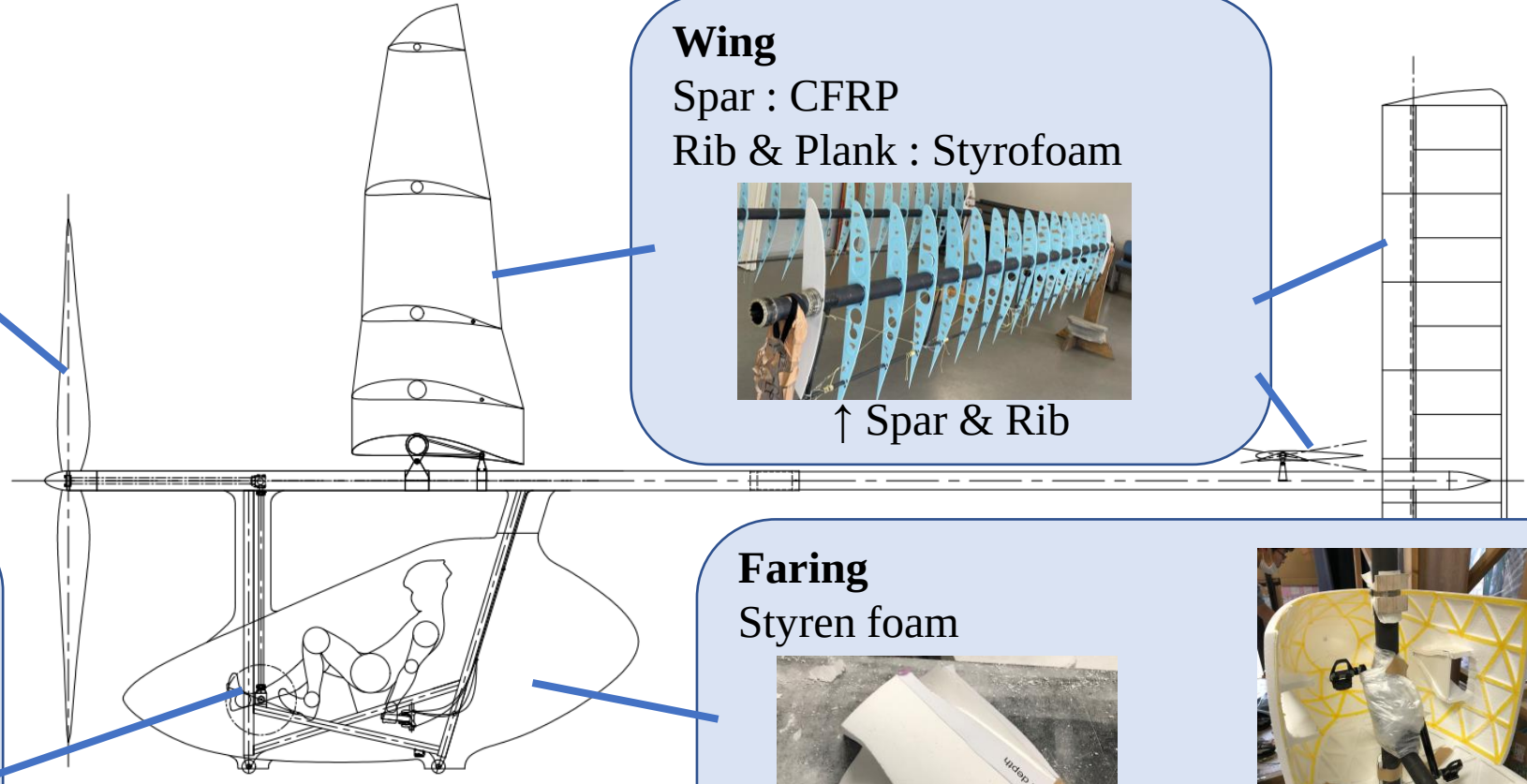
Styren foam



↑ A part with intake

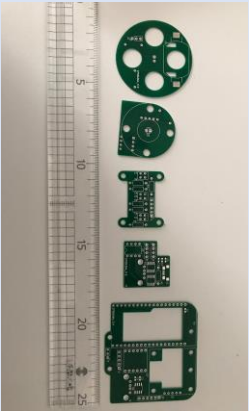


↑ Inside

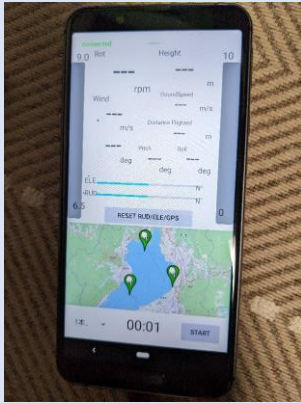


Production

Avionics



↑ Circuit board



↑ Display

Steering system



↑ Control stick

Cockpit

Frame : CFRP

Saddle & Backrest : Styrofoam, CFRP



↑ Inside the saddle



↑ Frame

Testing

Load test

Ensured airworthiness of wing structure (1.5 G)



Drive system test

Check operation of drive system and propeller



Steering system test

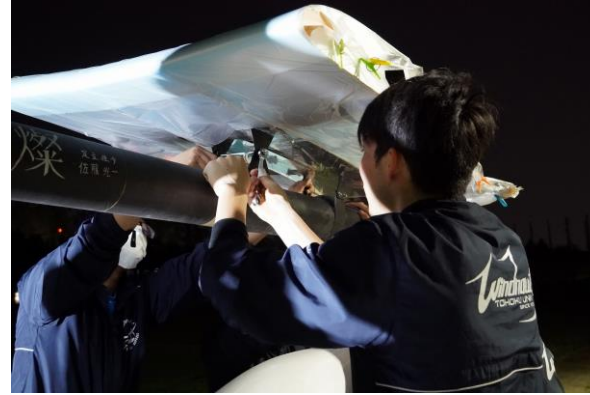
Check and adjust operation of control stick and tailplanes



Testing

Test Flight

- ✓ Assembly test
 - Check the **assembly procedure**
- ✓ Running test
 - Check the aircraft behavior and wing balance
- ✓ Jump test
 - Check the center of gravity
 - Get the feeling of floating
- ✓ Steady flight
 - Fly longer distance and train of aircraft handling
- ✓ Advanced flight



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Testing

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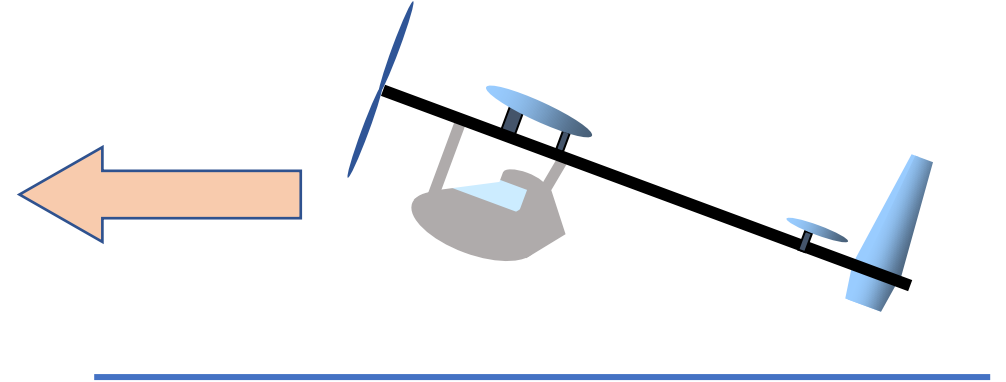
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Advanced flight

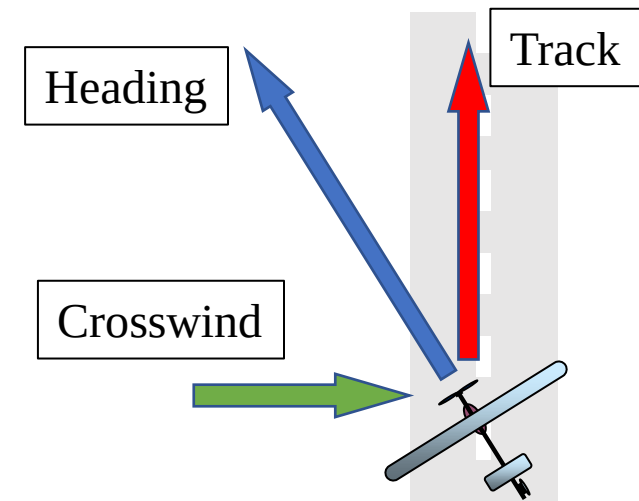
✓ Pitch-up flight

- Flight by **elevator** operation
- Increasing the AoA reduces **speed** and **power**.
- While power can be reduced, it becomes **sensitive to wind**.



✓ Drift flight

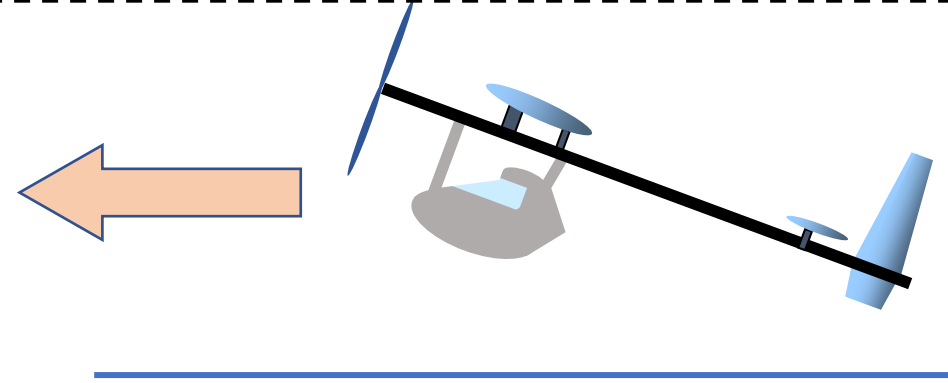
- Flight by **rudder** operation
- In crosswind conditions, the heading and track are different.



Advanced flight

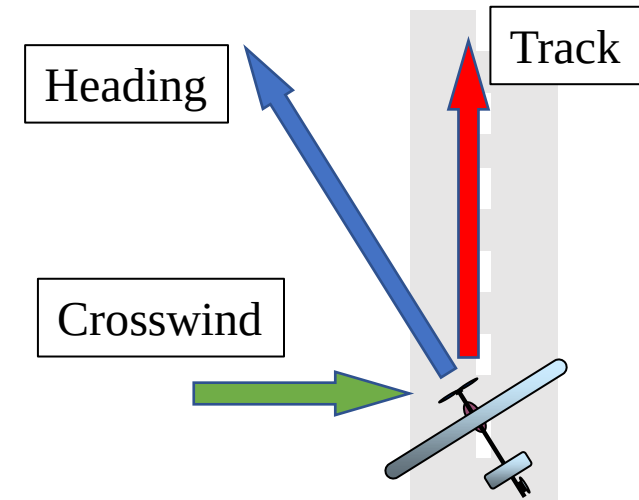
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Pitch-up flight

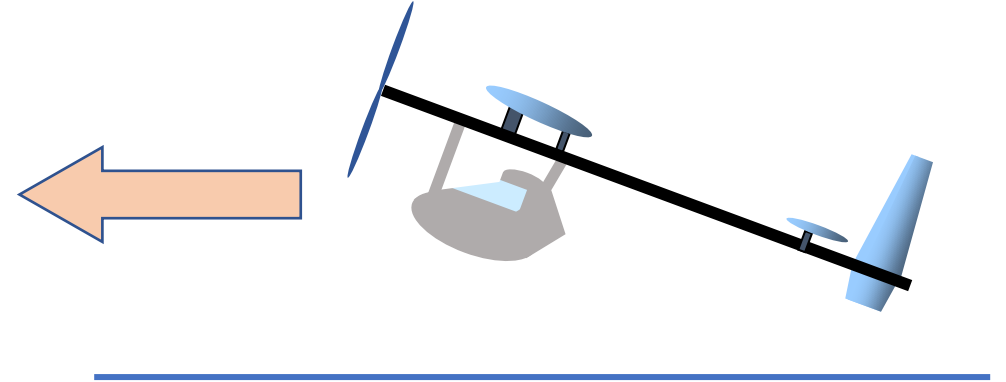
You can find it here ↓↓

<https://www.youtube.com/watch?v=6jbEyTQh7K0>

Advanced flight

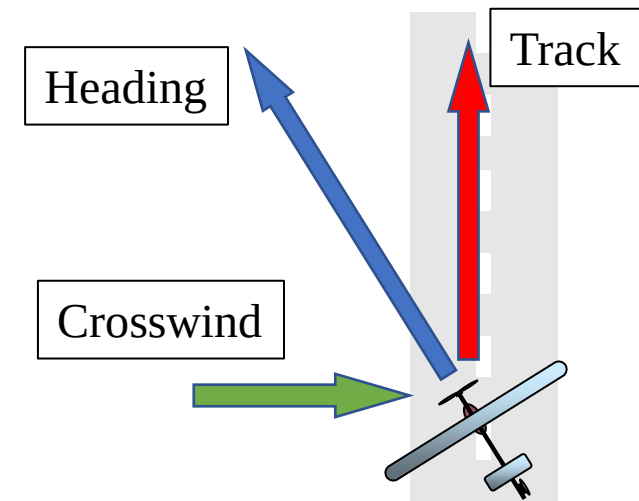
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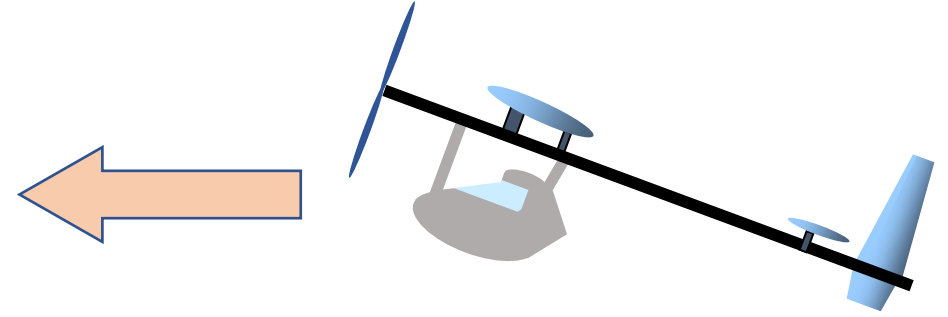
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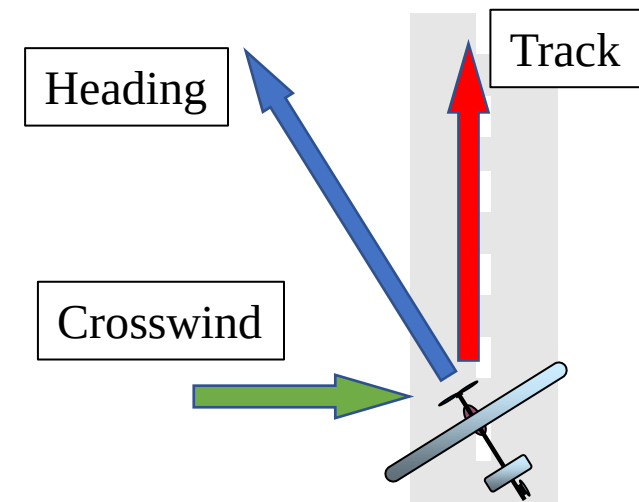
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Drift flight

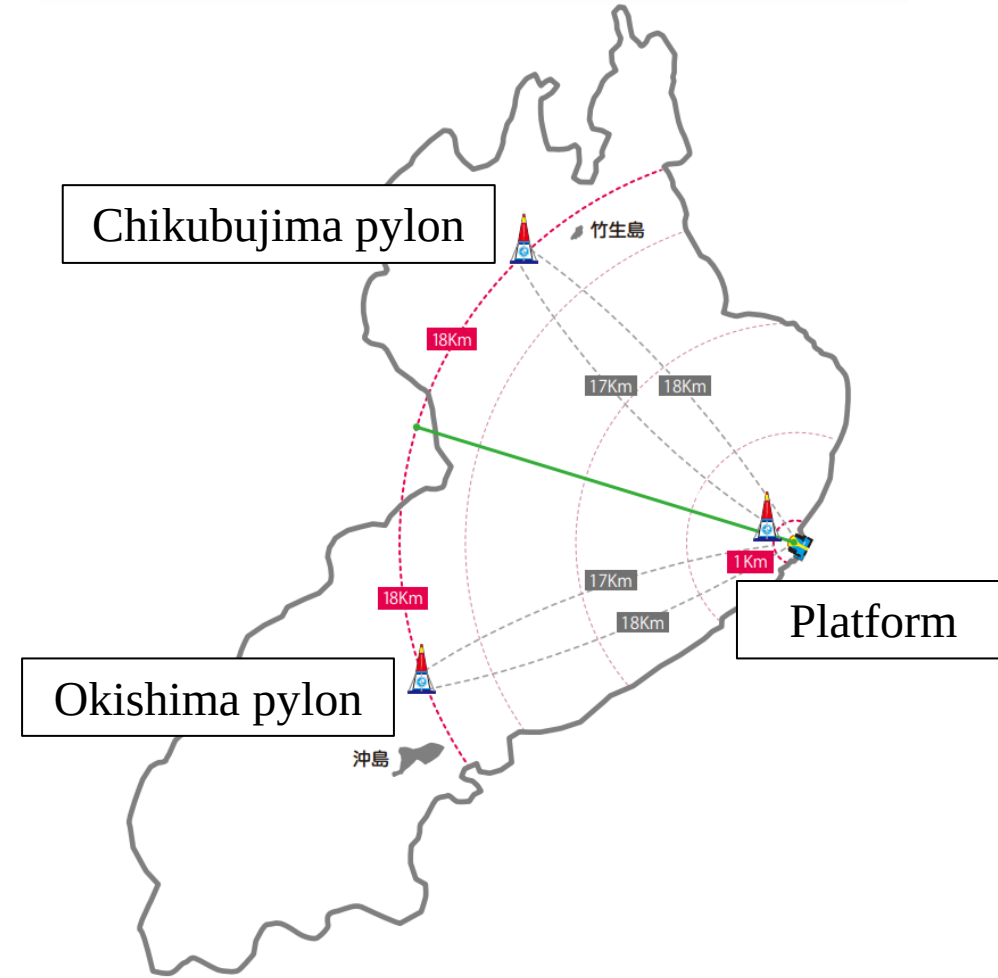
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<https://www.youtube.com/watch?v=IDz2nTBtYC4>

Competition

Rules

- ✓ The goal is to complete the southern route and the northern route, for a total of 70 km.
- ✓ Pilots can choose whether to complete the southern or northern route first.
- ✓ Pilots have to circle the pylons when turning around.
- ✓ If either route is cleared, the pilot have to then take the other route.



Competition

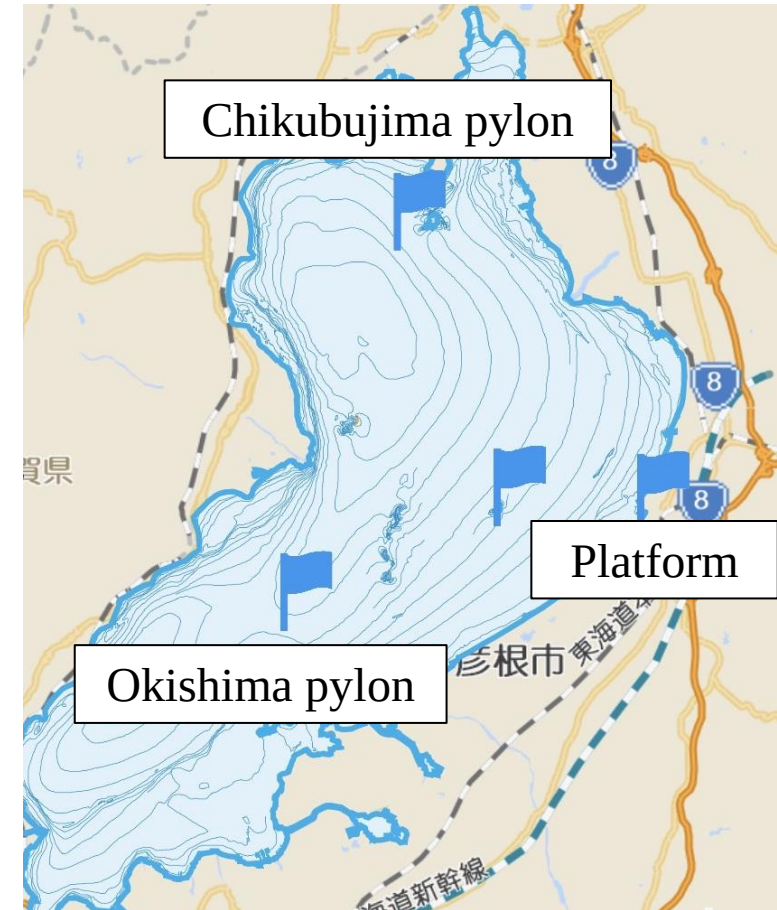
Condition of the day

Based on many other flights and forecast, We estimated that...

- ✓ Northerly wind were developing at the center of the lake
- ✓ Lake land wind were developing near the shore

Flight strategy

- ✓ We chose the southern route with the aim of catching the tailwind and gaining ground speed.
- ✓ To avoid the lake land wind, do not aim for Okishima immediately after take-off, but aim for the center of the lake.
- ✓ In areas with weak wind, pitch up to save his energy.



Competition

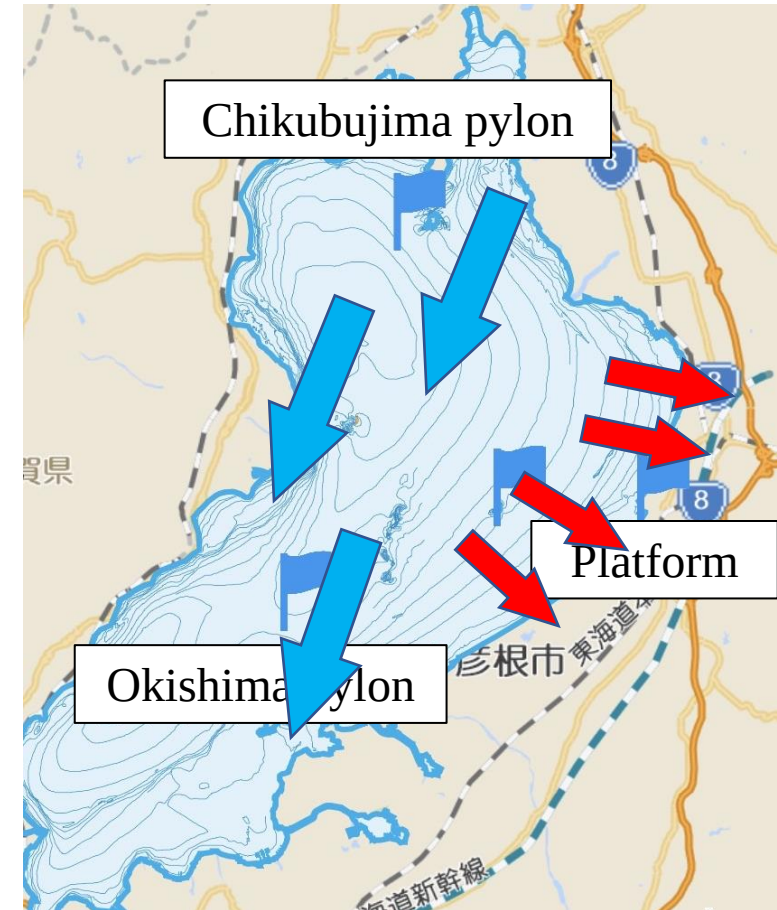
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Result

Flight distance : 36,868.80 m

Flight time : 111 minutes

Rank : 1st

WE WON THE COMPETITION!

&

WE SET A TEAM RECORD!



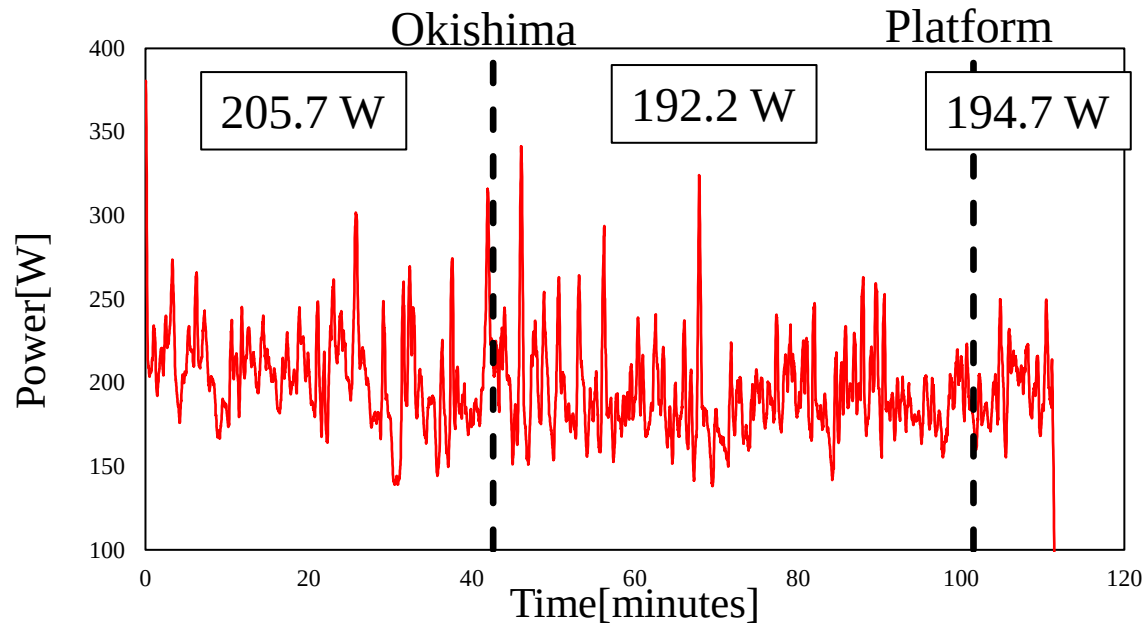
Flight route



Rank	Record	Team
1	36,868.80 m	Tohoku University
2	14,274.23 m	Osaka Institute of Technology
3	6,429.12 m	Tokyo Metropolitan University

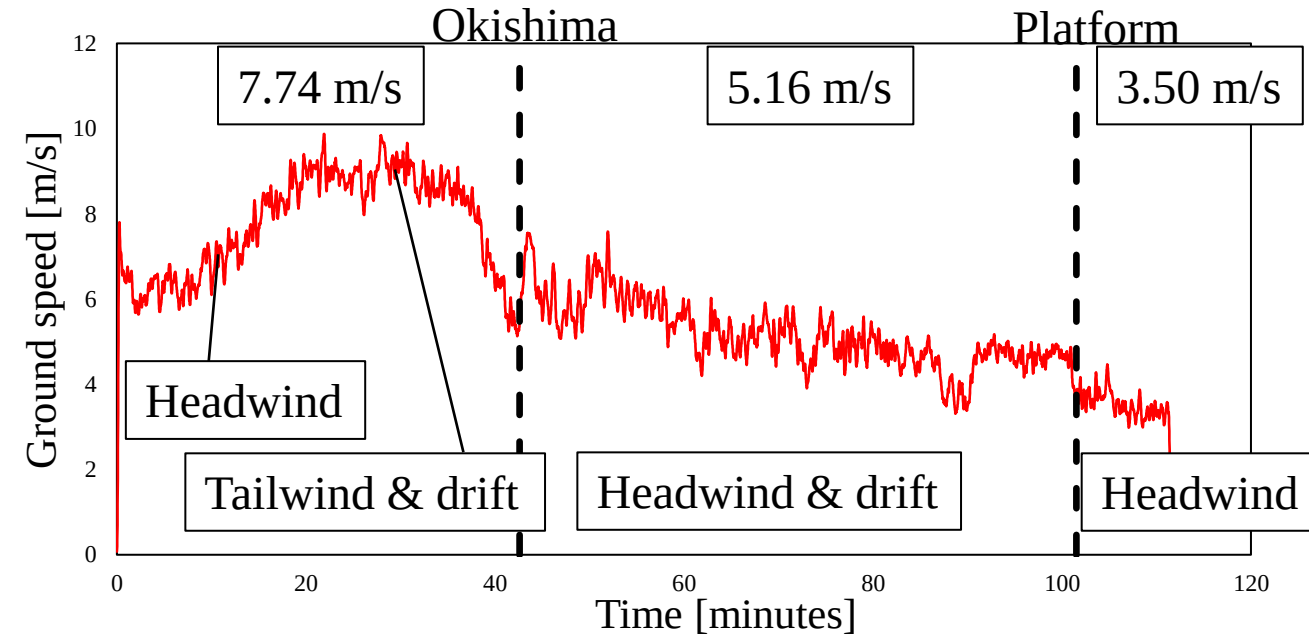
Result analysis

Power result



- ✓ Power varies widely from time to time.
- ✓ Pitch-up flight reduced the average power.

Ground speed result



- ✓ Ground speed reflects the wind conditions at the time.
- ✓ Main wind shifted from lake wind to northerly wind.
- ✓ Wind conditions were what we assumed they would be.

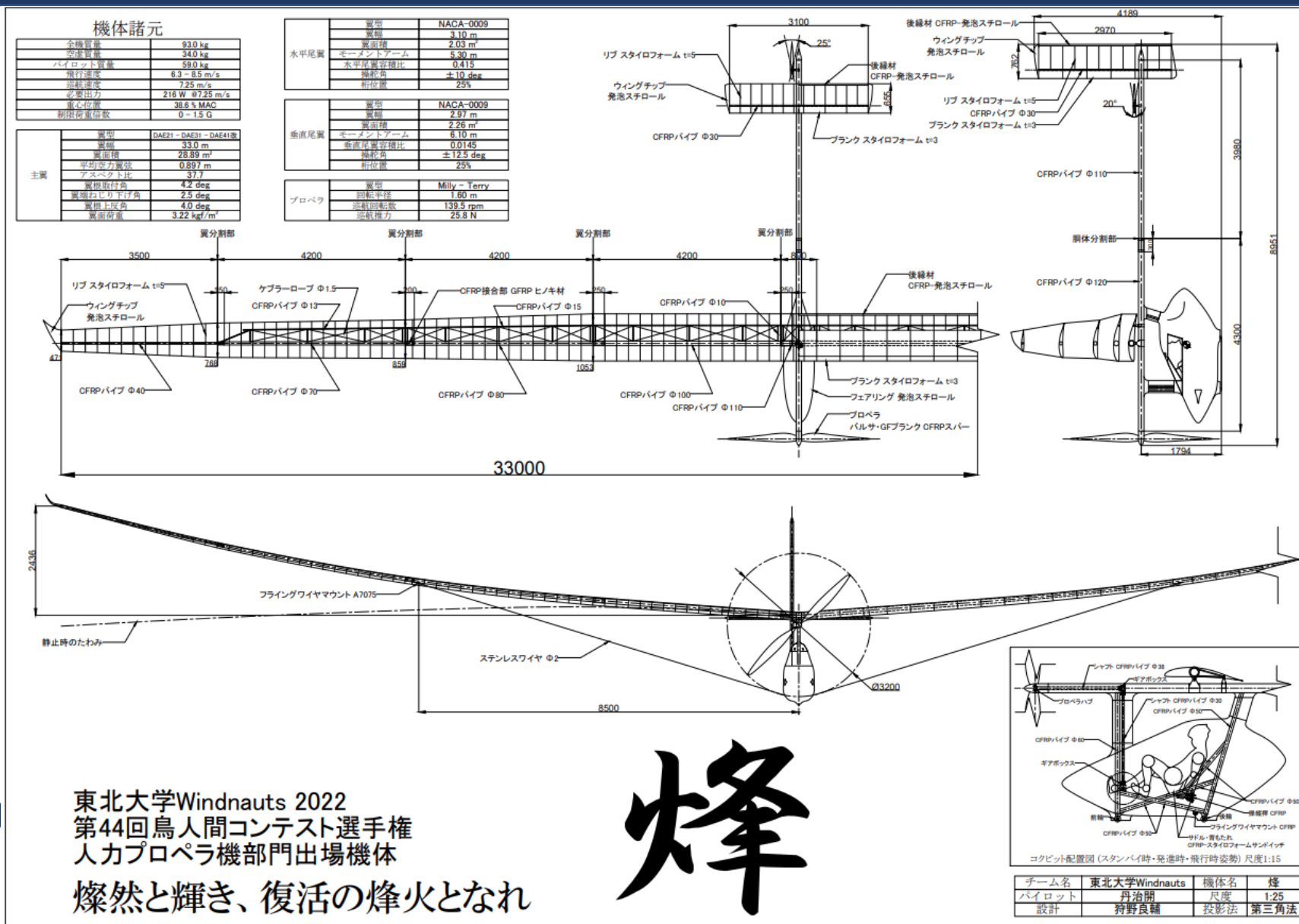
Conclusion

All these elements contributed to the victory.

- ✓ Low-power design
- ✓ Production focused on accuracy
- ✓ High-quality pilot training in the TF
- ✓ Appropriate planning of the strategy ...etc

The pandemic caused some difficulties, but thanks to the help of many people, we were able to achieve this result.

(Appendix) Three views



(Appendix) Specification

Specification	
Gross weight	93.0[kg]
Empty weight	34.0[kg]
Design cruising speed	7.25[m/s]
Need Power	216[W]

Propeller	
Airfoil	Milly-Terry(original)
Rudius	1.60[m]
Rotational speed	139.5[rpm]
Thrust power	25.8[N]

Main wing	
Airfoil	DAE21 - DAE31 - DAE41modified
Span of wing	33.0[m]
Wing area	28.89[m ²]
Aspect ratio	37.7
Dihedral angle	4.0[deg]
Angle of attack	4.2[deg] – 2.9[deg] – 1.7[deg]