# KITEMILL

**Technical Development**
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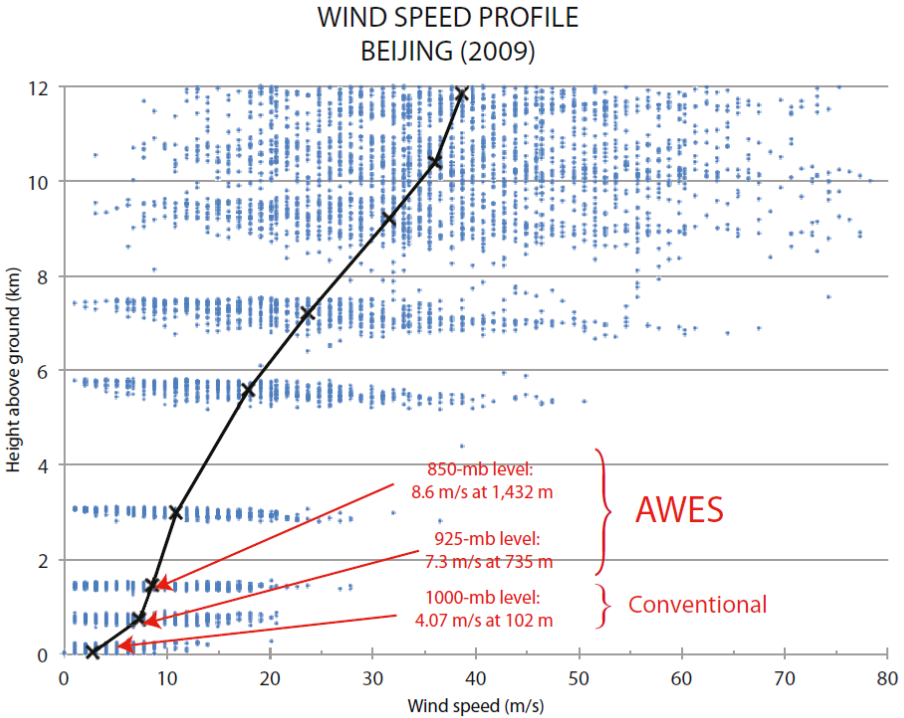
**March 2021**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 881193

# Product Technology (1/3)

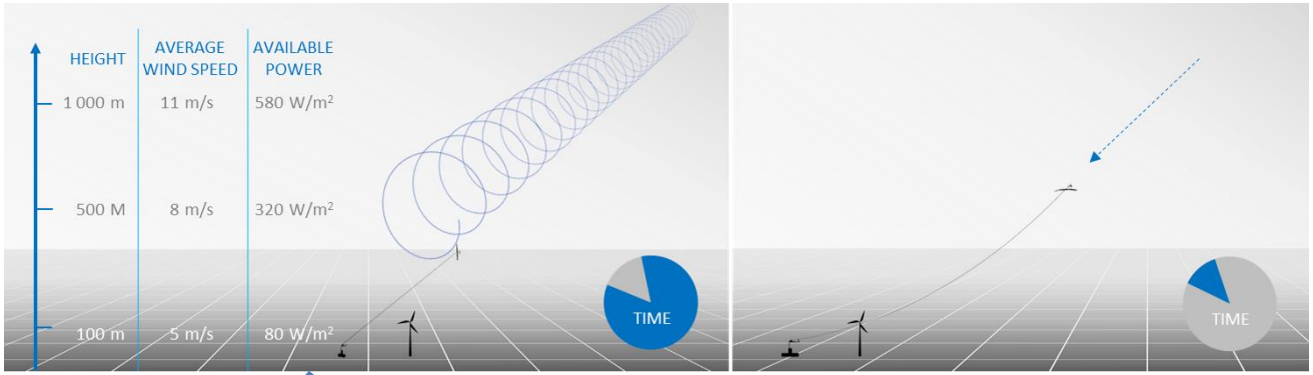
Airborne wind energy has a great potential to change the global energy mix:

1. More full-load hours
2. 10% of materials needed
3. 50% reduced LCOE
4. More geographical areas are suitable



# Product Technology (2/3)

Wind at higher altitudes allows for **larger capacity factors** (i.e. >> 50%)




$$\frac{P_{wind}}{m^2} = \frac{1}{2}\rho v_w^3$$

# Product Technology (3/3)

Kite turbines use less materials than wind turbines.

The blades are replaced by a kite. The rest is replaced by one / multiple tethers.


# Kitemill

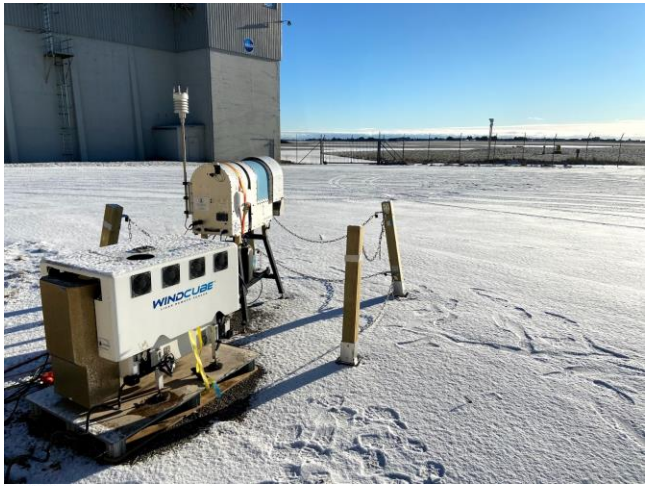
- Founded in 2008 in Norway, aimed to developed airborne wind energy using yo-yo principle
- 11 employees + external consultants covering all disciplines
- Workshop at Lista, Offices in Voss
- Operational area in Lista up to 4000 ft

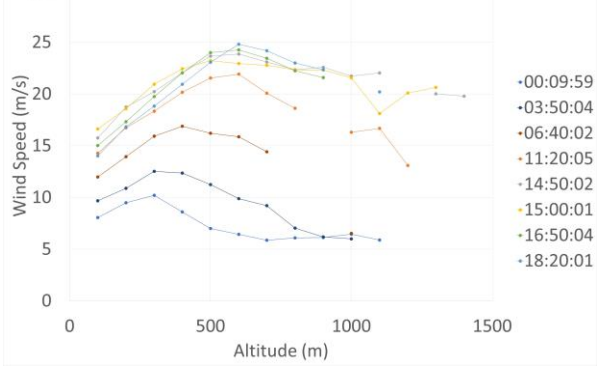
# Kitemill – UiB collaboration

- Kitemill is a secondment partner in the LIKE (Lidar Knowledge Europe) project together with Bergen University (J. Reuder)

- Jan Markus Diezel is Ph.D. Student investigating Lidar technology for AWE application in Lista

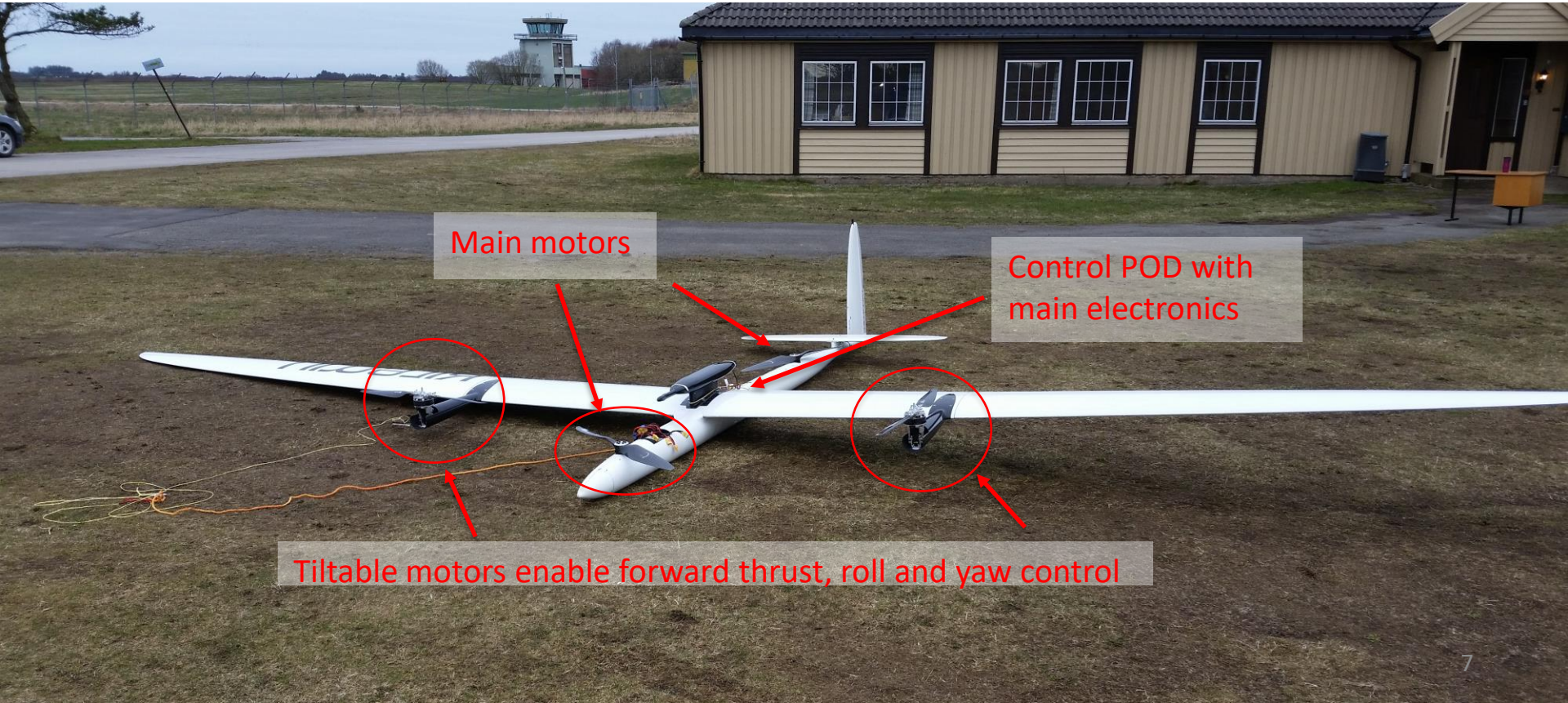
$$P_{kite} = \frac{2}{27}\rho A v_w^3 C_l \left(\frac{C_l}{C_d}\right)^2$$




https://cordis.europa.eu/project/id/858358

# The KM1 kite turbine system



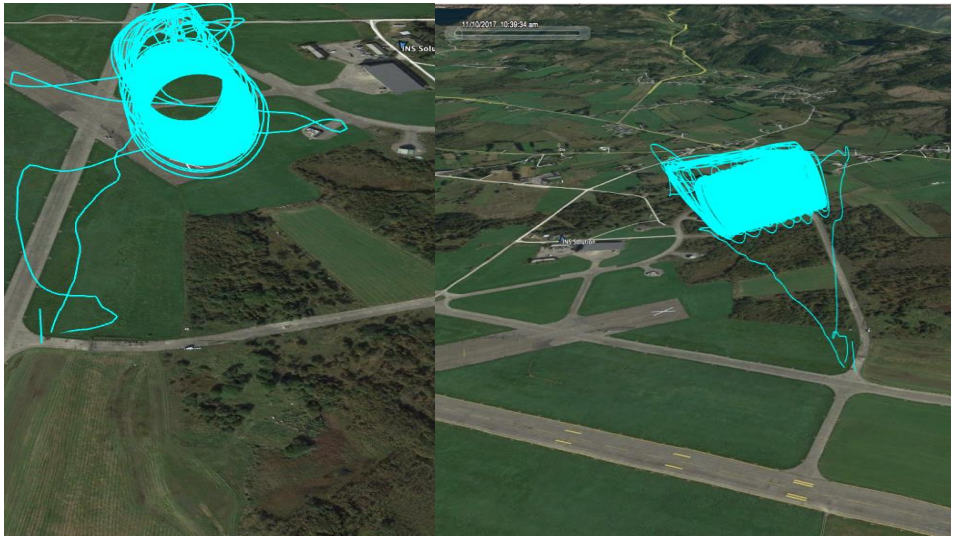
# Kite




| 2009 | 2010 - 2012 | 2013 - 2015 | 2017 - … |
|---|---|---|---|
| Kite pulls more than expected performance per square meter | First rigid kites tested to achieve a better performance, controllability and durability | Different designs are tested to find the optimum between aerodynamics, stability and controllability (KM0) | Chosen design is scaled towards a larger unit that is currently flown (KM1) |

# Control System

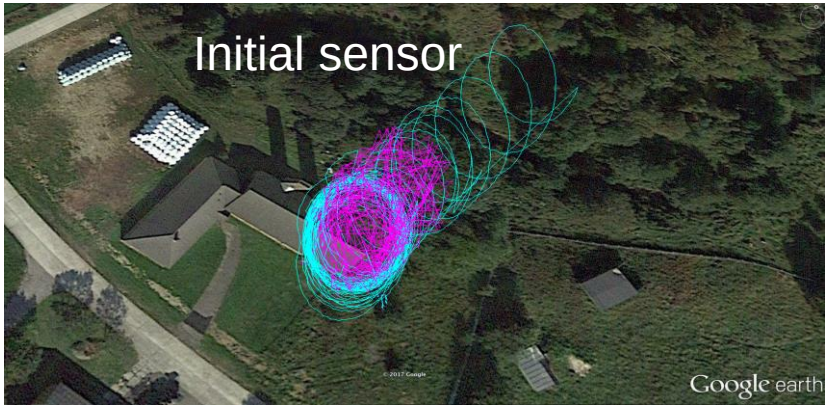
- Automatic flight in all modes for several hours with KM0
- Testing of:
  - new sensors
  - advanced controllers
- Working hardware lead to focus on maximum flight time
- Future work increases robustness & redundancy



# Test rig, rotating arm 20 m diameter

# Control System, navigation component

Blue line: Estimated position
Pink line: Raw data points




drifting of sensors


no drifting of sensors

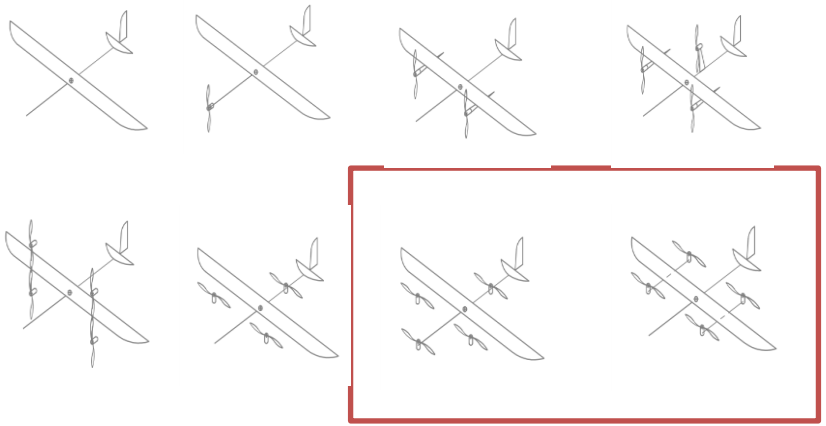
# Looping

# Looping

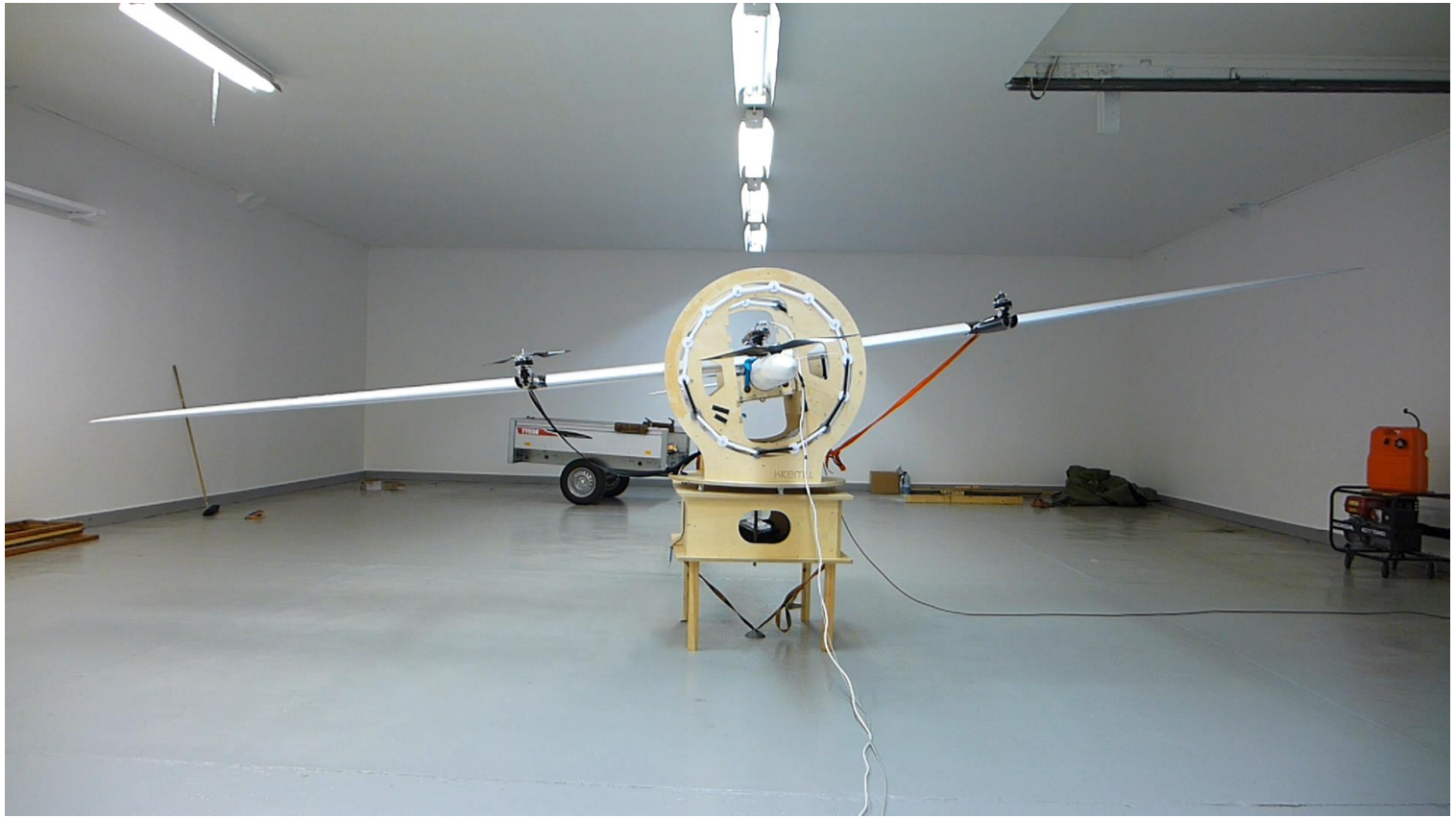
# Take-Off and Landing

- Vertical Take-Off and Landing is best candidate for airborne wind energy using drone technology

- VTOL from a landingsplatform
  - compact
  - repeatable
  - redundancy
  - on-board energy generation



# Test Rig for Easy Testing of VTOL System



# VTOL testing

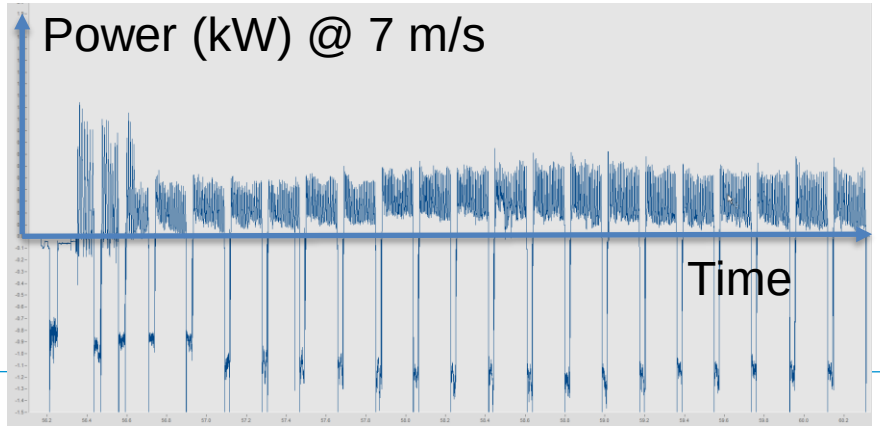
# Ground station

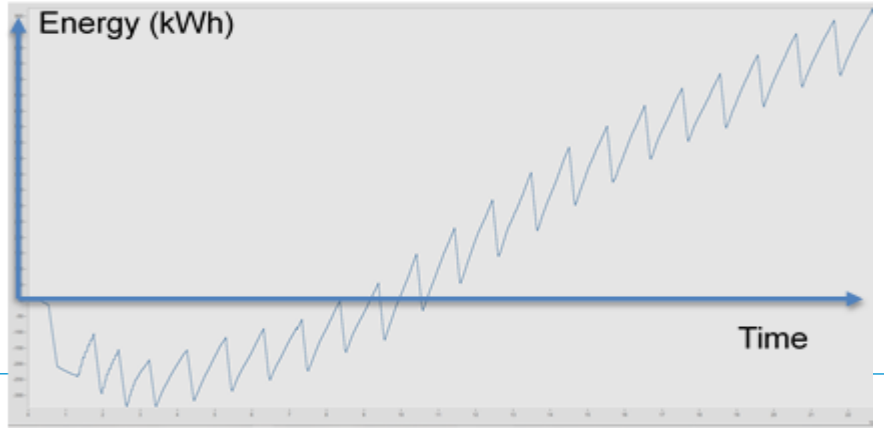
Ground station is designed by Kitemill

5 kW ground station

30 kW ground station

- Produced with Siemens components



# Technical status – summary

| 2009 - 2013 | 2014 - 2015 | 2016 - 2017 | 2018 - 2020 |
|---|---|---|---|
| KM0 Proof-of-concept<br>KM0 Manual control<br>KM0 Manual launch | KM0 control system v1 | KM0 VTOL<br>KM1 kite<br>KM1 winch | KM0 control system v2<br>KM0 2+ hours auto flights<br>KM1 auto VTOL |

- Outlook: 2021 - ...
  - flying KM1 model autonomously
  - > 5h continuous autonomous operation
  - KM2 development


THANK YOU FOR THE
PRESENTATION
☺