Assessment of the Impact of Walcourt on Belgian Military Surveillance Sensors for WindVision

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1 Introduction

1.1 Scope

This report is an assessment of the potential impact of the proposed Walcourt wind farm on the surveillance sensors safeguarded by the Belgian Military (Military), as described in the study proposal [1].

1.2 Background

WindVision (the Customer) and Elawan are jointly developing the Walcourt wind farm in Belgium. The project definition is not finalised. The assessment is carried out using the Customer's preferred definition (six turbines, 169m maximum tip height). The sensitivity of the results to changes to the project definition will be discussed.

The proposed wind farm is approximately 13.8 km north west of the Tactical Air Navigation (TACAN) system at Florennes air base. The Customer has advised [2] that an assessment is required by the Military in line with International Civil Aviation Organisation (ICAO) guidance [3]. Also, a QinetiQ pre-assessment [4] indicated that the turbines may also be in radar line of sight (LoS) from the Beauvechain primary surveillance radar (PSR). The distance between the wind farm the Beauvechain PSR is approximately 57 km. The visibility of the turbines will be quantified in this study, and if the Military requires a Eurocontrol assessment [5] for the Beauvechain PSR, the study can be updated.

1.3 Scope

The proposed activities are listed in the QinetiQ statement of work [1]. The scope has been agreed with the Military [6]. The assessment will only focus on the Florennes TACAN and the Beauvechain PSR. Any additional constraints caused by changes to the project definition will not be discussed.

1.4 Proposed Walcourt wind farm

Figure 1-1 shows the proposed turbine layout [7]. Turbine coordinates were provided in Lambert 72 map coordinates, and were converted to World Geodetic System 1984 (WGS 84) latitude and longitude format by QinetiQ. The coordinates used in the study are given in Table 1-1, along with turbine identification (ID) numbers. The terrain heights above mean sea level (AMSL) are also shown. These values were calculated by QinetiQ using the Shuttle Radar Topography Mission (SRTM) 3 digital elevation model (DEM).

Figure 1-1: Proposed turbine locations (green dots)

Turbine ID	WGS 84 location		SRTM3 DEM height (metres AMSL)
	Latitude (°N)	Longitude (°E)	
WT1	50.279454	4.449876	200.2
WT2	50.278829	4.455982	205.8
WT3	50.278769	4.463566	210.2
WT4	50.274377	4.450662	188.4
WT5	50.275189	4.459699	201.3
WT6	50.275692	4.467931	203.3

Table 1-1: Turbine locations used in the study

2 Turbine Visibility

2.1 Discussion

Radar LoS visibility can be used as an approximation of whether a radar will be able to detect an object. Radar waves curve downwards in the atmosphere and so a radar LoS region will cover a slightly wider area than a geometric (straight line) LoS region. When an object is in radar LoS it is likely that it will be detectable and may have an impact on the radar's operation. When an object is out of radar LoS it is likely the impact will be less or there may be no impact.

The QinetiQ DEM[a] tool was used to calculate the LoS visibility of the proposed turbines with respect to the Florennes TACAN and Beauvechain PSR. The calculations take account of Earth curvature, atmospheric refraction and terrain blocking.

2.2 Results

The height to radar LoS results for each system are shown in Figure 2-1 and Figure 2-2. Dark blue indicates a height to LoS of 0m above ground level (AGL), which means the sensor can see the ground. Dark red indicates a height to LoS of at least 200m AGL (a 200m turbine is completely out of radar LoS).

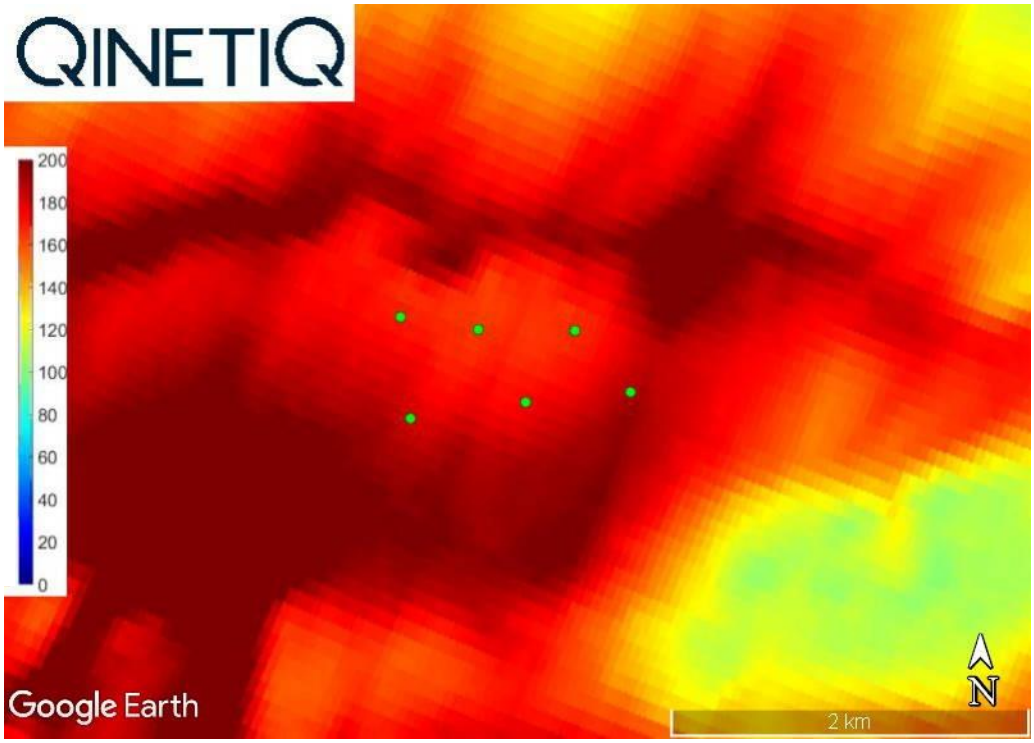

Figure 2-1: Height to LoS (m AGL) as viewed from the Beauvechain PSR. Green dots = proposed turbines

[a] The SRTM 3 digital elevation model was used in the modelling. This provides terrain heights on a roughly 90m spaced grid.

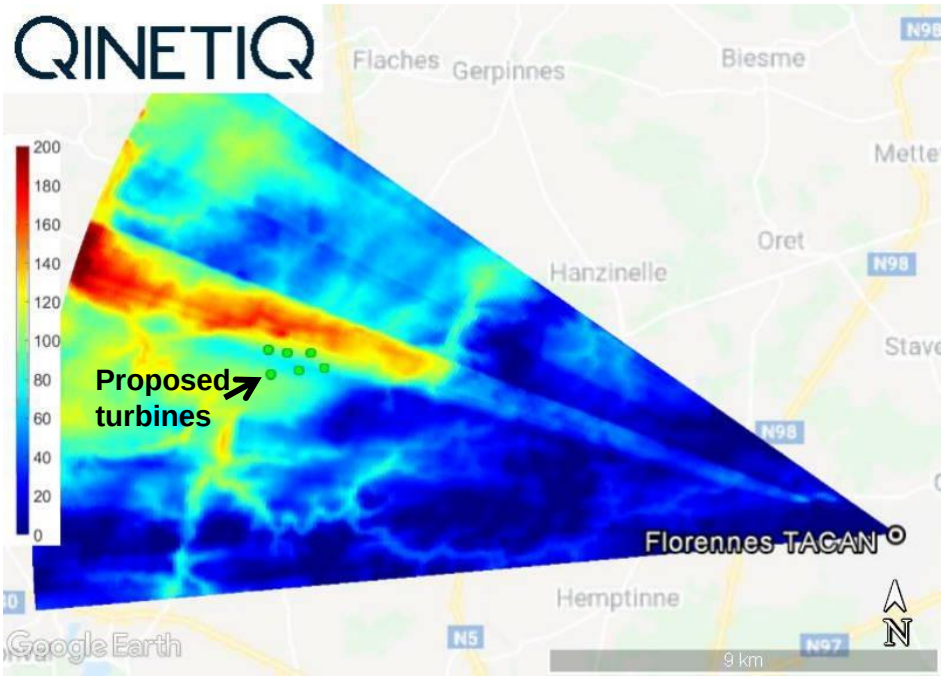

Figure 2-2: Height to LoS (m AGL) as viewed from the Florennes TACAN

The height to LoS values at the proposed turbine locations are listed in Table 2-1 for each system. Cells are coloured red or green to indicate if a 169m high turbine is in radar LoS (red) or out of radar LoS (green).

Turbine ID	Height to LoS (m AGL)	
	Beauvechain PSR	Florennes TACAN
WT1	169.1	92.8
WT2	163.0	95.8
WT3	166.6	110.0
WT4	184.0	92.8
WT5	174.3	72.6
WT6	190.2	83.2

Table 2-1: Height to LoS values (m AGL) at the proposed locations, as viewed from the Beauvechain PSR and the Florennes TACAN. Red cells = a 169m high turbine is in radar LoS; green cells = a 169m high turbine is out of radar LoS

The following observations are made for each system:

- Beauvechain PSR: Table 1-1 shows that two proposed turbines are in radar LoS, and one turbine (WT1) is only out of radar LoS by 10cm. Following the Eurocontrol guidelines [5], a PSR simple assessment is recommended. The visibility of the turbines will potentially be sensitive to small changes to the project definition. Layout changes or reducing the height of the turbines could move the turbines out of radar LoS; and
- Florennes TACAN: Figure 2-2 shows that all turbines are in radar LoS from the Florennes TACAN using a maximum tip height of 169m AGL. There are no nearby areas where a 169m high turbine is fully out of radar LoS. However, there is a small area to the north of the proposed turbines where 150m high turbines are out of radar LoS.

3 Florennes TACAN Assessment

The Florennes TACAN is safeguarded by the Military using ICAO guidance [3]. It is assumed the exclusion zones for an omni-directional navigation facility are used for safeguarding. In this section, the TACAN safeguarding zones are shown in relation to the proposed turbines.

3.1 Site details

The locations of the TACAN and the proposed turbines are shown in Figure 3-1. The location of the TACAN has been taken from [8].

Figure 3-1: Florennes TACAN (white circle) and Walcourt wind farm (green dots)

The TACAN comprises two sub-systems, summarised in Table 3-1. The ground elevation at the TACAN was estimated to be 278 metres AMSL. It is assumed the two systems are co-located for the purpose of the assessment.

Sub-system	Purpose	Antenna height
Very High Frequency (VHF) omni-range (VOR)	Provides aircraft with bearing from the TACAN	An antenna height of 952 feet (290.2 metres) above sea level is given in [8]). This value is assumed for the DME and the VOR transmissions.
Distance Measuring Equipment (DME)	Provides aircraft with distance from the TACAN	

Table 3-1: TACAN sub-systems

3.2 Safeguarding zones

The TACAN is an omnidirectional sensor. The safeguarding zones for omni-directional sensors are given in Table 1 of the guidelines [3]. The TACAN is safeguarded using the criteria for Conventional VOR (CVOR) and DME [9]. Figure 3-2 and Figure 3-3 show the proposed turbines and the safeguarding zones for an omnidirectional DME and CVOR. No turbines are inside the safeguarding zone for the DME. However, several turbines are within the CVOR safeguarding zone.

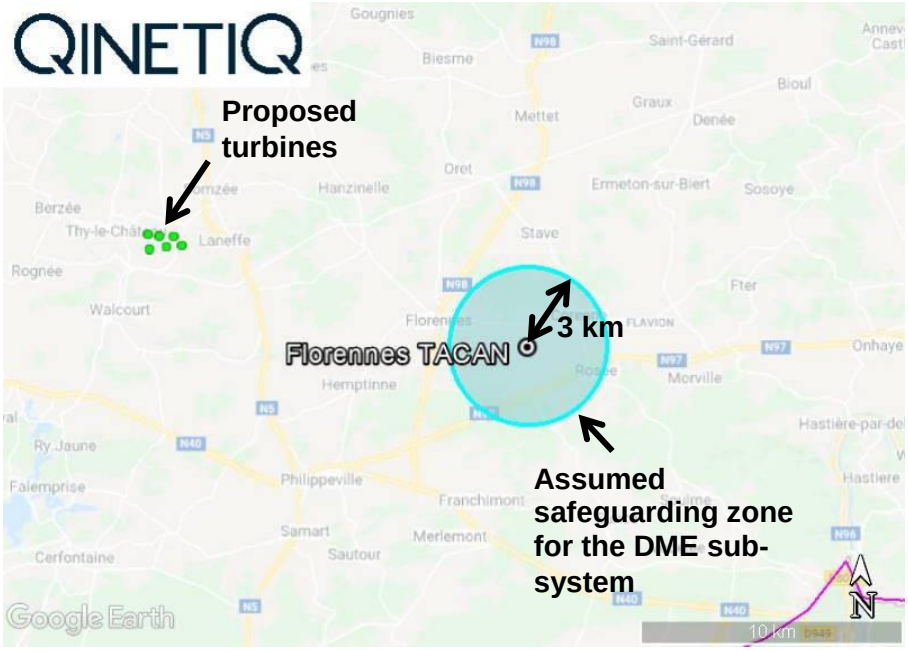

Figure 3-2: Safeguarding zone (blue) for the DME sub-system, assuming the criteria for an omni-directional DME. Green dots = proposed turbines

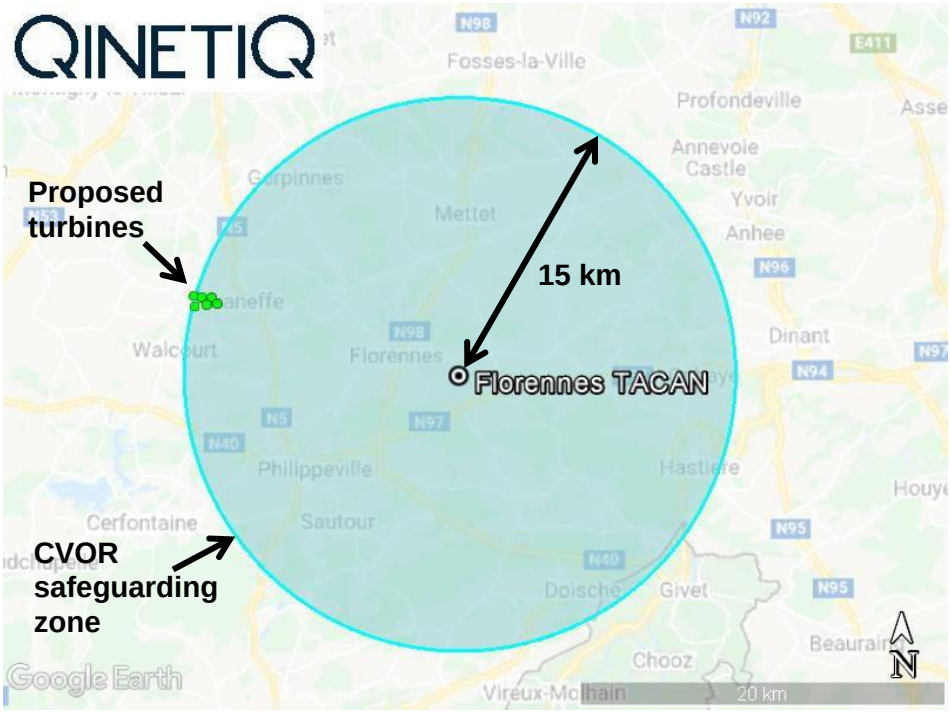

Figure 3-3: Safeguarding zone (blue) for the VOR sub-system, using the criteria for a CVOR. Green dots = proposed turbines

Figure 3-4 shows a close-up view of the CVOR safeguarding zone in the vicinity of the proposed turbines. The red circles indicate the extent of a swept rotor, assuming a rotor diameter of 122 metres. This is the maximum rotor diameter under consideration. It can be seen from the figure that turbine WT1 is fully outside the zone. The other five turbines (WT2 to WT6) are laterally within the zone and there could potentially be a breach. This will be confirmed in section 3.3.

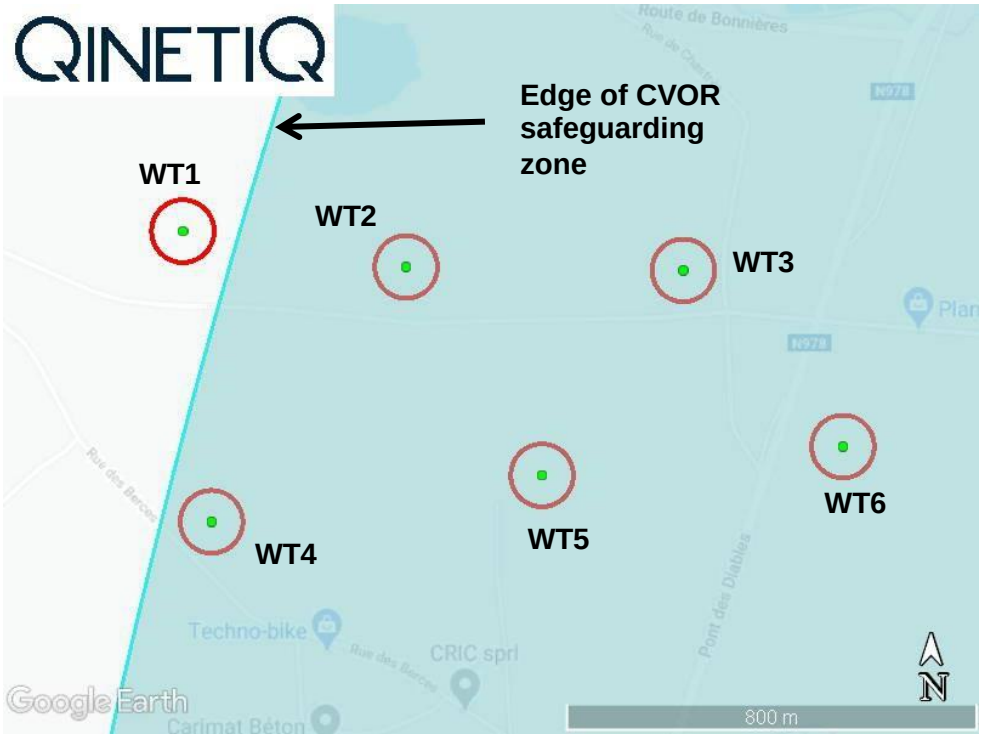

Figure 3-4: Close-up view of the CVOR safeguarding zone in the vicinity of the proposed turbines (green dots). Red circles = rotor sweep area, using a rotor diameter of 122 metres

3.3 Height analysis

The results in section 3.2 showed that five of the proposed turbines (WT2 to WT6) are laterally within the CVOR safeguarding zone. In this section, the heights of the turbines are compared against the height of the zone, to see if there will be a breach. The maximum turbine height that does not breach the zone will be quantified.

A side view of the CVOR zone is illustrated in Figure 3-5. The surface of the zone comprises three shapes [3]:

- A first cylinder (radius 600 metres, origin at antenna ground level);
- A cone (radius 3 km, 1° cone angle, origin at antenna ground level); and
- A second cylinder (radius 15 km, origin 52 metres above antenna ground level).

Figure 3-6 shows a side view of turbine WT3 in relation to the CVOR safeguarding zone. Turbine WT3 was chosen because the ground elevation at this turbine location is highest out of all proposed locations. It can be seen that the turbine breaches the second cylinder. The result is the same for turbines WT2, WT4, WT5, and WT6.

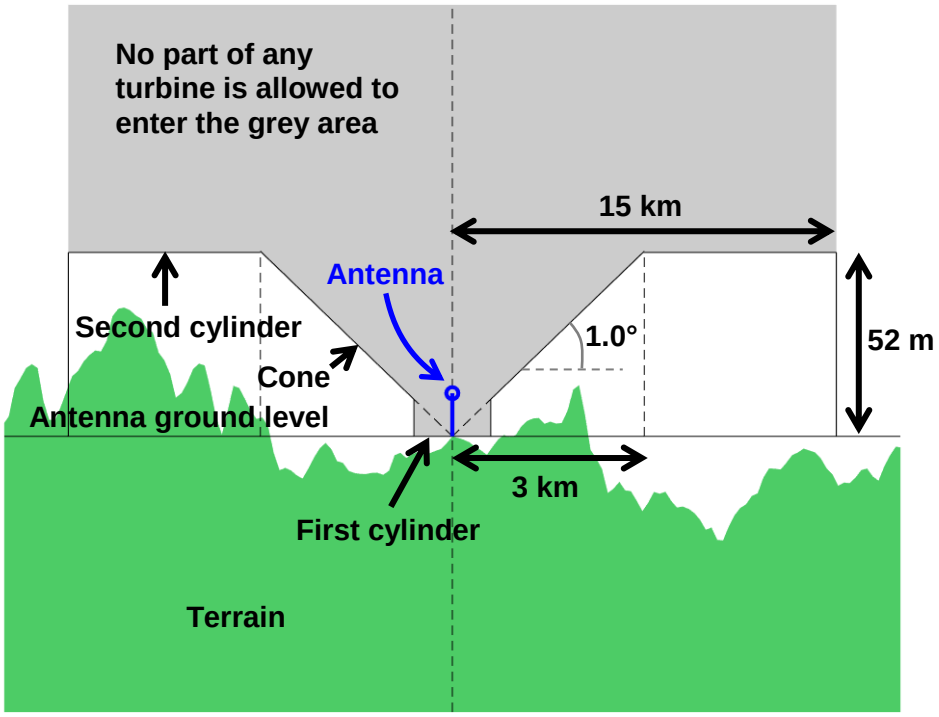

Figure 3-5: Illustration of the CVOR safeguarding zone in side view. The drawing is not to scale. Blue line = antenna. Green area = terrain. Grey area = zone where turbines are not allowed

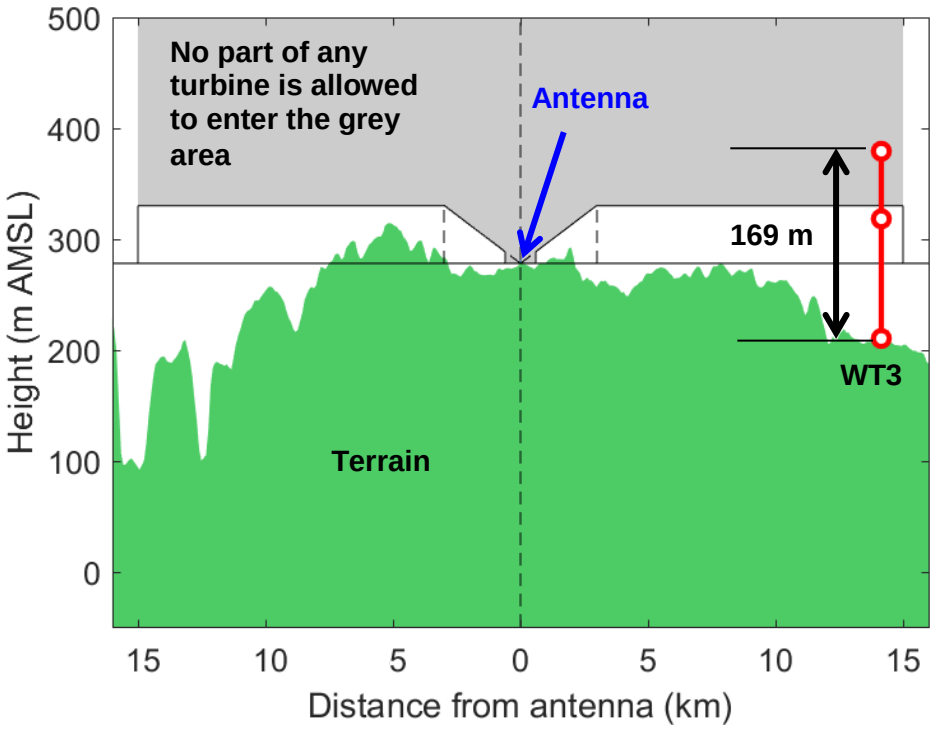

Figure 3-6: Turbine WT3 in relation to the CVOR safeguarding zone. Green area = terrain. Grey area = zone where turbines are not allowed. Red line = vertical extent of turbine, assuming 169 metre maximum height. Red circles indicate the ground elevation, hub height, and maximum blade tip height

The maximum turbine height that does not breach the safeguarding zone is shown in Table 3-2.

Turbine ID	DEM height (metres AMSL)	Height of zone at this location (m AMSL)	Maximum turbine height (m AGL) of turbine that does not breach the zone
WT1	200.2	n/a	no constraint
WT2	205.8	330	124.2
WT3	210.2	330	119.8
WT4	188.4	330	141.6
WT5	201.3	330	128.7
WT6	203.3	330	126.7

Table 3-2: Maximum turbine heights that do not breach the zone

4 Summary

WindVision, the Customer, is jointly developing the Walcourt wind farm with Elawan. Using the Customer's preferred layout (six turbines, 169m maximum height), a short study has been carried out to confirm the LoS visibility of the turbines from the Beauvechain PSR. A Florennes TACAN assessment has also been carried out at the request of the Military.

4.1 Beauvechain PSR

A LoS analysis showed that the proposed turbines are partially in radar LoS from the Beauvechain PSR. The visibility of the turbines will be sensitive to small changes to the project definition. Reducing the height of the turbines or changing the turbine layout could potentially move the turbines out of radar LoS. If the turbines cannot be moved out of radar LoS, the Military may require a PSR simple assessment. This could be carried out in a future study.

4.2 Florennes TACAN

All proposed turbines are in radar LoS from the Florennes TACAN.

An assessment has been carried out in accordance with the ICAO guidelines for a CVOR and omnidirectional DME [3]. Turbine WT1 is outside the safeguarding zone. Turbines WT2 to WT6 breach the zone. The maximum turbine heights that do not cause a breach have been calculated.

5 References

[1] QinetiQ, *Walcourt Assessment for WindVision*, Contract Reference No. 201219-717v2

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[3] International Civil Aviation *Organisation, European Guidance Material on Managing Building Restricted Areas*, 3rd Edition, 2015

[4] Ellis, J. (QinetiQ), *RE: UC Walcourt Assessment for Windvision*, email to Hautot, C. (WindVision), 25th March 2020 13:18

[5] Eurocontrol, *Eurocontrol Guidelines on How to Assess the Potential Impact of Wind Turbines on Surveillance Sensors*, Version 1.2, September 2014. Available URL: http://www.eurocontrol.int/sites/default/files/publication/files/20140909-impact-wind-turbines-sur-sensors-guid-v1.2.pdf

[6] Belgian Military, *RE: UC Walcourt assessment for WindVision (ref 3D/3237-1 and 3D/3237-2)*, email to Ellis, J. (QinetiQ), 30th April 2020

[7] Hautot, C. (WindVision), *RE: UC 717 Walcourt Assessment for Windvision*, email to Ellis, J. (QinetiQ), 4th May 2020 11:25

[8] Skeyes, *Aeronatical Information Package, EBFS - Florennes (Military), EBFS AD 2.19 Radio Navigation and Landing Aids*, https://ops.skeyes.be/html/belgocontrol_static/eaip/eAIP_Main/html/index-en-GB.html

[9] Belgian Military, *RE: UC Safeguarding criteria for TACANs,* email to Ellis, J. (QinetiQ), 3rd September 2020