

TECHNICAL NOTE ON VISUALISATIONS

Hiiumaa, offshore wind farm

Estonia

Hiiumaa meretuuleparkide visualiseeringu tõlge asub KMH aruande ptk-s 5.12.5 „Visuaalne mõju“

158 or 182 Turbines
2 Technology Scenarios Considered

31. OKTOBER 2016



Hiiumaa, offshore wind farm

Estonia

DATE

31 October 2016

PREPARED BY

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EDITION

Edition 1, task # 15336/0712



Index

1	Method	3
1.1	Assumptions	3
1.1.1	The turbines	3
1.1.2	The photos	3
1.2	Calibration of the photos.....	3
1.2.1	The Horizon line	3
1.2.2	Control Points.....	4
1.2.3	Existing turbines, trees, rocks, buildings	4
1.3	Visualization of the turbines.....	4
2	Results	5
3	Appendices.....	5

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1 Method

The software used for the visualizations of Hiiumaa offshore wind farm is WindPRO 3.0, developed by EMD International A/S and largely recognized worldwide.

The official WMS Online map from Maat-Amet have been used as well as a valuable source of localisation.

EMD has not been on site and rely mainly on the information provided by the client and the findings from the aerial photo from Maat-Amet.

1.1 Assumptions

1.1.1 The turbines

Two layouts have been provided:

- 158 x V164 Vestas turbines with 105m hub height and 164m rotor diameter
- 182 x SWT 4- 130 turbines with 100m hub height and 130m rotor diameter

The visual data of the turbines are the official data as provided by WindPRO.

The coordinates have been provided.

1.1.2 The photos

Photographs have been provided by the client to EMD.

The position from which the photos were taken have been provided to EMD. The position has been adjusted when calibrating the photo (see section Calibration).

When it was possible, photos have been stitched in order to form a panorama view.

From the EXIF data of the photo file, the following data is used: focal length, date and time.

1.2 Calibration of the photos

In order to have WindPRO calculate the correct position and dimension of the WTGs, the camera model needs to be calibrated. The calibration consists in finding the exact properties of the camera which were used to take the photo:

1. position (usually known by GPS reading)
2. aiming direction: pan or horizontal center
3. aiming direction: tilt or vertical center
4. rotation
5. focal length (affects the apparent interdistances and sizes of objects); linked to the zoom of the Camera. The focal length is available from the EXIF data of the image file. However, small adjustments are often required since the lens might be affected slightly by the temperature.

Having entered the relevant references (Digital Elevation Model, reference points, ...) one has to adjust the camera settings until the references are on the right place on the photo. This can be done in different ways.

1.2.1 The Horizon line

The apparent horizon line consists of the blocking points of the line of sight, calculated for each degree from the camera position. For offshore projects the horizon line matched the horizon of the photo.



1.2.2 Control Points

Control Points are objects that can be identified precisely on both the map and on the image. The best Control Points are those furthest away from the camera (some kilometers away and preferably at least one in the left and one in the right part of the photo).

Control Points are used to verify the accuracy of the camera model as well as to establish any missing/uncertain information in the model (like the position of the photo point). The more unknown/uncertain parameters one has in the model, the more Control Points one will need in order to establish a correct Camera Model.

Control Points close to the planned turbines give accurate positioning of the turbines in the image; but these are very rare in the case of offshore wind farm projects. Control Points near the edge of the image, on the other hand, give good control over the focal length which in turn results in accurate image proportions. The Control Point coordinates may be established by using GPS equipment or from a reliable background map (or aerial photo).

Some control points close to the camera were provided to EMD and gave a good starting point. Many other control points had to be found from the aerial photo from Maa-Amst. The main issue was the position of the Camera object and the direction of the photo.

When no control points are available on a photo, it is possible to use intermediate control points which are calibrated from a photo next to that is already calibrated.



Figure 1 Example of calibration with horizon line and rocks

1.2.3 Existing turbines, trees, rocks, buildings

All these landscape features represent invaluable tools for calibrating the camera model, if they appear in the image.

1.3 Visualization of the turbines

Once the camera model has been calibrated, i.e. all four involved parameters are correctly entered, the software will simulate the turbines at the defined position, with the resulting size and the correct light.

The light conditions may vary a lot within a short period of time so that it seems impossible to obtain a result for all the different situations. WindPRO assumes that the light is uniform (all the wind turbines receive the same amount). Still the lighting and the resulting exposure to the Sun is precisely calculated by the software. WindPRO combines the date and the time of the day the picture was taken with the latitude of the site to simulate how the sun rays fall on the turbines and thus how bright or shadowed turbines should appear. Moreover the intensity of the light can be decided through various sky coverage options (clear sky, overcast, fog, etc). On some visualisations where the background sky is grey, the light has artificially been increased in order to see the turbines.

The orientation of the rotor is decided by the entered wind direction. A representative wind direction of 230-250 degrees has been applied.



Last but not least, the removal of the parts of the rendered WTGs that should be actually behind certain objects in the landscape (typically, horizon, vegetation or buildings) is done with a rubber tool. In case of offshore wind farm projects, windPRO deletes automatically the part of the tower hidden by the horizon due to the curvature of the Earth.











2 Results

The photomontages are delivered as:

- image file
- pdf file in the windPRO format of the photomontage in full page in A3. On this page the details of the calibration as well as the recommended observation distance are given; the recommended observation distance depends on the printing format (A4, A3...) from the printer setup; when printed, the page can be hold at the recommended observation distance to give a realistic size of the projected wind turbines. In case of panorama with a wide angle the recommended observation distance get very small (about 10 cm).

A given uncertainty is associated to the realization of the photomontages; especially for offshore projects where control points are usually few and close the photo point. The main uncertainty is related to the horizontal position of the turbines. This uncertainty depends on the position of the photo point and on the aiming direction of the photo. Although the position of the photo point is measured by GPS, the uncertainty of the devices has proven to be sometimes about 15m off. The lowest uncertainty on the position of the photo point is obtained when it is possible to check the position from the aerial photo. The uncertainty on the size of the turbine is limited in the case of visualization based on a single photo since the value of the focal length comes from the file data. In the case of a panorama, the uncertainty on the size of the turbine is more important but it can be decreased by the simultaneous use of single calibrated photos. The uncertainty on the vertical position and on the rotation is minimal thanks to the calibration with the horizon line. In general, poor visibility on the photos increases the uncertainty, because the use of reference points and the exact position of the horizon line is less precise.

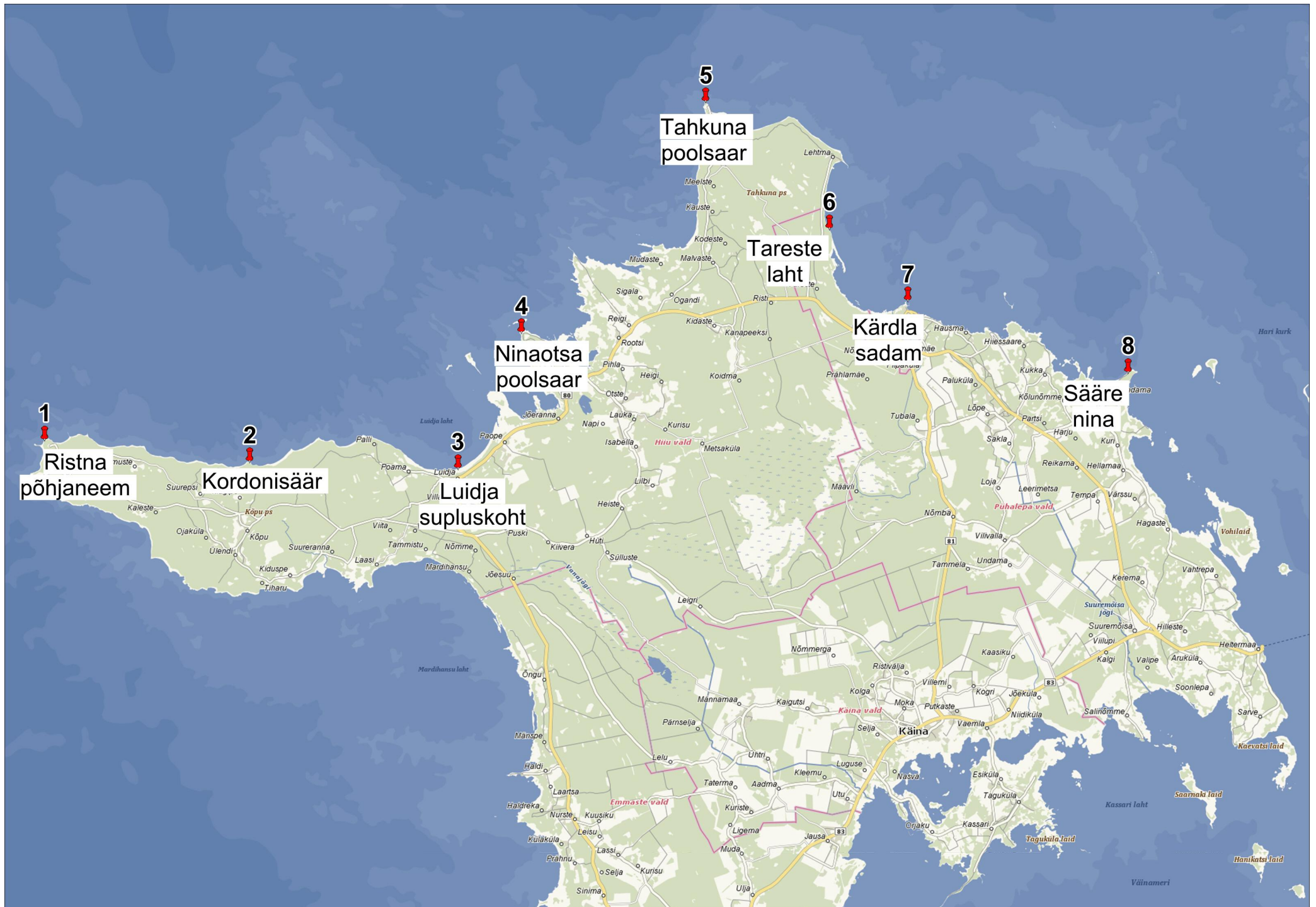
3 Appendices

-  P1-Map.JPG
-  P2-Map.JPG
-  P3-Map.JPG
-  P4-Map.JPG
-  P5-Map.JPG
-  P6-Map.JPG
-  P7-Map.JPG
-  P8-Map.JPG
-  Siemens_coordinates and distances.pdf
-  Vestas_coordinates and distances.pdf

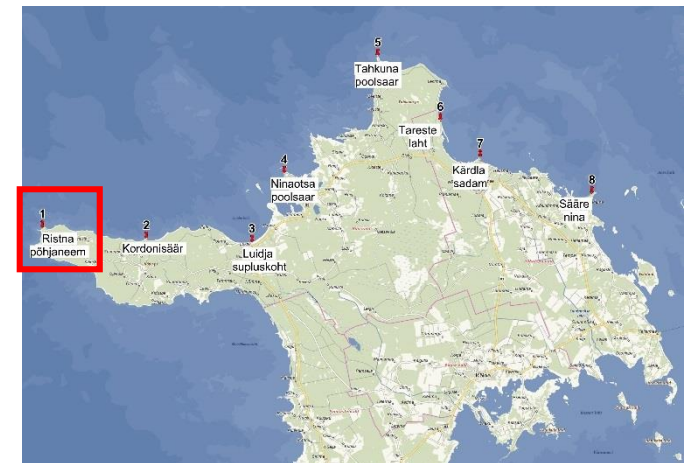
Lisa 9.

Hiumaa meretuuleparkide visualiseeringud.

EMD International A/S, 2016



1. Ristna põhjaneem (Mugasäär)





Project:
Hiimuaa Offshore wind farm

Recommended observation distance: 9 cm

Photo exposed: 09-12-2015 10:17:16
Panorama field of view: 245,0°x20,0° Pixels: 2336x556
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 387.832 North: 6.535.369
Wind direction: 250° Direction of photo: 309°
Camera: P1 zoom siemens
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P1-2-57mm_Pano.jpg

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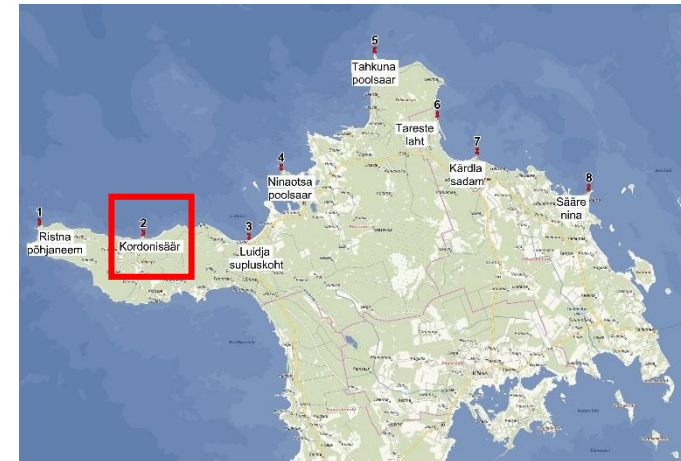
Project:
Hiimuaa Offshore wind farm

Recommended observation distance: 9 cm

Photo exposed: 09-12-2015 10:17:16
Panorama field of view: 245,0°x20,0° Pixels: 2335x565
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 387.832 North: 6.535.369
Wind direction: 250° Direction of photo: 309°
Camera: P1 zoom
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P1-2-57mm_Pano.jpg

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2. Kordonisäär (RMK Mägipää puhkekoht)





Project:
Hiimuaa Offshore wind farm

WTGs: 182

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 14:45:45
Field of view: 69,4°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 397.406 North: 6.534.372
Wind direction: 250° Direction of photo: 35°
Camera: P2 right
Photo: G:\...\Visual, nov15\WindPRO data\Photos\Punkt_2\Kaamera_1\P1050842.JPG

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Project:
Hiimuaa Offshore wind farm WTGs: 182

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 14:45:36
Field of view: 69,4°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 397.406 North: 6.534.372
Wind direction: 250° Direction of photo: 335°
Camera: P2 left
Photo: G:\...\Visual, nov15\WindPRO data\Photos\Punkt_2\Kaamera_1\P1050841.JPG

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Project:
Hiimuaa Offshore wind farm

WTGs: 182

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 15:21:20
Field of view: 69,4°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 407.310 North: 6.534.060
Wind direction: 250° Direction of photo: 293°
Camera: P3 left
Photo: G:\...\From client\Visualiseerimine-pildid\Punkt_3\Kaamera_1\P1050845.JPG

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Project:
Hiimuaa Offshore wind farm

WTGs: 182

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 15:21:29
Field of view: 71,5°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 407.308 North: 6.534.059
Wind direction: 250° Direction of photo: 340°
Camera: P3 right
Photo: G:\...\Visual, nov15\WindPRO data\Photos\Punkt_3\Kaamera_1\P1050846.JPG

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Project:
Hiimuaa Offshore wind farm

WTGs: 158

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 14:45:45
Field of view: 69,4°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 397.406 North: 6.534.372
Wind direction: 250° Direction of photo: 35°
Camera: P2 right
Photo: G:\...\Visual, nov15\WindPRO data\Photos\Punkt_2\Kaamera_1\P1050842.JPG

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Project:
Hiimuaa Offshore wind farm WTGs: 158

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 14:45:36
Field of view: 69,4°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 397.406 North: 6.534.372
Wind direction: 250° Direction of photo: 335°
Camera: P2 left
Photo: G:\...\Visual, nov15\WindPRO data\Photos\Punkt_2\Kaamera_1\P1050841.JPG

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Project:
Hiimuaa Offshore wind farm

WTGs: 158

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 15:21:20
Field of view: 69,4°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 407.310 North: 6.534.060
Wind direction: 250° Direction of photo: 293°
Camera: P3 left
Photo: G:\...\From client\Visualiseerimine-pildid\Punkt_3\Kaamera_1\P1050845.JPG

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Project:
Hiimuaa Offshore wind farm

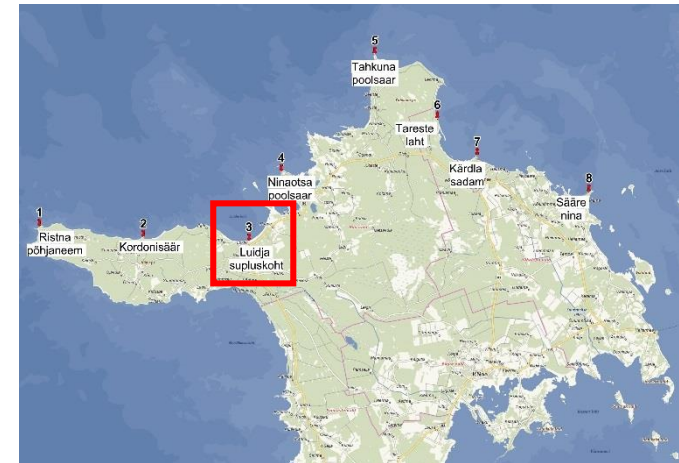
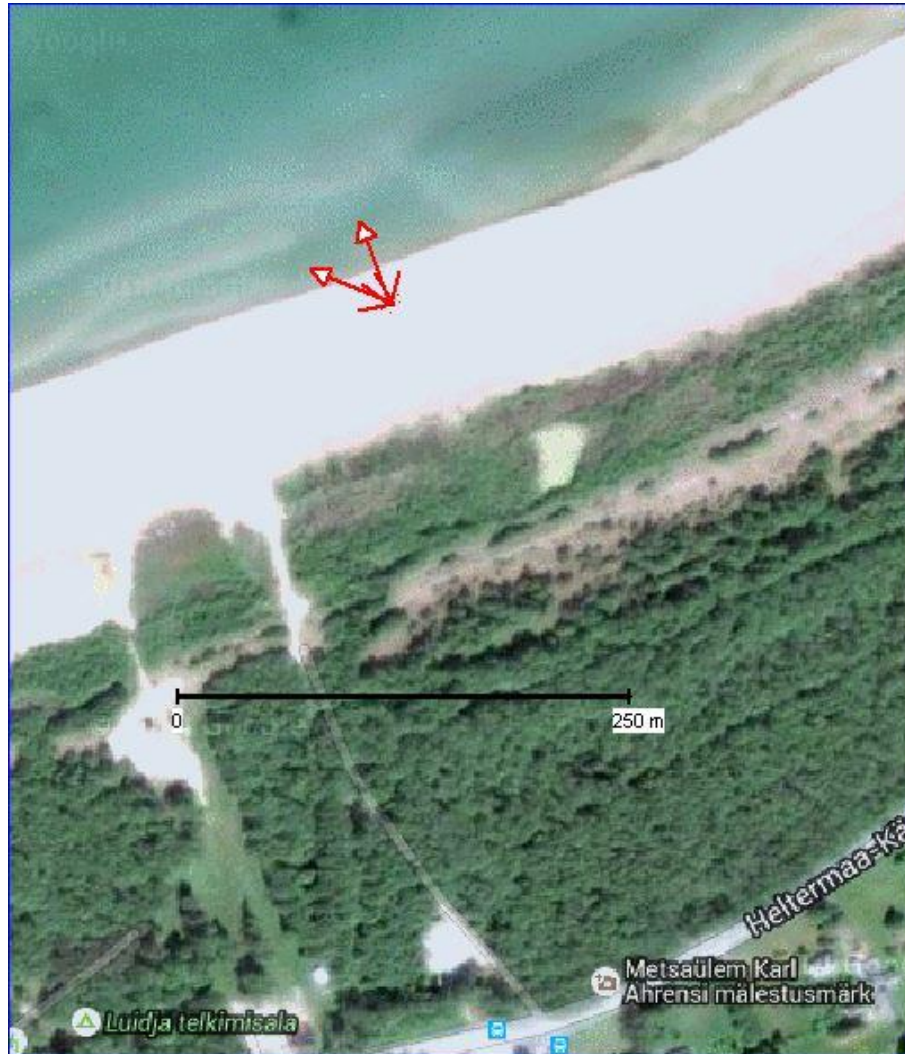
WTGs: 158

Recommended observation distance: 23 cm

Photo exposed: 04-11-2015 15:21:29
Field of view: 71,5°x54,9° Lens: 25 mm Film: 35x26 mm Pixels: 4000x3000
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 407.308 North: 6.534.059
Wind direction: 250° Direction of photo: 340°
Camera: P3 right
Photo: G:\...\Visual, nov15\WindPRO data\Photos\Punkt_3\Kaamera_1\P1050846.JPG

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3. Luidja supluskoht



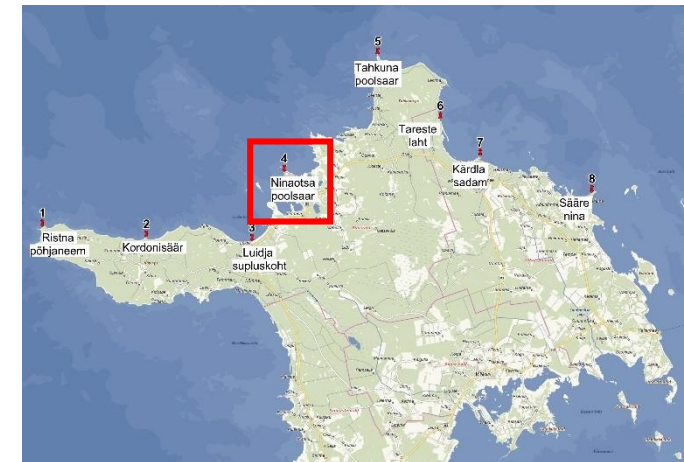








4. Ninaotsa poolsaar (RMK puhkekoht)





Project:
Hiimuaa Offshore wind farm

WTGs: 182

Recommended observation distance: 11 km

Photo exposed: 09-12-2015 12:03:32
Panorama field of view: 202,5°x19,7° Pixels: 24000x2349
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 410.212 North: 6.540.424
Wind direction: 230° Direction of photo: 330°
Camera: P4
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P4-2-9pic 57mm.jpg

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Project:
Hiimuaa Offshore wind farm

Recommended observation distance: 11 cm

Photo exposed: 09-12-2015 12:03:32
Panorama field of view: 202,5°x19,7° Pixels: 4426x1172
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 410.212 North: 6.540.424
Wind direction: 230° Direction of photo: 330°
Camera: P4 zoom siemens
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P4-2-9pic 57mm.jpg

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Project:
Hiimuaa Offshore wind farm

WTGs: 158

Recommended observation distance: 8 cm

Photo exposed: 09-12-2015 12:03:32
Panorama field of view: 202,5°x19,7° Pixels: 24000x2349
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 410.212 North: 6.540.424
Wind direction: 230° Direction of photo: 330°
Camera: P4
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P4-2-9pic 57mm.jpg

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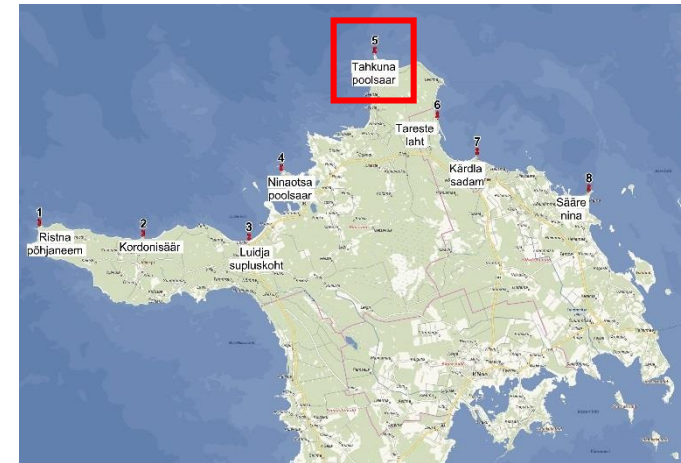
Project:
Hiimuaa Offshore wind farm

Recommended observation distance: 11 cm

Photo exposed: 09-12-2015 12:03:32
Panorama field of view: 202,5°x19,7° Pixels: 4396x1172
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 410.212 North: 6.540.424
Wind direction: 230° Direction of photo: 330°
Camera: P4 zoom
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P4-2-9pic 57mm.jpg

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5. Tahkuna poolsaar („Estonia“ laste mälestusmärk)





Project:
Hiimuaa Offshore wind farm

Recommended observation distance: 5 cm

Photo exposed: 09-12-2015 12:44:43
Panorama field of view: 310,0°x40,1° Pixels: 1168x407
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 418.871 North: 6.551.248
Wind direction: 230° Direction of photo: 343°
Camera: P5 zoom left siemens
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P5-all.jpg

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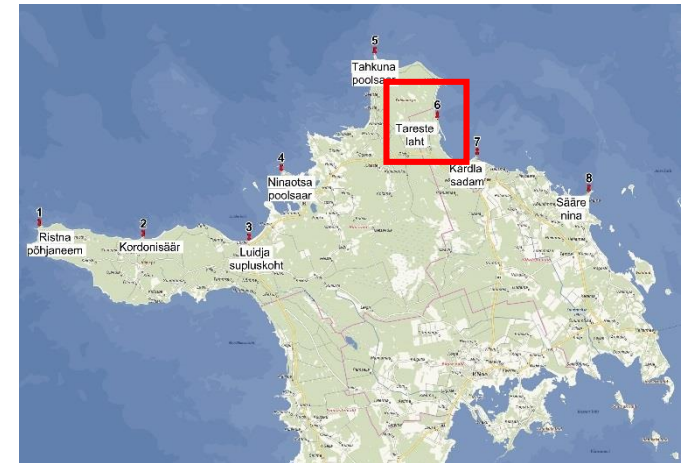
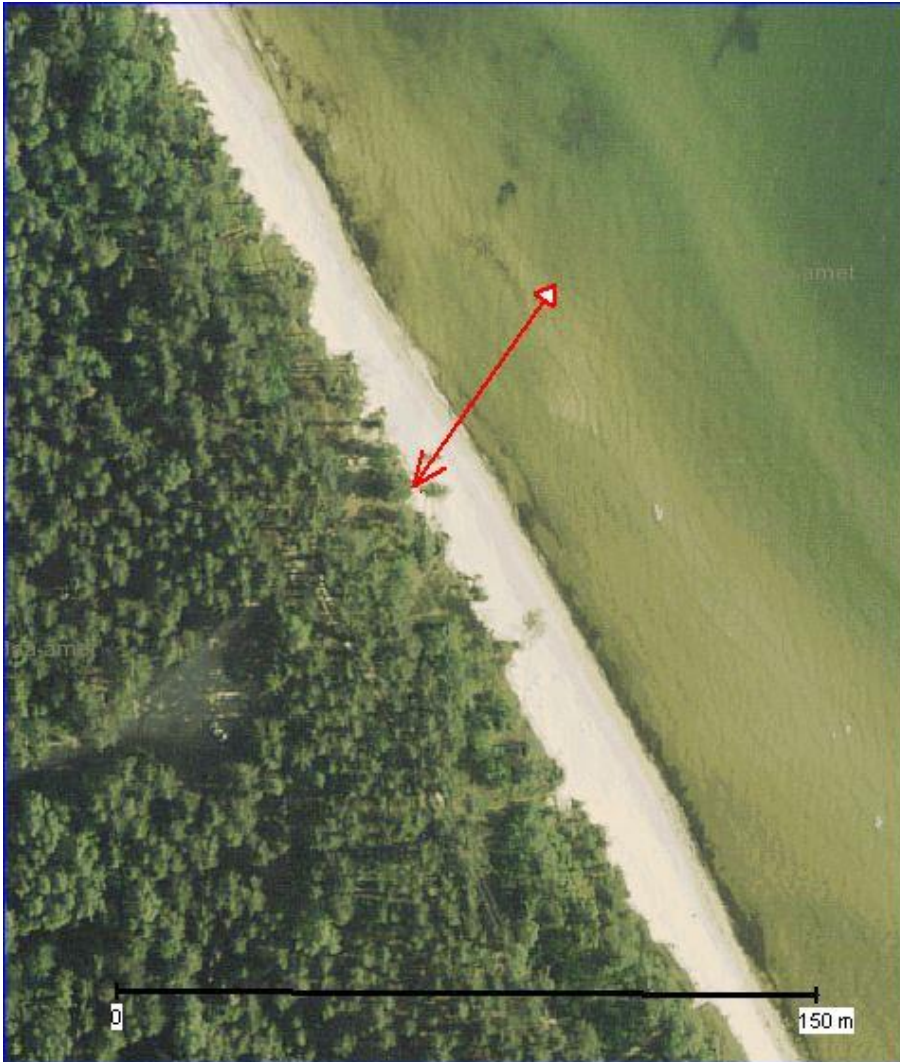
Project:
Hiimuaa Offshore wind farm

Recommended observation distance: 5 cm

Photo exposed: 09-12-2015 12:44:43
Panorama field of view: 310,0°x40,1° Pixels: 1157x406
Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 418.871 North: 6.551.248
Wind direction: 230° Direction of photo: 343°
Camera: P5 zoom left
Photo: G:\...\Visual, nov15\WindPRO data\Pano\P5-all.jpg

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6. Tareste laht (RMK Tõrvanina puhkekoht)





Project:
Hiiumaa Offshore wind farm

WTGs: 69

Recommended observation distance: 28 cm

Photo exposed: 09/12/2015 09:00:00

Field of view: 46.5°x31.8° Lens: 42 mm Film: 36x24 mm Pixels: 4928x3264

Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 424,670 North: 6,545,298

Wind direction: 230° Direction of photo: 37°

Camera: P6

Photo: G:\...\From client\Photos\Fotod_09122015\Punkt_6\seeria_2\DSCN6649.JPG

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Project:
Hiiumaa Offshore wind farm

WTGs: 51

Recommended observation distance: 28 cm

Photo exposed: 09/12/2015 09:00:00

Field of view: 46.5°x31.8° Lens: 42 mm Film: 36x24 mm Pixels: 4928x3264

Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 424,670 North: 6,545,298

Wind direction: 230° Direction of photo: 37°

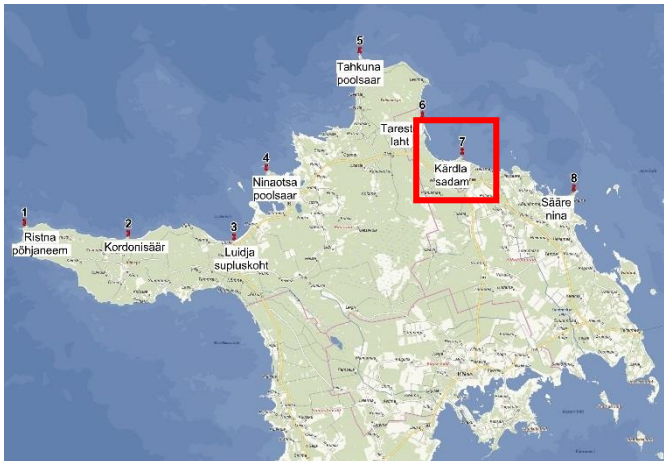
Camera: P6

Photo: G:\...\From client\Photos\Fotod_09122015\Punkt_6\seeria_2\DSCN6649.JPG

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Madalina / mj@emd.dk

7. Kärđla sadam





Project:
Hiiumaa Offshore wind farm

WTGs: 69

Recommended observation distance: 15 cm

Photo exposed: 09/12/2015 13:41:14

Panorama field of view: 98.0°x20.8° Pixels: 12884x2771

Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 428,347 North: 6,541,910

Wind direction: 230° Direction of photo: 41°

Camera: P7

Photo: G:\...\Visual, nov15\WindPRO data\Pano\P7-4pic.jpg

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Project:
Hiiumaa Offshore wind farm

WTGs: 51

Recommended observation distance: 15 cm

Photo exposed: 09/12/2015 13:41:14

Panorama field of view: 98.0°x20.8° Pixels: 12884x2771

Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 428,347 North: 6,541,910

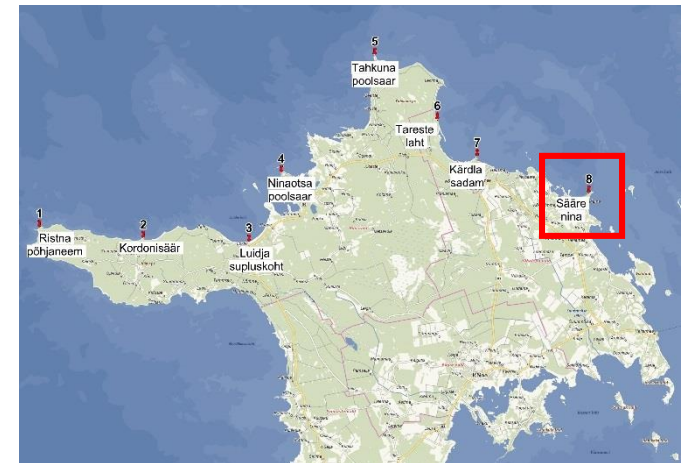
Wind direction: 230° Direction of photo: 41°

Camera: P7

Photo: G:\...\Visual, nov15\WindPRO data\Pano\P7-4pic.jpg

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Madalina / mj@emd.dk

8. Sääre nina (RMK puhkekoht)





Project:
Hiiumaa Offshore wind farm

WTGs: 69

Recommended observation distance: 14 cm

Photo exposed: 09/12/2015 14:15:25

Panorama field of view: 102.0°x21.8° Pixels: 13950x3018

Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 438,724 North: 6,538,567

Wind direction: 230° Direction of photo: 1°

Camera: P8

Photo: G:\...\Visual, nov15\WindPRO data\Pano\P8-pano_c.jpg

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Project:
Hiiumaa Offshore wind farm

WTGs: 51

Recommended observation distance: 14 cm

Photo exposed: 09/12/2015 14:15:25

Panorama field of view: 102.0°x21.8° Pixels: 13950x3018

Eye point: Estonian Lambert L-EST97-EST97 (EE) East: 438,724 North: 6,538,567

Wind direction: 230° Direction of photo: 1°

Camera: P8

Photo: G:\...\Visual, nov15\WindPRO data\Pano\P8-pano_c.jpg

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