Tohoku University

Windnauts

(Human-Powered Airplane)

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Department of Mechanical and Aerospace Engineering

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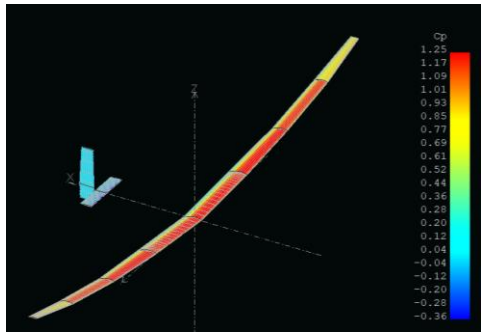
About us

- ✓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 six championships in the past.

The process to the competition



Designing

Producing

Testing

Competition

The process to the competition

Pilot

Physical training

Flight simulator

RC airplane

Test Flight (TF)

Competition

“Mr.Tanji, I exceeded your record !”

New challenges

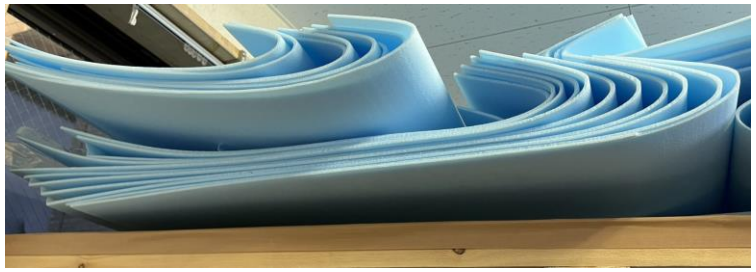
✓Reexamination of wing secondary structure

- From split plank to one-piece molding one

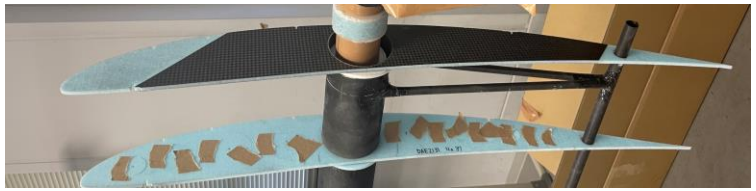
  → Eliminate joints to reduce aerodynamic drag

- Edge ribs of styrofoam sandwiched between carbon fiber

  →Stiffer with the same lightness



One-piece molding plank

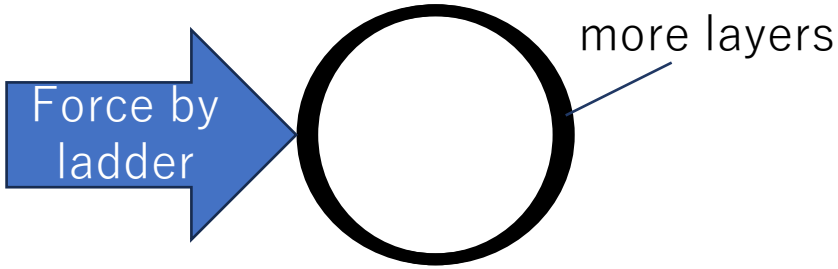


Edge rib with carbon fiber

✓Renewal of tailpipe

- Reduced vertical layers and increased horizontal layers

  →Reduced weight and improved rudder response



Cross-sectional image of tailpipe

New challenges

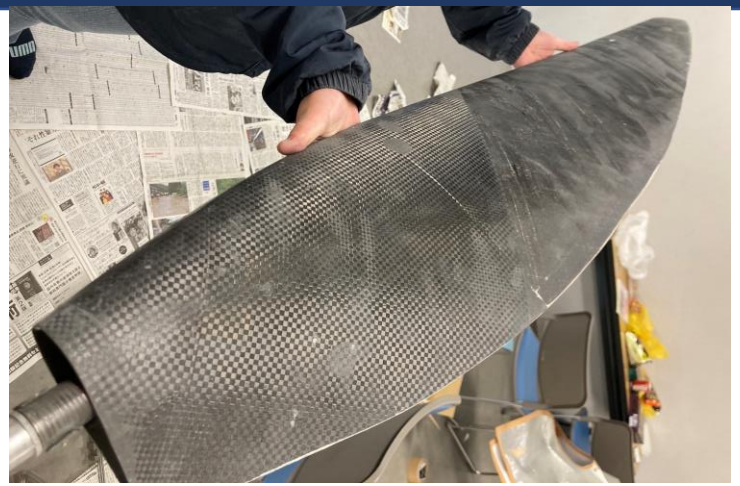
✓Carbon propeller

We made a prototype carbon propeller. (December 2022)

Good points	Bad points
- Good moisture resistant	- High difficulty of production
- Lightweight and rigid	- Cost a lot of money

Future

The team's juniors have been conducting spinning tests with new carbon propellers and will use them for Test Flight in 2024.



Prototype carbon propeller

Production scene

Design

Target

“To win the competition again and set a longer record ”

Specification

✓ Smallest drag and power in Windnauts history (216→203 W)

✓ Lightweight and rigid airframe (94→87 kg)

✓ Low steady-state speed (7.2 m/s)

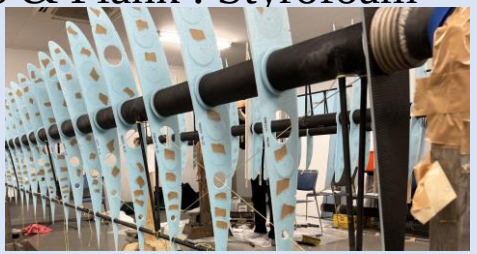
✓ Low wing loading (3.10 kgf/m^2)

→ Flying at low speeds to reduce power requirements, and aiming for long-distance flight.

Production

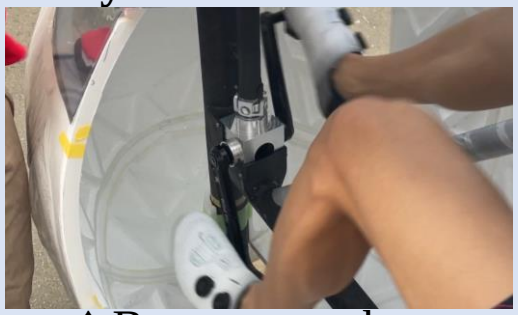
Propeller
Spar : CFRP
Rib & Plank : Balsa

Wing
Spar : CFRP
Rib & Plank : Styrofoam



↑ Spar & Rib

Drive system



↑ Bottom gear box

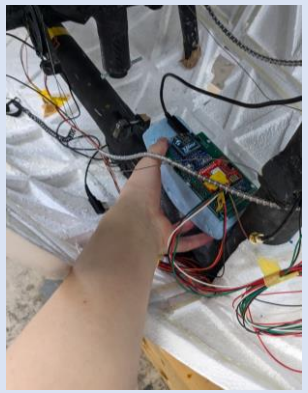
Faring
Styren foam

↑ intake

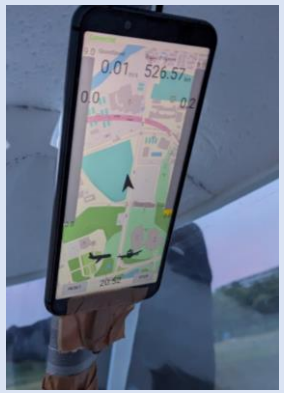
↑ Inside

Production

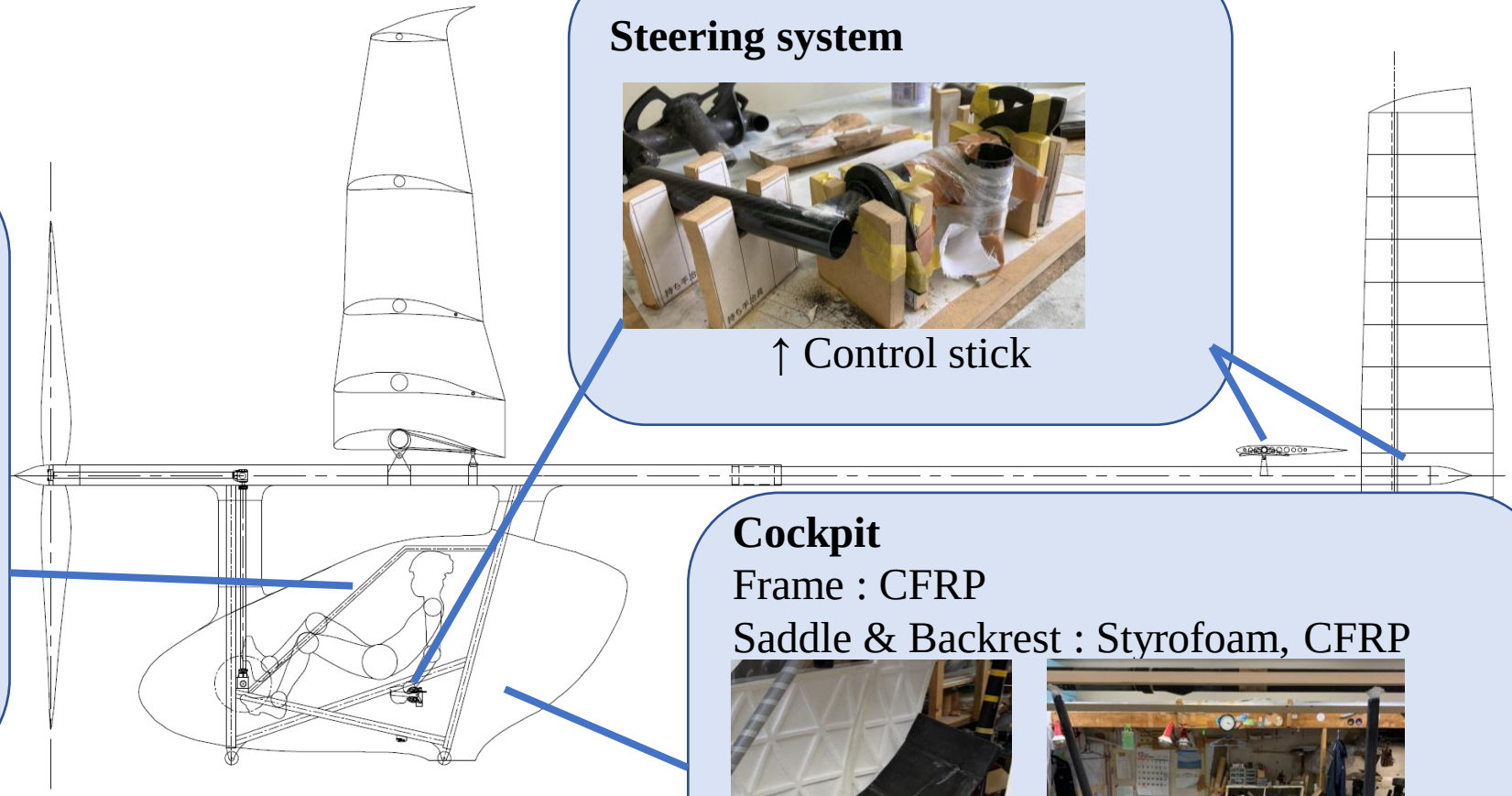
Avionics



↑Circuit board



↑Display



Steering system

↑ Control stick

Cockpit

Frame : CFRP

Saddle & Backrest : Styrofoam, CFRP

↑ 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 Flights

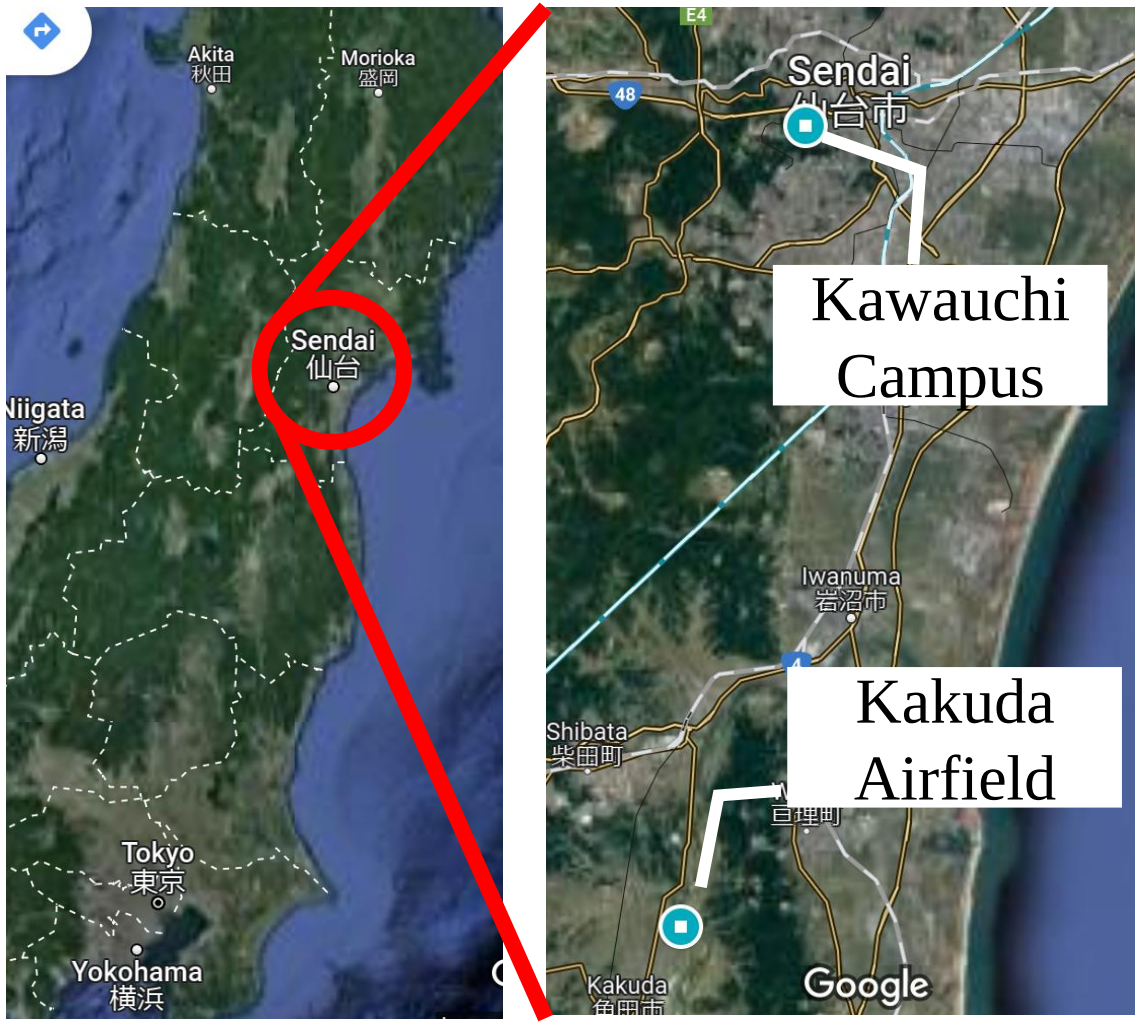
purpose

- ✓ Training of the pilot and the members.
- ✓ Check-up of assembly correctness
- ✓ Training of airplane handling

→High quality Test Flights are the key to flying safely in the competition.

Location

- ✓ at Kawauchi Campus
- ✓ at Kakuda Airfield



Testing

Test Flights at Kawauchi campus

Menu

✓ Assembly test
✓ Running test
✓ Adjustment of center of gravity
✓ Elevator test
✓ Steady flight

Good points	Bad points
- On weekdays	- Short runway (100 m)
- Free	- Slow flight speed (7.20→6.50 m/s)

Dates: 5/10, 5/13, 5/17, 5/19, 5/25, 5/31, 6/4, 6/21, 6/27

Test Flights at Kawauchi campus

5thGTF 飛行試験 7本目 横 後ろ2023/05/25 https://www.youtube.com/watch?v=qg0pFEE67fY

Testing

Test Flights at Kakuda Airfield

Menu

✓ Adjustment of center of gravity (design speed)
✓ Elevator test
✓ Steady flight
✓ Rudder test
✓ Advanced flight

Good points
- Long runway (400 m)

Bad points
- Only on weekends
- High cost

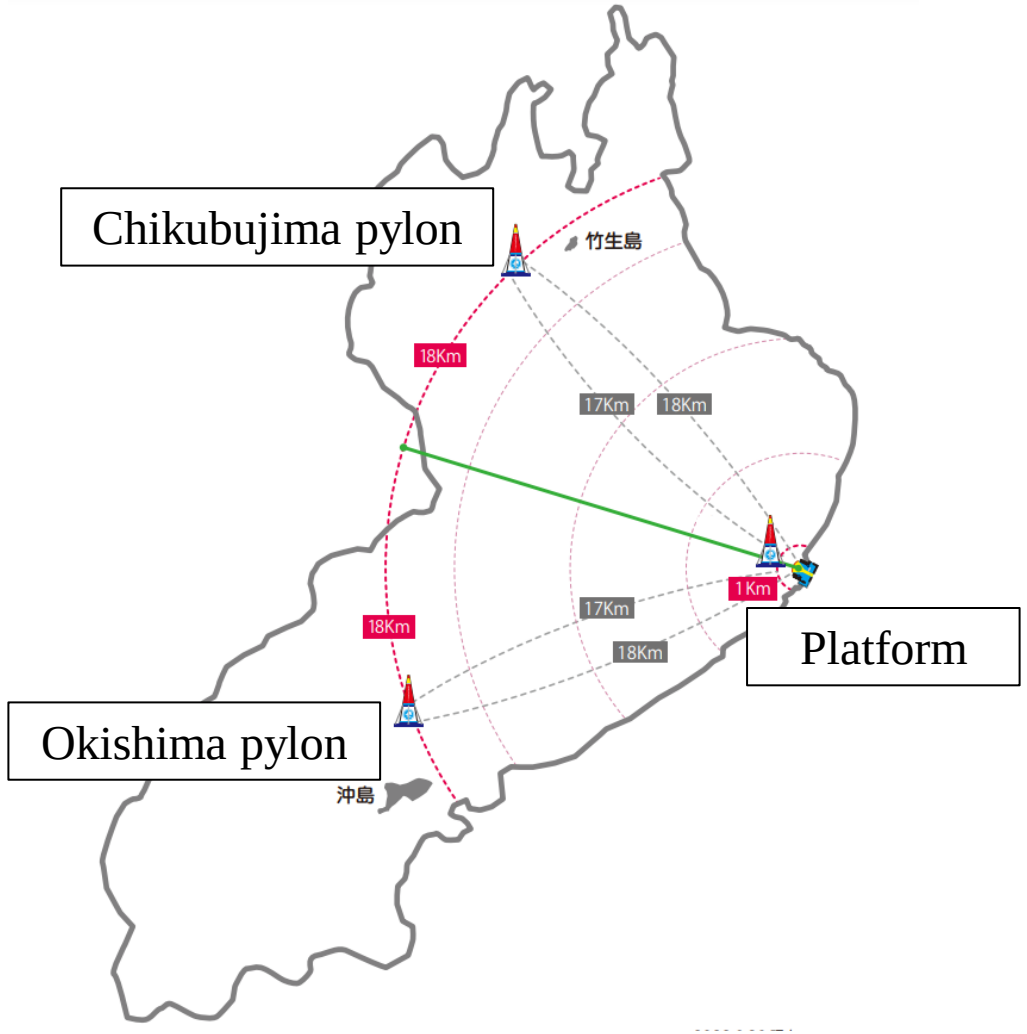
Dates: 5/27, 6/18, 6/25, 7/2, 7/8

Test Flights at Kakuda Airfield

Competition

Rules (2022~)

- ✓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.



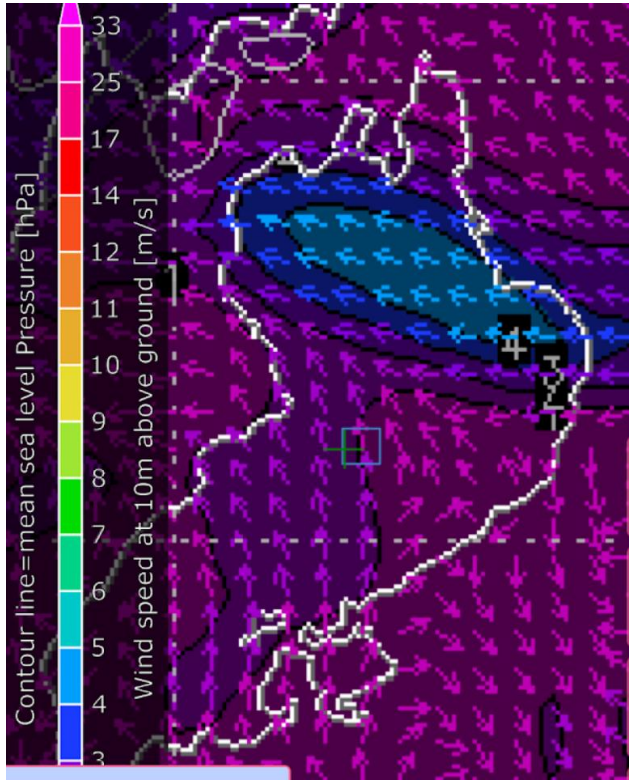
Competition

Condition of the day

✓The first flight of the second day was decided by Rally management.

✓The weather forecast predicted lower winds throughout south of the lake early in the morning.

→We decided that flying close to shore would not be a problem and decided to go for the less-lossy southern route first.

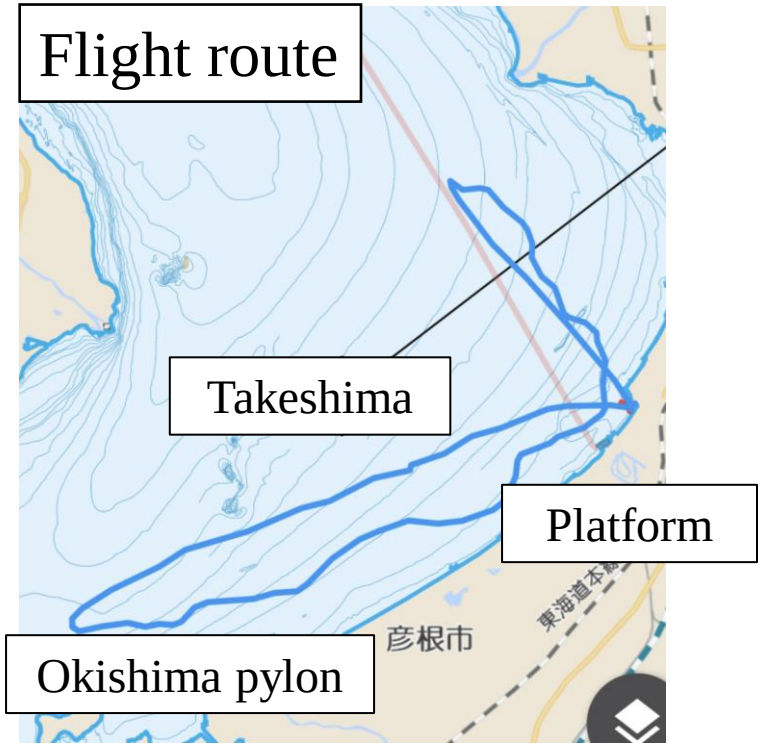


Predicted wind at 7:00

Result

Flight distance : 42,837.78 m
Flight time : 118 minutes
Rank : 2nd

Flight route



Rank	Record	Team
1	69,682.42 m	BIRDMAN HOUSE IGA
2	**42,837.78 m**	**Tohoku University Windnauts**
3	8,566.72 m	Osaka Institute of Technology

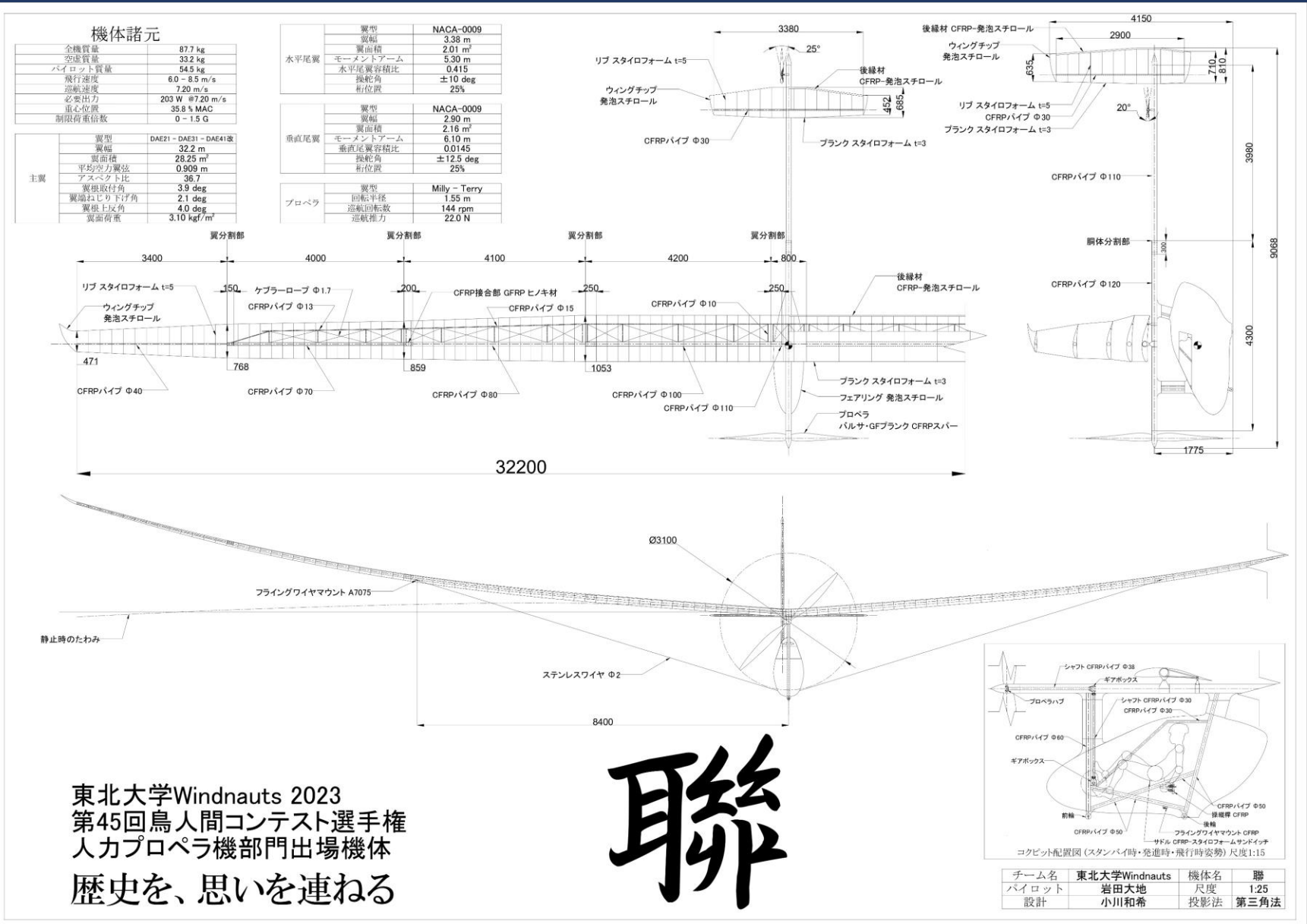
We achieved…

- ✓ **Success of pylon turn in front of the platform for the second year in a row.**
- ✓ **The team's longest record for the second year in a row.**
- ✓ **Breaking student record.**
- ✓ **The third longest record in the competition's history.**

Conclusion

- ✓ We made the new aircraft in 1 year and participated in Birdman Rally.
- ✓ While making the aircraft, we also took new challenges.
- ✓ We cleared various tests (Lord test, Drive system test, Steering system test, etc…) and were able to conduct a sufficient amount of test flights safely.
- ✓ We achieved the third best flight record (42,837.78 m) and broke the team and student records at the competition.

(Appendix) Three views



(Appendix) Specification

Specification	
Gross weight	87.7[kg]
Empty weight	33.2[kg]
Design cruising speed	7.20[m/s]
Need Power	203[W]

Propeller	
Airfoil	Milly-Terry(original)
Radius	1.55[m]
Rotational speed	144[rpm]
Thrust power	22.0[N]

Main wing	
Airfoil	DAE21 - DAE31 - DAE41modified
Span of wing	32.2[m]
Wing area	28.25[m^2]
Aspect ratio	36.7
Dihedral angle	4.0[deg]
Angle of attack	3.9[deg] – 2.8[deg] – 1.8[deg]

(Appendix) Historical records

Rank	Year	Record[m]
1	2023	42,837.78
2	2022	36,868.80
3	2008	36,000.00
4	2015	35,367.02
5	2006	28,628.43
6	2003	24,823.01
7	2017	22,657.79
8	2016	19,669.59
9	2011	18,687.12

Rank	Year	Record[m]
10	2012	14,129.34
11	2010	11,456.97
12	2019	5,438.19
13	2007	3,672.71
14	2018	2,347.58
15	2014	1,849.41
16	2005	140.10
17	2004	134.47
18	2013	41.72