METCentre
MARINE ENERGY TEST CENTRE • KARMØY

Luftfartstilsynet
Postboks 243
8001 Bodø

Haugesund, 15. Oktober 2018

Søknad om etablering av midlertidig luftfartshinder

Det søkes med dette om tillatelse til å etablere midlertidig luftfartshinder i sjøen utenfor Karmøy. Bakgrunn for dette er testing av vindkraftproduksjon basert på drage teknologi.

Varighet: 1.5.2019 – 31.10.2020
Posisjon: N: 59° 09.550' Ø: 5° 02.421'

Radius: 0,50 nautiske mil
Høyde: 2500 fot inkludert sikkerhetssone

Nærmere beskrivelse av prosjektet er gitt i vedlagt prosjektbeskrivelse.

Med vennlig hilsen
Marin Energi Testsenter AS

Arvid Nesse
Daglig leder

Vedlegg:

- Project description
- Avinor: Operational assessment – Energy kite in the ocean outside Karmøy

Project description: Makani floating wind turbine – Kite technology

About Marin Energi Testsenter AS

Marin Energi Testsenter AS (Metcentre) was established in connection with Statoil´s Hywind project to facilitate full scale testing of floating offshore wind turbines.

An increasing global market for floating offshore wind turbines is expected in the coming years. Offshore wind power and solar energy are expected by many analysts to become the most important renewable energy sources in the future.

An addition goal for the test center is to include Norwegian companies with experience from maritime and offshore oil and gas into international offshore wind projects. In this project a number of Norwegian companies are involved. This applies both to anchor solution, installation, base, instrumentation, etc.

Metcentre is owned by:
Equinor ASA: 35%
Rogaland County Municipality: 35%
Haugaland Power: 13%
Karmøy Municipality: 8%
Uni Research Polytec: 5%
Others: 4%

About Makani

Makani is a project within X, a division of Google LLC with business address Mountain View, California. Google LLC is an Alhapbet company. Metcenter's contract partner in Norway will however be Google Norway AS.

X, the moonshot factory, has as a business strategy to find radical solutions to key issues through groundbreaking new technology.

In this case, the breakthrough will consist in producing pure renewable wind energy with kite technology. Nearly three billion people reside in areas near the coast. Two-thirds of these areas have deep water and wind resources suitable for this technology. There is potential for this technology to have a very large influence on a global scale.

About Makani Kite technology

Makani Kite Technology is based on a 28-meter wingspan, hard-sided kite. The kite is driven around in loops by the wind, guided by an autonomous controller on the kite. When it runs, the propellers produce power. The same propellers are used to lift the kite up in position and to take the kite safely down into the ground station.

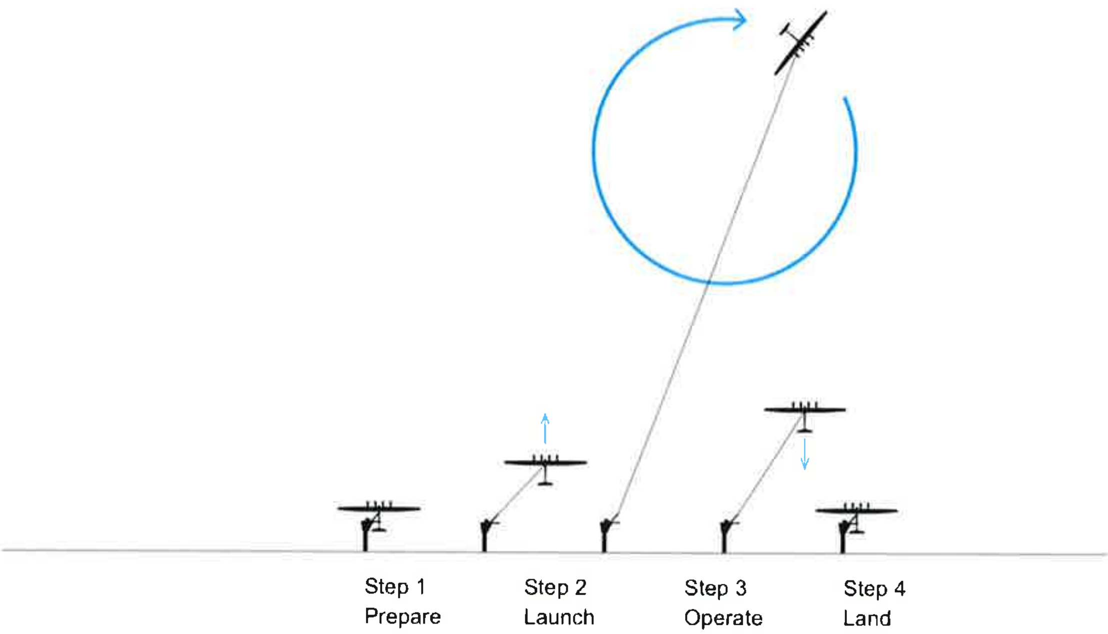


Figure 1: Makani technology

The ground station is installed on a floating spar buoy.

Makani Kite Technology has been tested on land in the United States extensively since 2006. The newest prototype has been in testing since 2016 over land. The purpose of the test outside Karmøy will be to test the kite offshore. The main element of the test will be to test all flight modes (launch, power production, land) from a floating buoy.

Figure 2: Testing at California

Location

The testing is planned in the area around Hywind.

N: 59° 09.550' E: 5° 02.421'
The sea depth at the site is 200 meters.

As anchor chain has a length of 576 meters, the floating unit can move at a distance of up to approximately 500 meters from the anchor position.

In addition to the floating device moving out of center position, the operating range of the kite could be up to 434 meters (0.23 nautical miles) based on the length of the cable creating a footprint (buoy swing plus tether cable) totaling 934 meters (0.5 nautical miles).

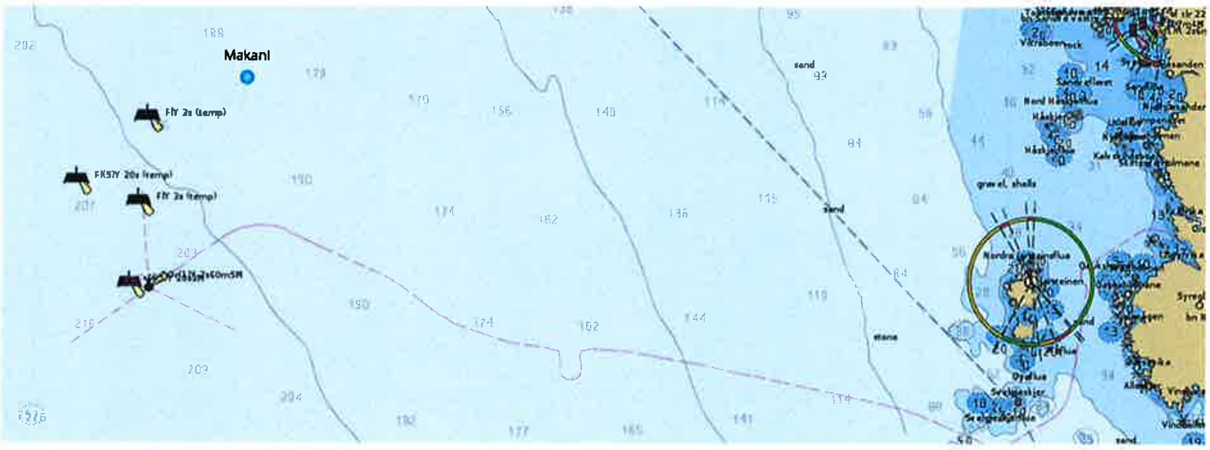


Figure 3 Anchor position

Installation

The floating spar buoy will be moored to an anchor at the given position.

Anchor and chain will be pre-installed with a floating marker for chain retrieval. The spar buoy will be towed to the location with a hired vessel before each test flight period. Then the anchor chain will be winched up and connected to the floater.

Operation

During test flights, operation will be handled from a chartered offshore vessel. Power supply will then be given from the ship. The operational control centre will also be installed at the vessel.

If a situation where clear airspace is required, the kite can be lowered to less than 200 meters height within two to five minutes after receiving an instruction. The kite could be back in the starting position on the floating buoy within 10 to 30 minutes.

The project will be staged at Haugaland Næringspark, Gismarvik during periods when there is no test flights. Before each test flight period, the floating spar buoy will be towed to the test area and connected to anchor chain. A limited number of test flight days is expected, likely fewer than ten days per month, although additional testing is possible depending on weather and test results.

Before days of test flight, Kvitsøy Traffic Center and Avinor Air Control Service will be notified.

Weather restrictions for test flights:

- Maximum wind speed of 20m/s (measured as 10 minutes average in height 10m above sea level)
- Maximum 3 meter significant wave height
- Minimum visibility is 1 km (A visual contact between control center and kite is required for testing)
- Temperature above 5 degrees Celsius.

When flying, the kite will be held by a 434 meter long cable. The cable works both as a tether and as a power cable. This will have direction depending on wind direction. See figure below.

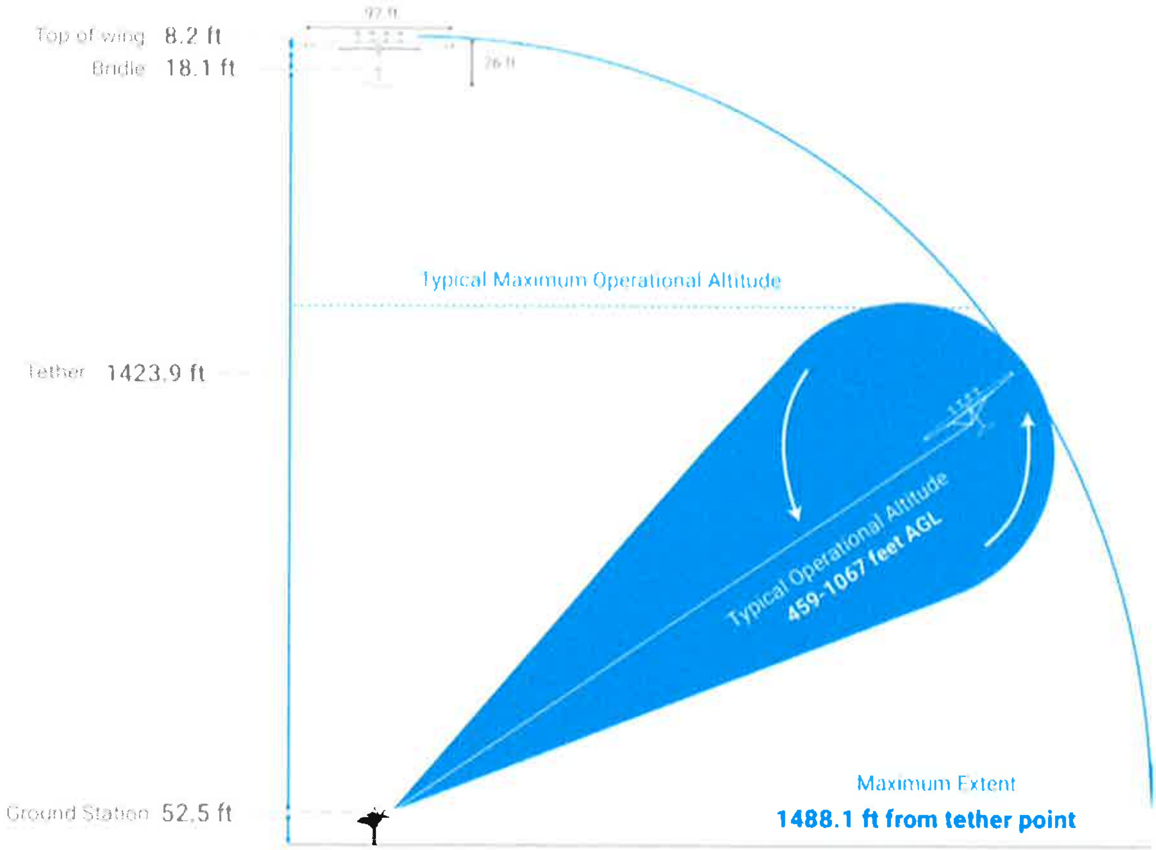


Figure 4: Operational area during flight

Duration

The offshore installation is planned to be performed spring 2019, but will not start earlier than 1.3.2019. Flights will start earliest from 1.5.2019. The project will be completed and all installations removed by 31.10.2020. Test flights will only happen during the summer season between 1.4 and 1.10.

A temporary connection to the power grid is an option in 2020. In this case, a license will be applied for under the Ocean Energy Act.

Marking of the floater

The marking of the floater will be based on international standards / recommendations established by the International Association of Lighthouses Authorities (IALA). Ref. including "IALA Recommendation 0-117 on The Marketing of Offshore Wind Farms", December 2004.

The spar buoy will be marked with three white lights. In addition, an AIS transponder will be installed on the spar buoy.

Marking of the kite during operation

The kite will be painted white, but will have a yellow area at starboard wingtip and an orange area at the portside wingtip.

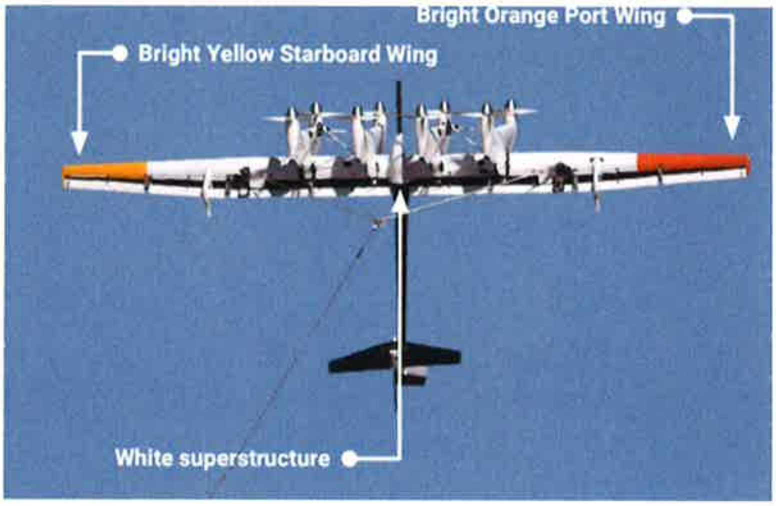
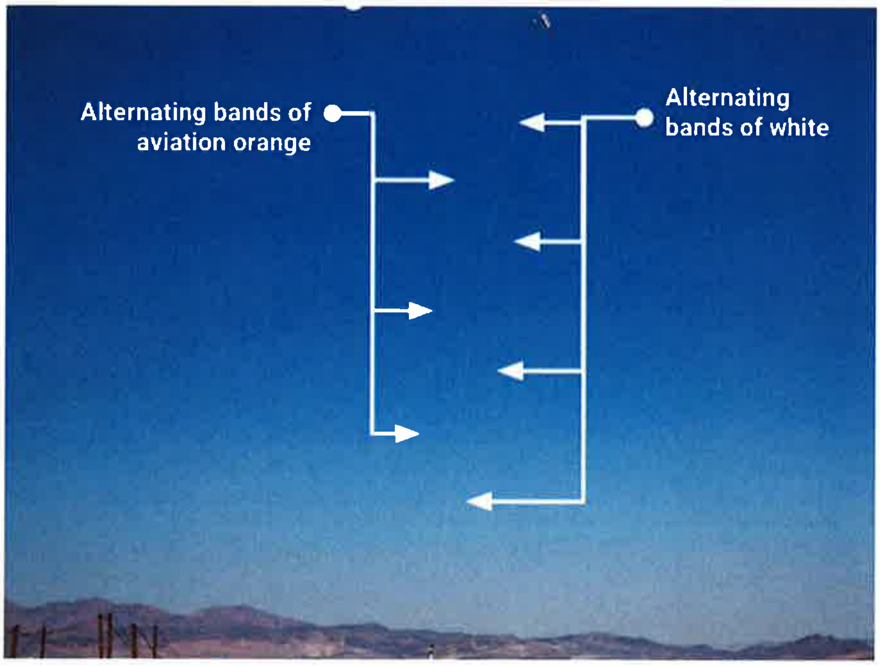


Figure 6: Markings on the kite

I addition there will be four white strobe lights on the kite. These lights will be placed at starboard wingtip (1x), portside wingtip (1x) and the tail (2x). The intensity will be greater than 400 effective candela.

The cable will be painted with white and orange bands each with 150 feet length.



Figuure 7: Markings on the tether

Figure 8: Tether striping

The lighting and marking scheme was developed in consultation with the United State Federal Aviation Administration (FAA). Airborne wind turbines are treated as an obstruction by the FAA.

Consequences for air traffic

Marine Energy Test Centre and representatives from the Makani team met Avinor at Sola 16.5.2018. Based on the discussions in this meeting, we have received the following report which is attached to this application:

- Operational assessment: Energy kite in the ocean outside Karmøy

Avinor has informed that necessary changes in procedures will be published on AIRAC before start of Makani test flights.

Operational assessment:
Energy kite in the ocean outside Karmøy

AVINOR

Date:	20.9.2018
Author:	Michael Katz
Based on:	ICAO DOC 8168 VOL II – Sixth edition AMDT 7 10/11/16

1 Contents

2 General information

2.1 Introduction

An energy kite will be established in the ocean outside Karmøy from **AIRAC 28 FEB 19**. The impact on published procedures at Stavanger Airport (ENZV) and Haugesund Airport (ENHD), in addition to any surrounding helicopter routes, is assessed in this document.

2.2 Coordinates

The energy kite will be anchored at the coordinates **59°09'33.000"N 005°02'25.260"E**.

2.3 Minimum altitude

The maximum theoretical altitude of the kite according to Figure 1 is 1502.7 ft = **458 m**. The highest minimum obstacle clearance for any procedure passing above is 300 m. This implies that the minimum obstacle clearance altitude above the kite must be 458 m + 300 m = 758 m ~ **2500 ft**.

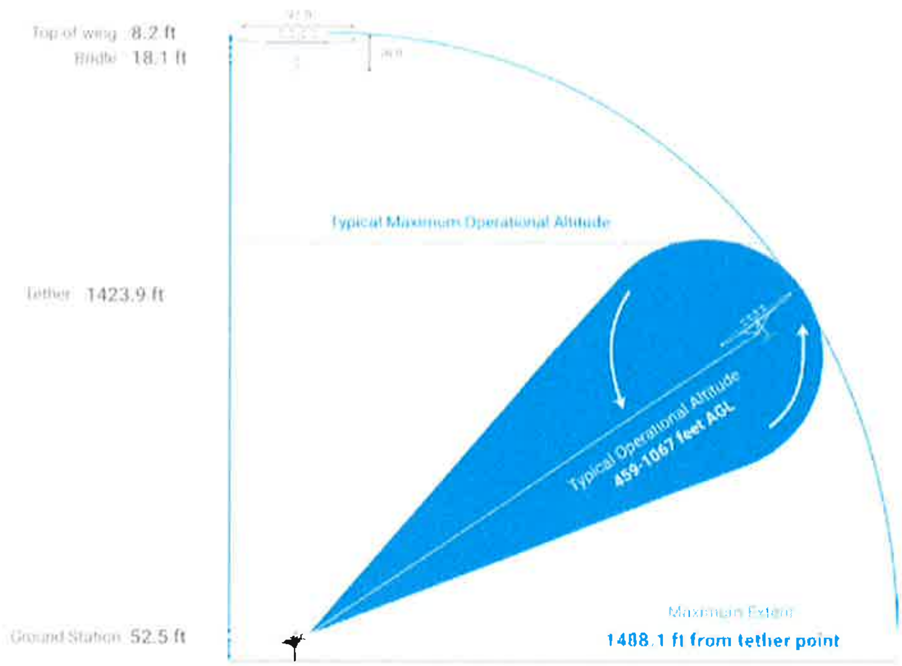


Figure 1. The operational parameters of the energy kite.

The kite is not fixed to the anchor coordinates, but can move in a radius of up to **0.58 NM** around the anchor point. The radius of this circle defines the lateral operational area of the kite.

3 Impact on published procedures

All fixed wing SIDs and STARs at ENZV and ENHD are either above 2500 ft when passing the operational area of the kite, or do not pass in its vicinity. The same applies to helicopter SIDs, except for OMNI SID RWY 18/36 and OMNI SID RWY 11/29 at ENZV (Figure 2). These procedures have climb to clearance of 2000 ft, and the Radio communication failure (RCF) procedure must therefore be changed to handle further climb.

All instrument approach procedures at ENZV and ENHD (including missed approaches with RCF procedure, base turns and circling areas) are either above 2500 ft when passing the operational area of the kite, or do not pass in its vicinity.

STANDARD DEPARTURE ROUTES - INSTRUMENT (RNAV 1 SID BASED ON GNSS) — **STAVANGER/Sola RWY 18/36**

REMARKS:	CAT H.
GENERAL:	Class A GNSS shall not be used. Surveillance service shall be available.
RADIO COMMUNICATION FAILURE:	Squawk A7600. Maintain last assigned LVL for 2 minutes, then climb to CPL cruising LVL. Aircraft under vectoring shall, after set transponder to A 7600, proceed in the most direct manner possible to rejoin the CPL route no later than the next significant point, climbing to the CPL cruising LVL taking into consideration the applicable MNM flight ALT.
CLOSE-IN OBSTACLES:	Raising terrain 0 m – 800 m South of THR RWY 36, require more than 7.0% climb gradient, and must be avoided visually or by other means.
VECTORING/ DIRECT ROUTING:	When being vectored or cleared for DCT routing, the climb gradient(s) stated in SID "RESTRICTIONS"-table apply.
NON RNAV 1 ACFT:	At first contact with SOLA ATC state "UNABLE RNAV 1 DUE (reason)". OMNI-DIRECTIONAL DEPARTURE available (see ENZV AD 2.24).

RWY 18

DESIGNATOR	ROUTE	RESTRICTIONS	CLIMB TO	CONTACT
INLUP 1G (INLUP ONE GOLF DEPARTURE)	Climb on course 179° to 450 FT, turn right DCT ZV490, to ZV491, to INLUP.	MNM climb gradient of 7.0% (425 FT/NM) to 700 FT. If unable to comply, inform ATC.	2000 FT.	When instructed by Sola TWR, contact Sola APP 119,6 MHz.

RWY 36

DESIGNATOR	ROUTE	RESTRICTIONS	CLIMB TO	CONTACT
ETROM 1H (ETROM ONE HOTEL DEPARTURE)	Climb on course 359° to 450 FT, turn left DCT ZV590, to ETROM.	MNM climb gradient of 6.0% (365 FT/NM) to 600 FT. If unable to comply, inform ATC.	2000 FT.	When instructed by Sola TWR, contact Sola APP 119,6 MHz.

Figure 2. The published helicopter omni-directional departure for RWY 18/36 at ENZV.

All holdings and TAAs below 2500 ft at ENZV and ENHD do not have a protection area that intersects with the operational area of the kite. MSA KRM has a minimum altitude of 2000 ft in its western sector (Figure 3). This sector must be increased to 2500 ft, or an additional sector must be created in the area of the kite. Other MSAs at ENZV and ENHD do not have any impact.

Figure 3. The published MSA at KRM VOR/DME.

The low level helicopter route between ETROM and LULOK passes above the operational area of the kite at 1200 ft (Figure 4). This helicopter route must be adjusted so that the kite's radius is outside the protection area of the route. The kite also has an impact on ETROM holding (1500 ft) and base turns. ETROM holding must be increased to 1800 ft, while the base turns must be removed or their altitude increased.

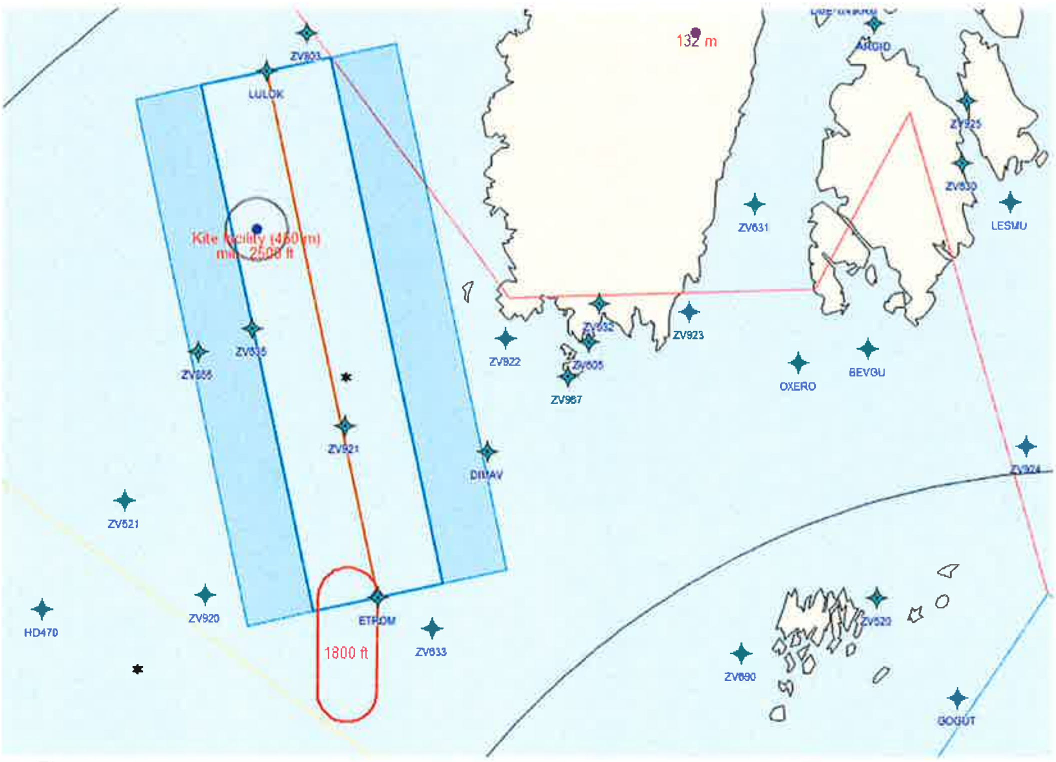


Figure 4. Location of the energy kite, and the protection area of the low level helicopter route between ETROM and LULOK.

4 Summary

The energy kite has an impact on the minimum altitudes of the following procedures:

- ENZV omni-directional SIDs RWY 18/36 and 11/29 for CAT H
- MSA KRM at ENHD
- Low level helicopter route between ETROM and LULOK (including holding and base turns at ETROM)

These procedures must be revised before AIRAC 28 FEB 19.