Tohoku University

Windnauts

(Human-Powered Airplane)

February 16, 2023

Department of Mechanical and Aerospace Engineering

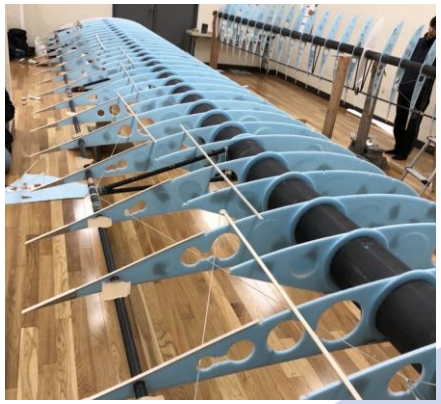
Ryosuke Kano

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.

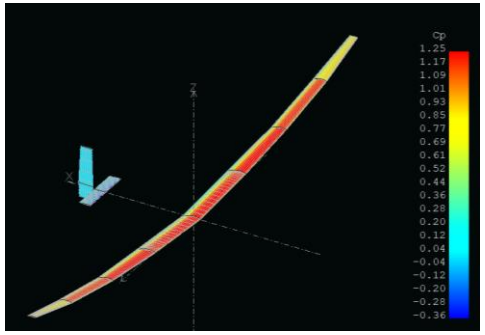
The process to the competition

Workers



Competition

Testing



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…

Test flight (Sun)

✓We were losing traditional production skills and technology.

- Thanks to the help of our alumni, we were able to take over the technology.

Production of a spar joint

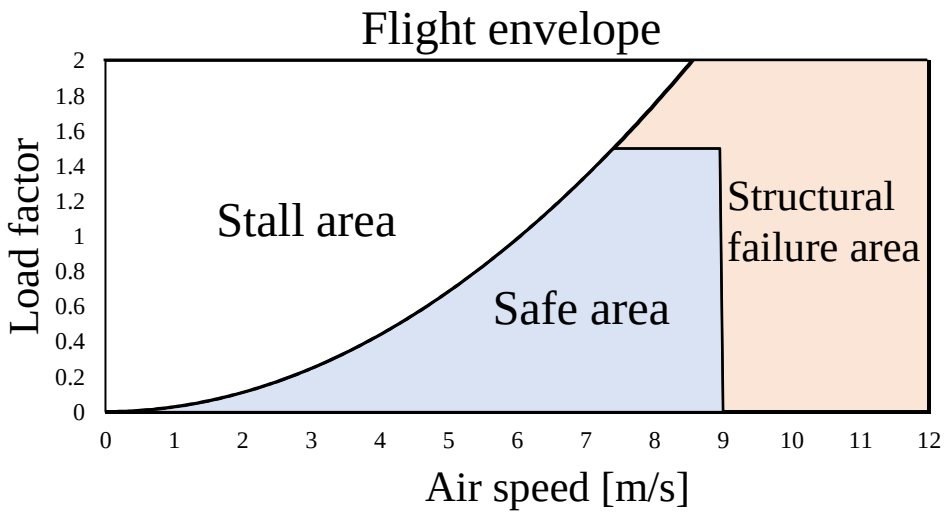
Design

Concept

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

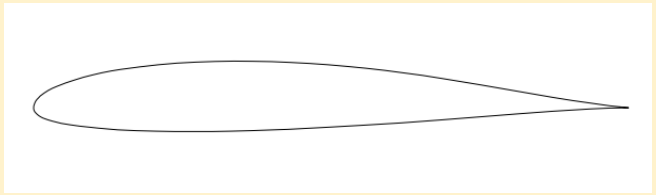
Specification

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



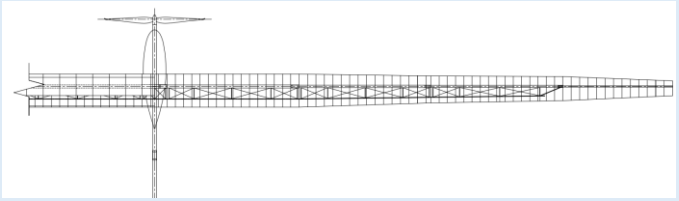
Design

Adoption of a new airfoil



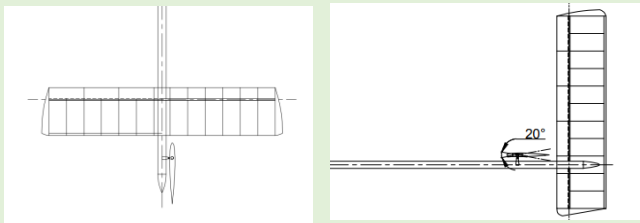
DAE-41 camber modified

High aspect ratio



Aspect ratio : 37.7

Large tail volume



horizontal stabilizer : 0.415
Vertical stabilizer : 0.0145

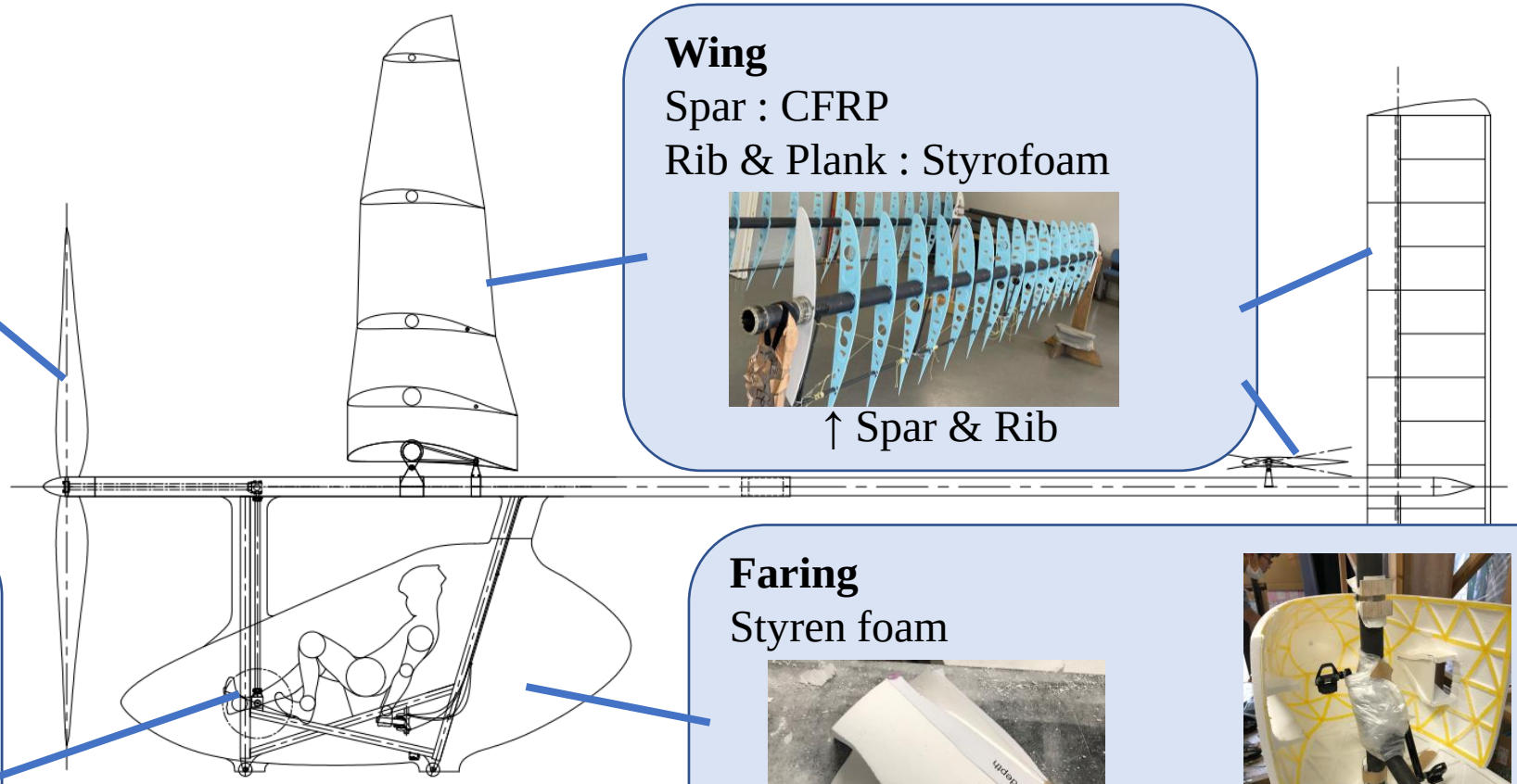
Production

Propeller
Spar : CFRP
Rib & Plank : Balsa

↑ Spar & Rib

Drive system

↑ Above gear box



Wing
Spar : CFRP
Rib & Plank : Styrofoam

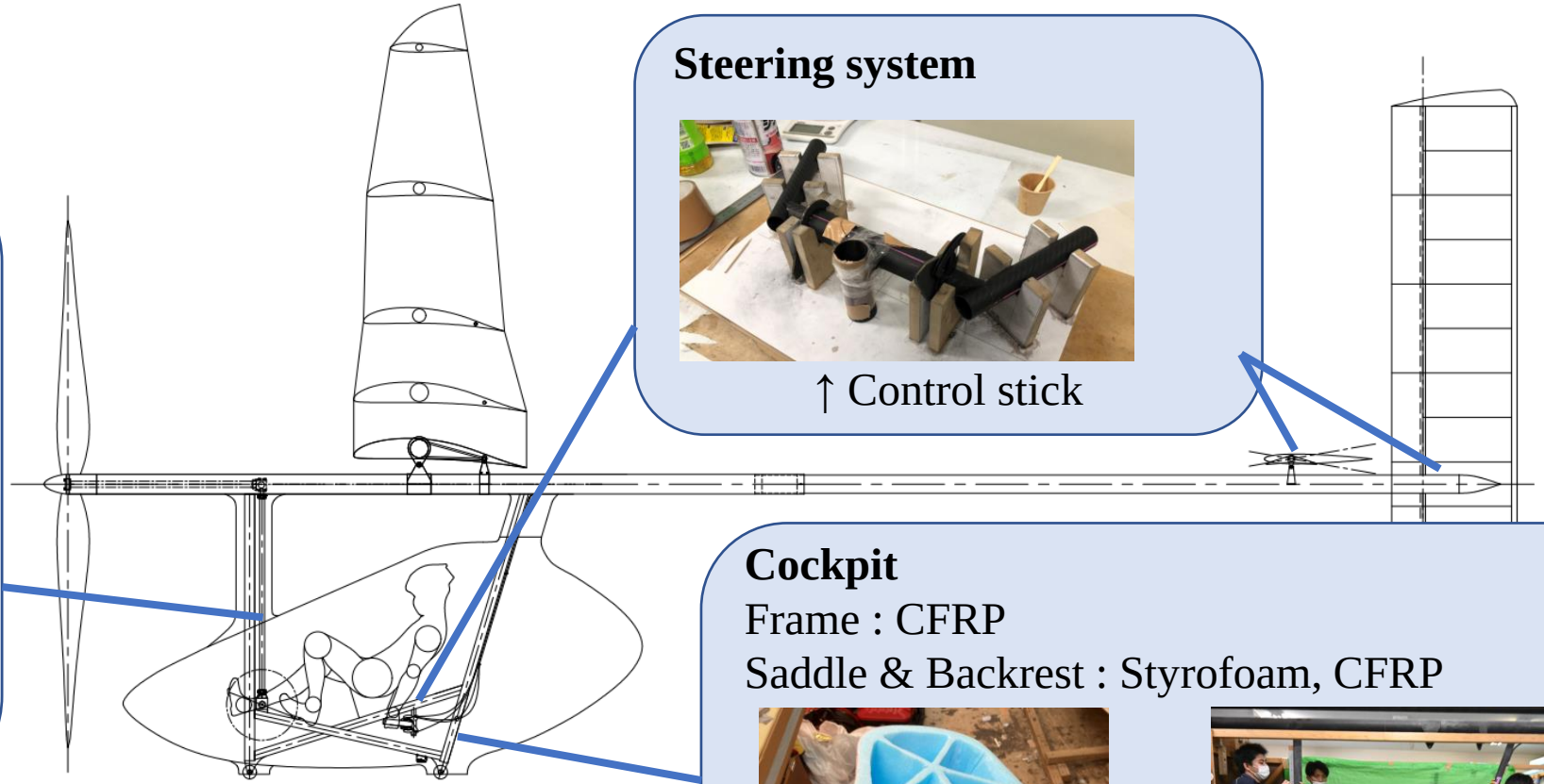
↑ Spar & Rib

Faring
Styren foam

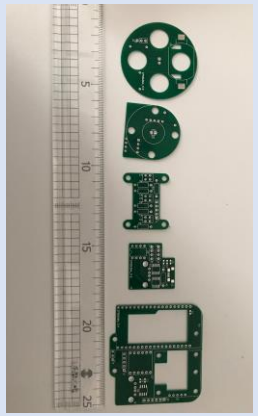
↑ A part with intake

↑ Inside

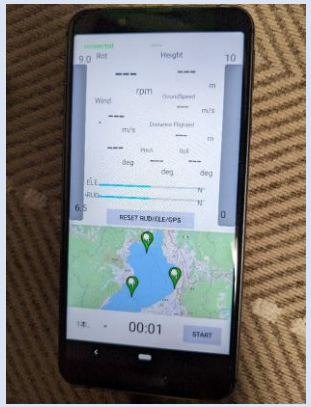
Production



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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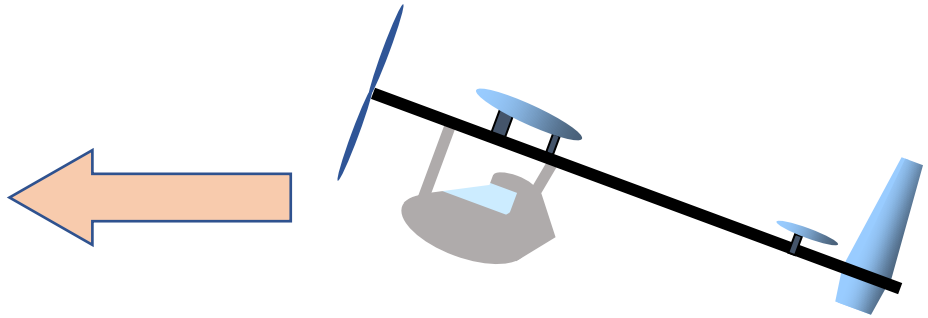
Advanced flight

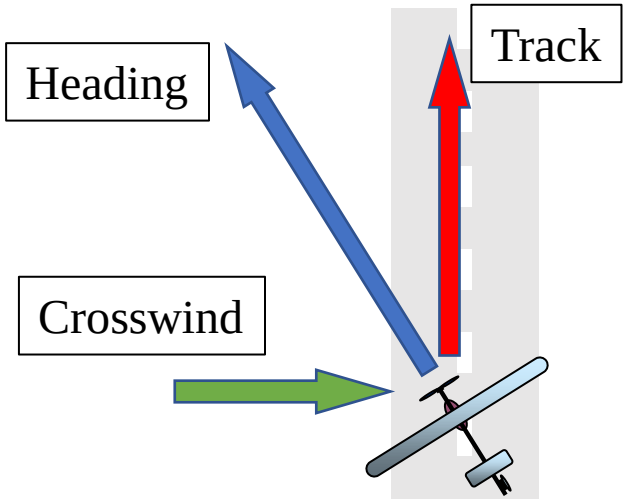
✓Pitch-up flight

- 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.



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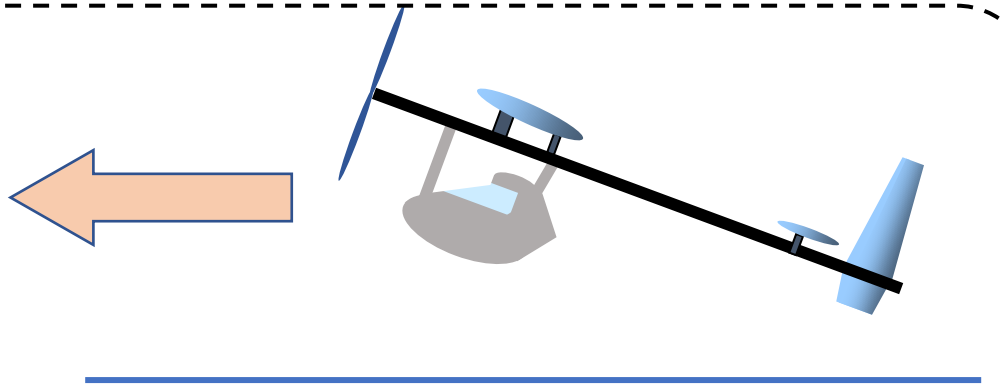

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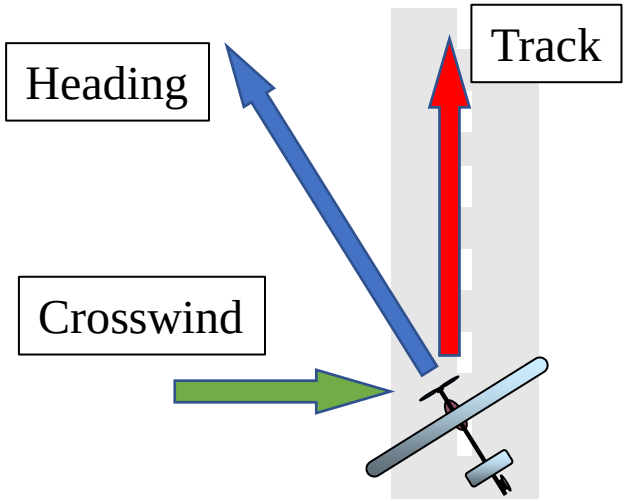

Pitch-up flight

You can find it here ↓↓

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

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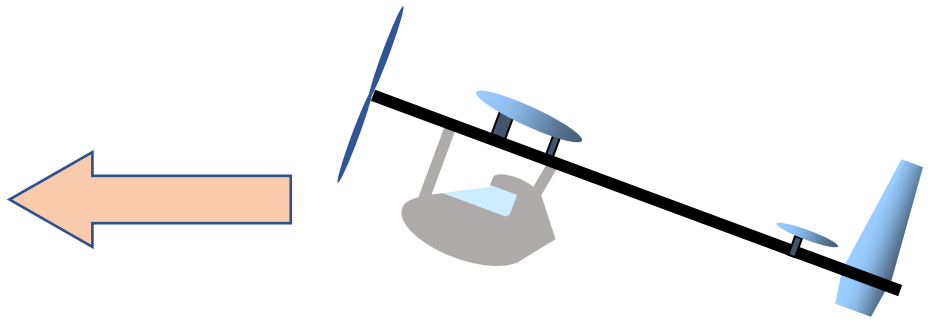

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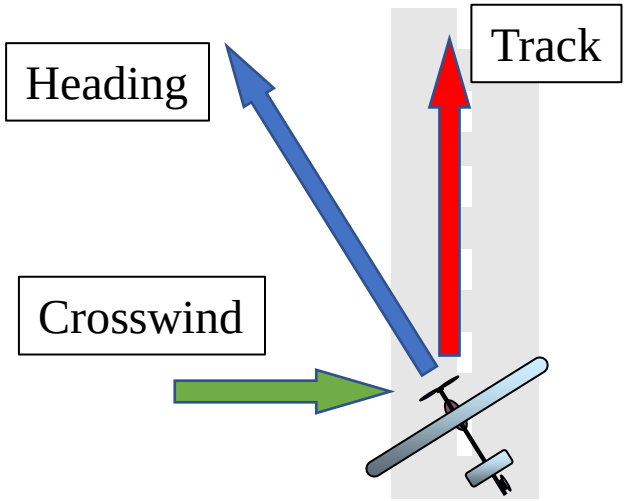

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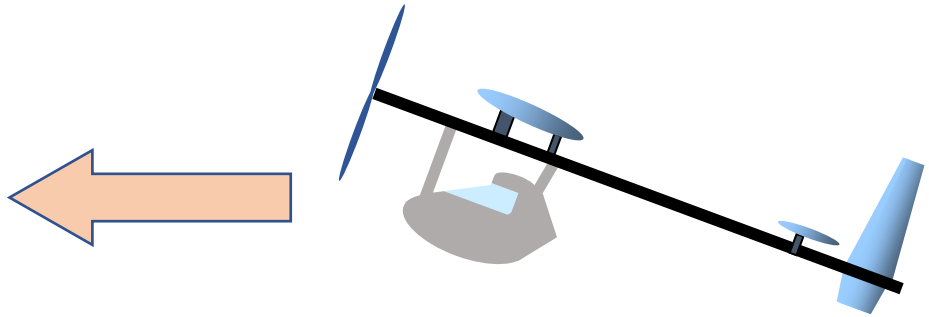

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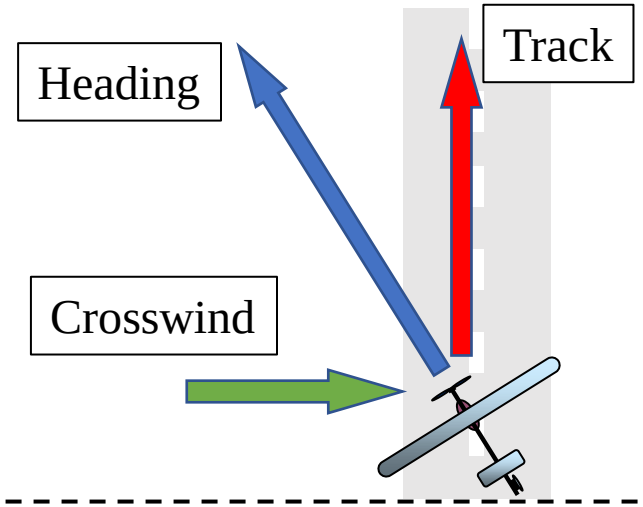

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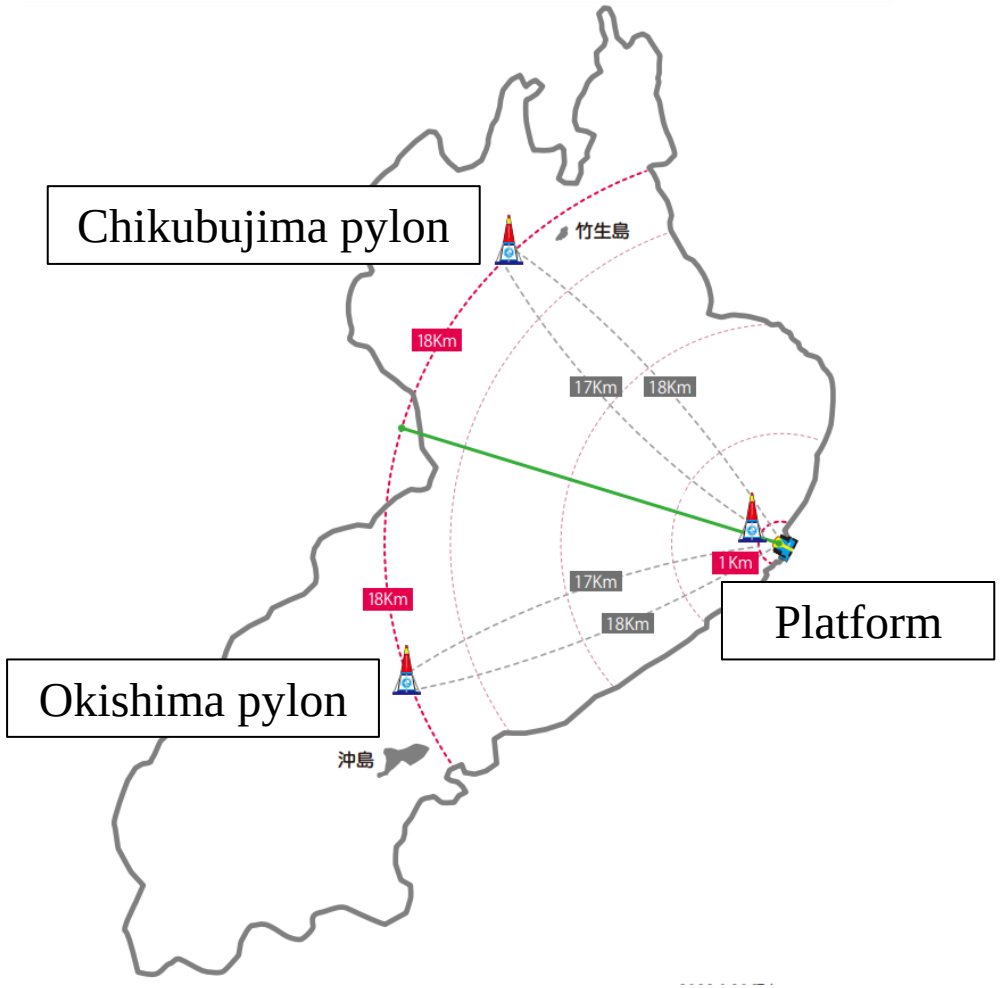
Competition

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

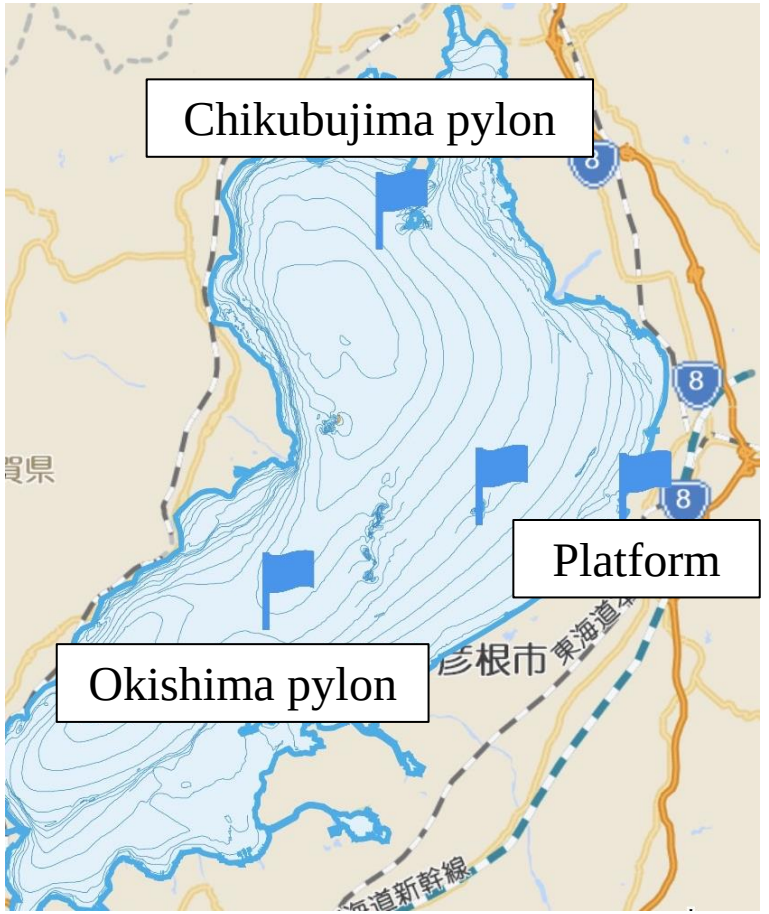
Condition of the day

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.



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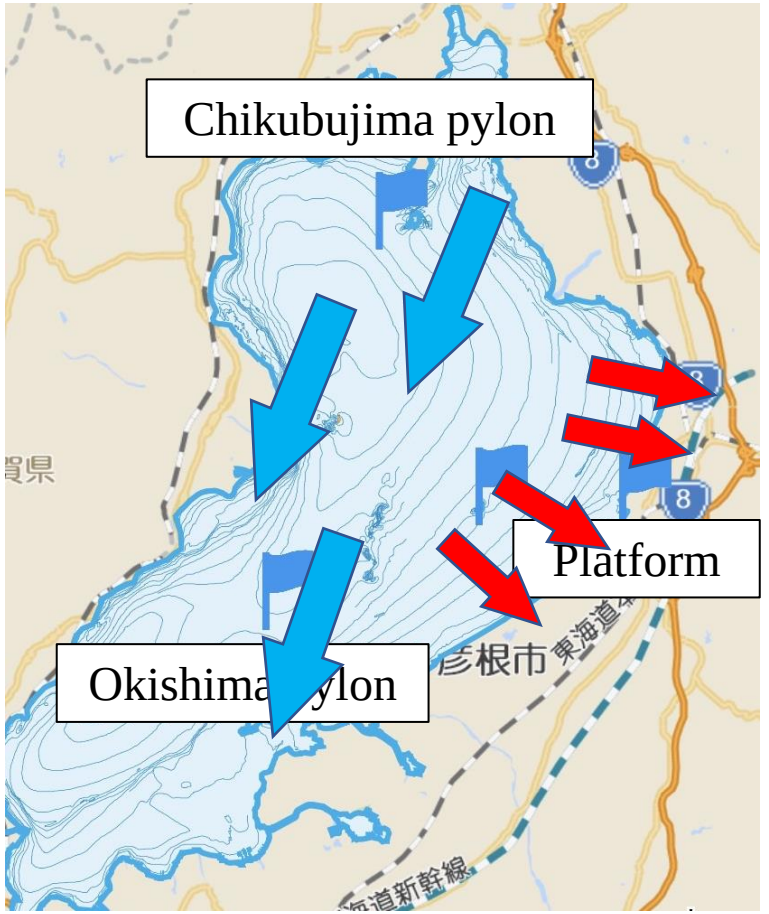

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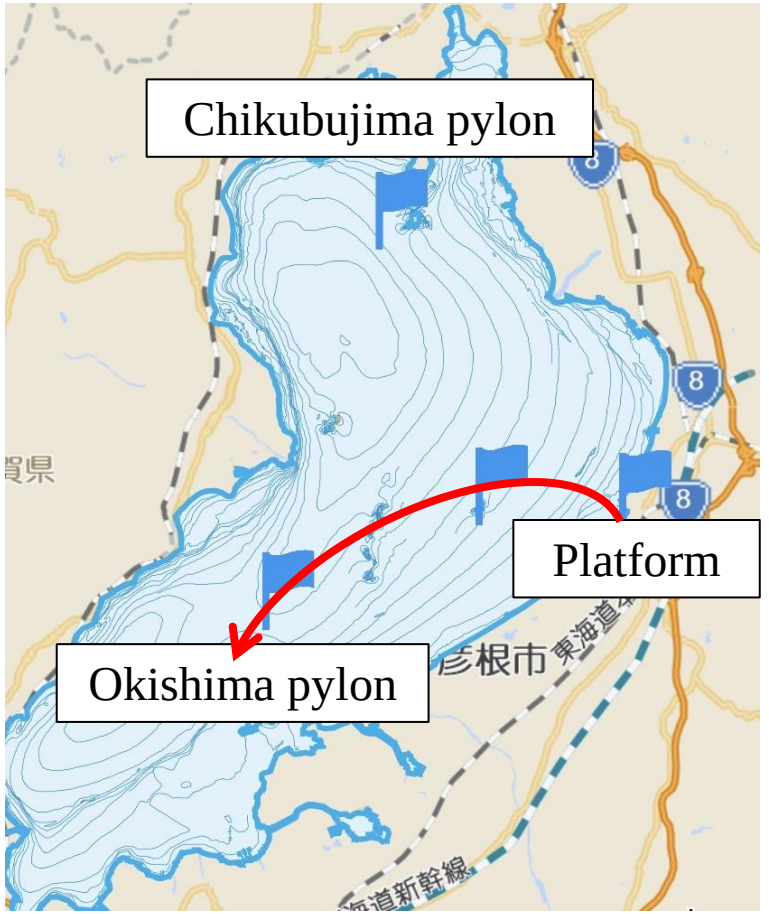


Result

Flight distance : 36,868.80 m
Flight time : 111 minutes
Rank : 1st

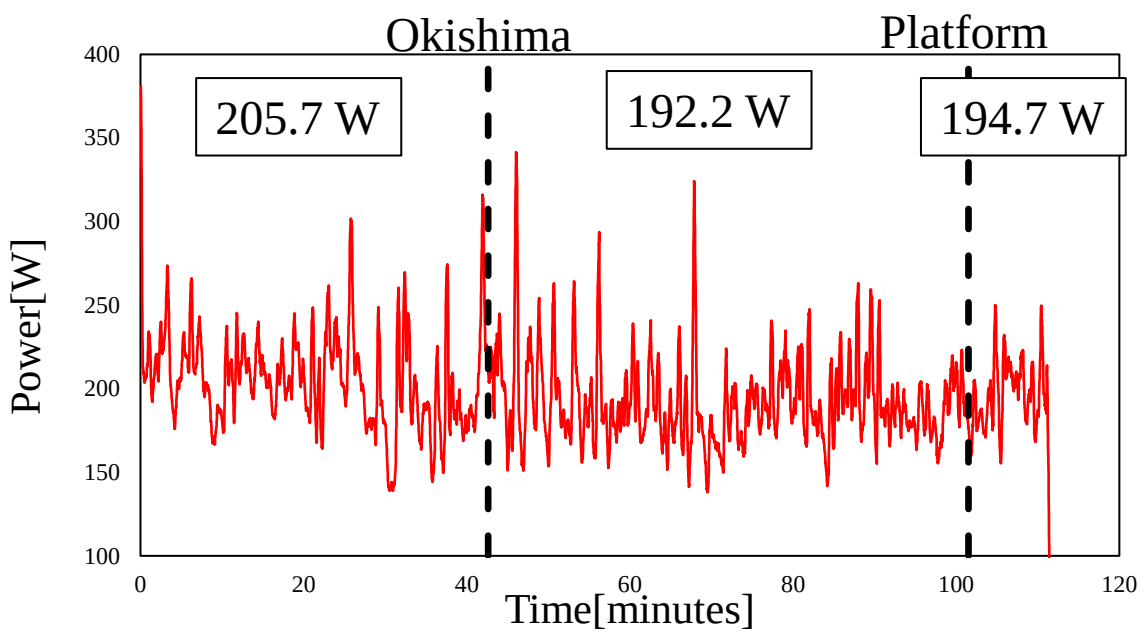
WE WON THE COMPETITION!
&
WE SET A TEAM RECORD!

Flight route

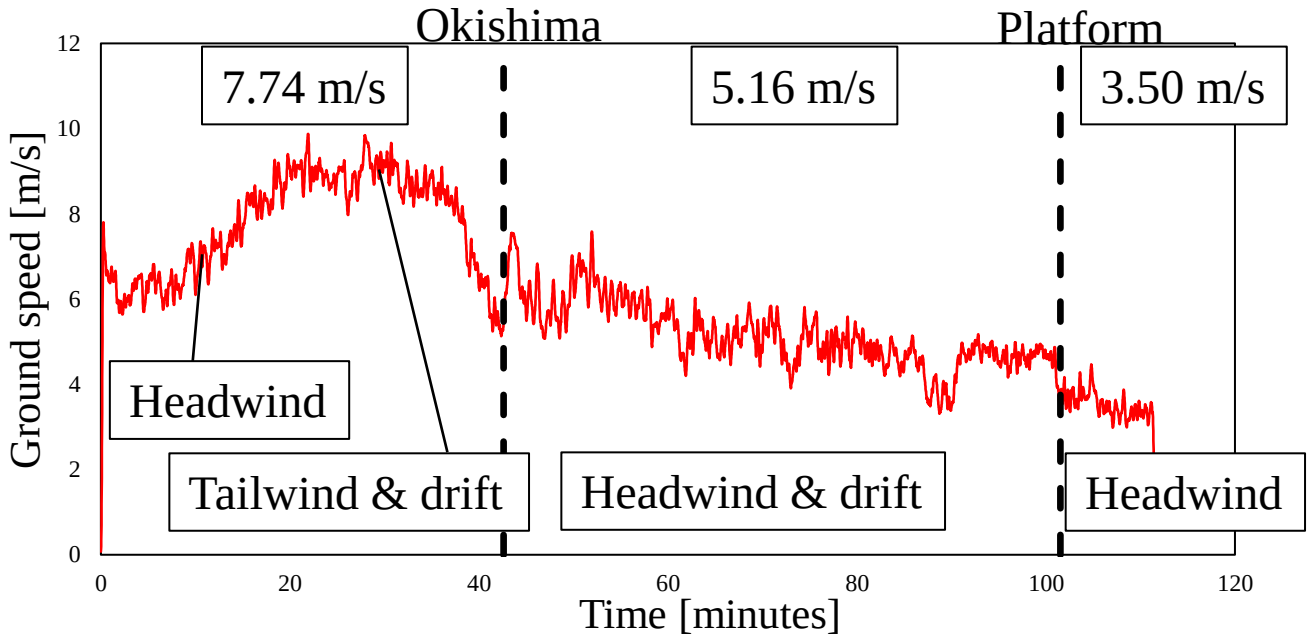
Rank	Record	Team
1	**36,868.80 m**	**Tohoku University**
2	14,274.23 m	Osaka Institute of Technology
3	6,429.12 m	Tokyo Metropolitan University

Result analysis

Power result



Ground speed result



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

- ✓ 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

<u>All these elements contributed to the victory.</u>

✓Low-power design

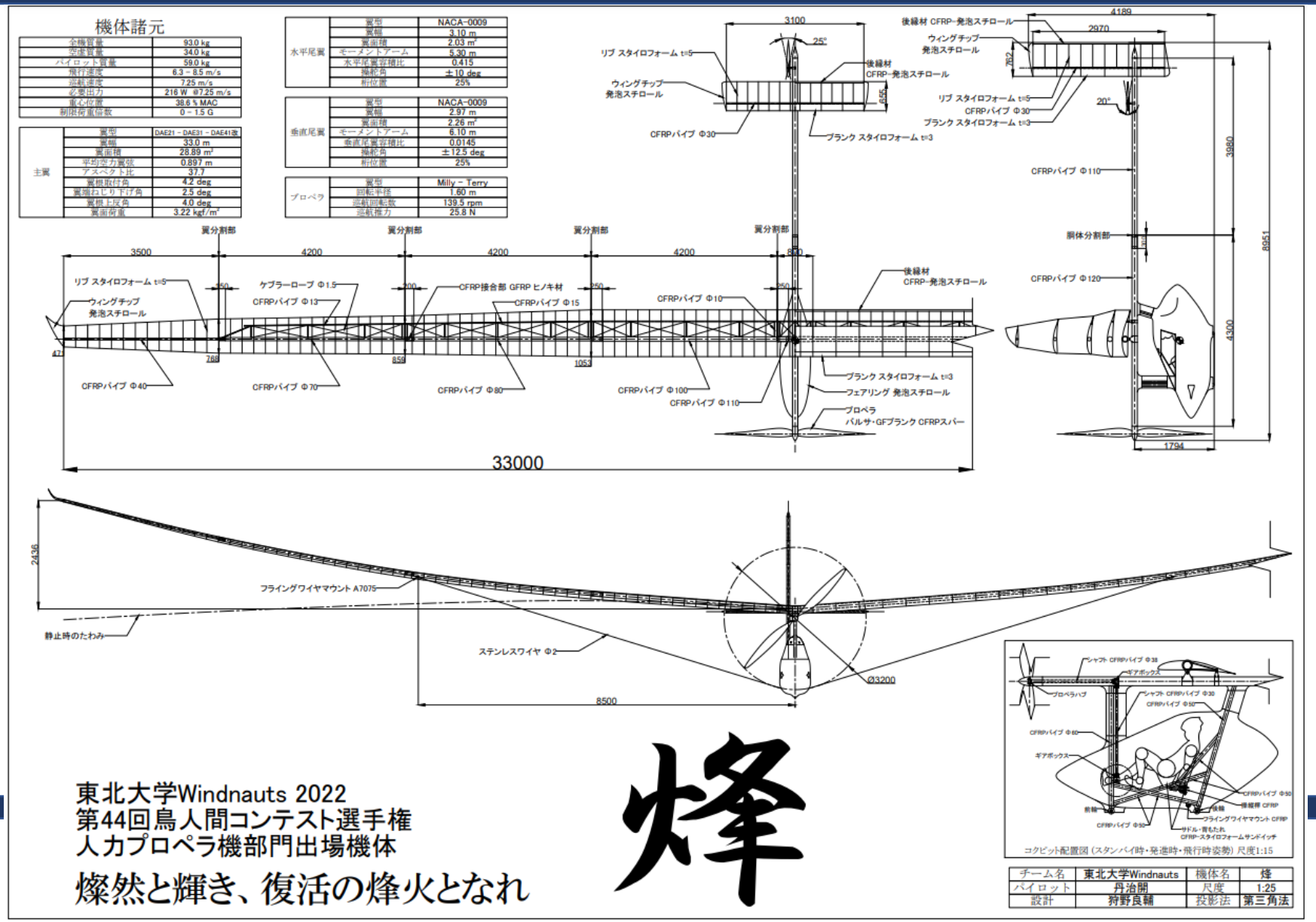
✓Production focused on accuracy

✓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]