1.5 Safeguarding zones

The French legislation for the development of wind farms near radar facilities in France is laid out in [6]. The safeguarding zones for Météo-France C-band, S-band and X-band radar facilities, as given by the legislation, are shown in Table 1-3.

Radar band	Distance between a turbine and a radar		
	Protection zone	Coordination area	Authorised zone
S	< 10 km	10 km to 30 km	> 30 km
C	< 5 km	5 km to 20 km	> 20 km
X	< 4 km	4 km to 10 km	> 10 km

Table 1-3: Safeguarding zones for the development of wind farms near Météo-France radar facilities

According to the legislation, wind farms are not allowed to be developed inside the protection zone of a Météo-France radar facility, except in special cases where Météo-France has been consulted and they have judged that impacts on the provision of their services are not operationally significant [7]. If a proposed wind farm is physically inside the coordination area of a Météo-France radar facility, a radar impact assessment is required. In order for the wind farm to be compliant withthe legislation, the following criteria of the Direction Générale de la Prévention des Risques (DGPR) must be satisfied:

- **Criterion 1.** The maximum percentage occultation of the wind farm (including the existing wind farm environment) must not exceed 10%;
- **Criterion 2.** The size of the impact zone due to a wind farm must not exceed 10 km, measured along the longest dimension. Only the parts of the impact zone that are inside the coordination area are taken into account in the calculation [7];
- **Criterion 3.** The interdistance between impact zones from different wind farms must be at least 10 km; and
- **Criterion 4.** The interdistance between wind farm impact zones and sensitive sites[c] must be at least 10 km.

If a proposed wind farm is in the authorised zone, an objection against the proposed wind farm on the grounds of radar impacts is unlikely.

1.6 Other wind farms

There are operational turbines in the vicinity of the Montclar radar. Also, details of the proposed Lestrade et Thouels wind farm were provided by Soleil du Midi [8].The Lestrade et Thouels wind farm is included in the feasibility study because it is likely to be constructed before Alrance, and will, therefore, be a potential constraint. The locations of the other wind farms, the Alrance development area and the Montclar radar are shown in Figure 1-3. The wind farms closest to Alrance are shown and labelled in Figure 1-4.

[c] Sensitive sites consist of Seveso sites (high threshold) and basic nuclear facilities (INBs) mentioned in Article L. 515-36 of the Environment Code.

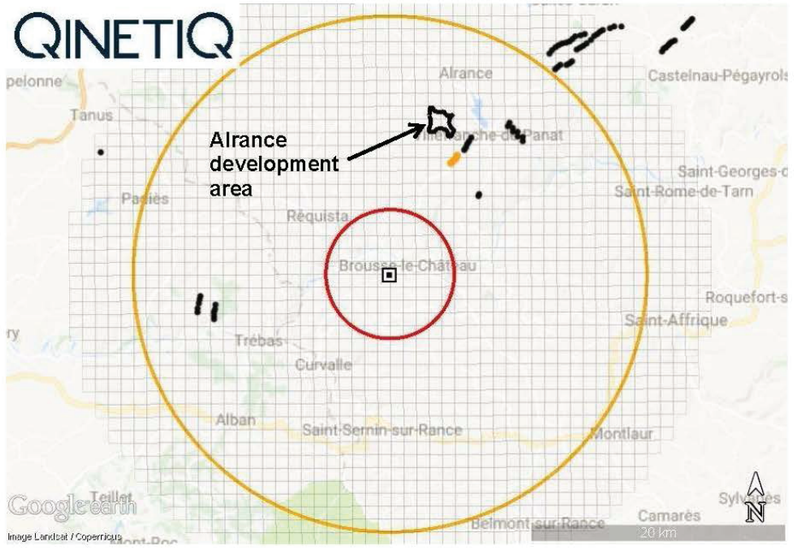

Figure 1-3: Other wind turbines in the vicinity of the radar. White square = Montclar radar; black dots = operational turbines; orange dots = planned turbines; red line = 5km radius protection zone; orange line = 20km radius coordination area; black polygon = Alrance development area

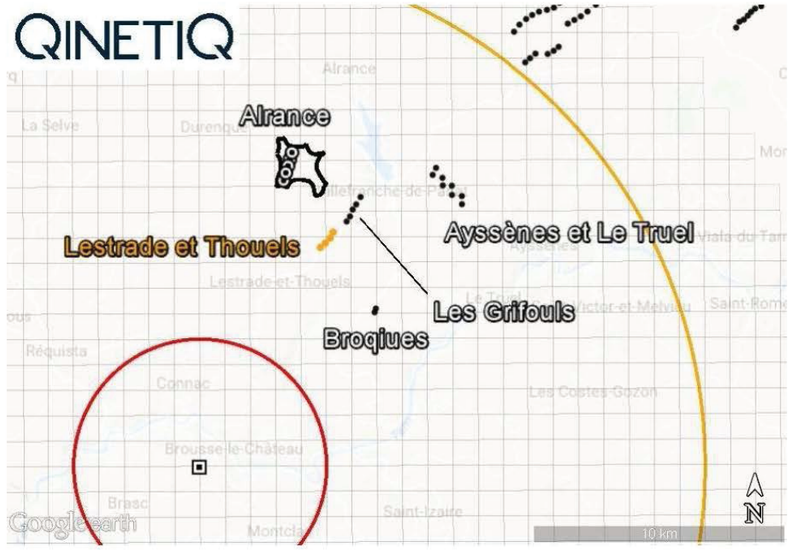

Figure 1-4: Wind farms close to Alrance. White square = Montclar radar; black dots = operational turbines; orange dots = planned turbines; red line = 5km radius

protection zone; orange line = 20km radius coordination area; black polygon = Alrance development area

1.7 Sensitive sites

Details of sensitive sites were obtained from the Customer [2] and the Autorité de sûreté nucléaire (ASN) and Ministère de l'Environnement, de l'Énergie et de la Mer websites [9][10]. Based on this, QinetiQ understands there are no sensitive sites within the radar coordination area.

2 Line of Sight

2.1 Line of sight analysis

Radar line of sight (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 anobject is out of radar LoS it is likely the impact will be less or there may be no impact. If no part of the turbine is in radar LoS, the turbine does not need to be assessed, and is, therefore, acceptable with respect to the DGPR criteria [7].

Figure 2-1 shows the height to LoS in the vicinity of the proposed Alrance wind farm, as viewed from the Montclar radar. The colours represent the minimum height(in metres AGL) that an obstacle would need to be in order for it to be in radar LoS. For example, orange (height to LoS = 150 metres) means that an obstacle less than150 metres in height will not be in radar LoS. It can be seen from Figure 2-1 that all proposed turbines are in a blue region, which means they are almost fully in radar LoS, and are likely to be detectable to the Montclar radar, and will need to be assessed. The same is true for the other operational and proposed turbines shown in the figure.

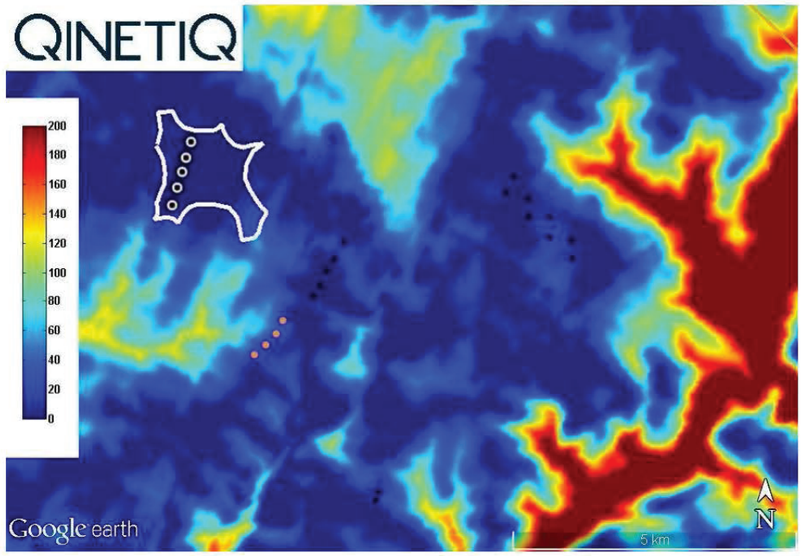

Figure 2-1: Height to LoS (metres AGL) in the vicinity of the proposed turbines (white circles), as viewed from the Montclar radar. Black dots = operational turbines; orange dots = proposed turbines; white polygon = Alrance development area

3 Feasibility Assessment

3.1 Criteria 1: Occultation

Any object in radar LoS may act as a blockage to radar, reducing the signal strength behind the object. Large objects like wind turbines can have a significant influence on signal strength which, in the case of a weather radar, can result in rainfall rates being underestimated. In order to be compliant with the French legislation, the percentage occultation of a wind farm must not exceed 10%.

The CLOUDSiS occultation results for the proposed Alrance wind farm are shown in Figure 3-1. The lowest radar scan angle is used because this gives the worst impact. The top plot shows the occultation percentage as the pencil beam rotates from 15° to 50° bearing. The bottom plot shows the positions of the turbines in the beam (pink band). The red circle in the bottom plot indicates the beam position at the maximum occultation value of 15.0% due to Alrance. This is greater than 10% and so is not compliant for the DGPR rule.

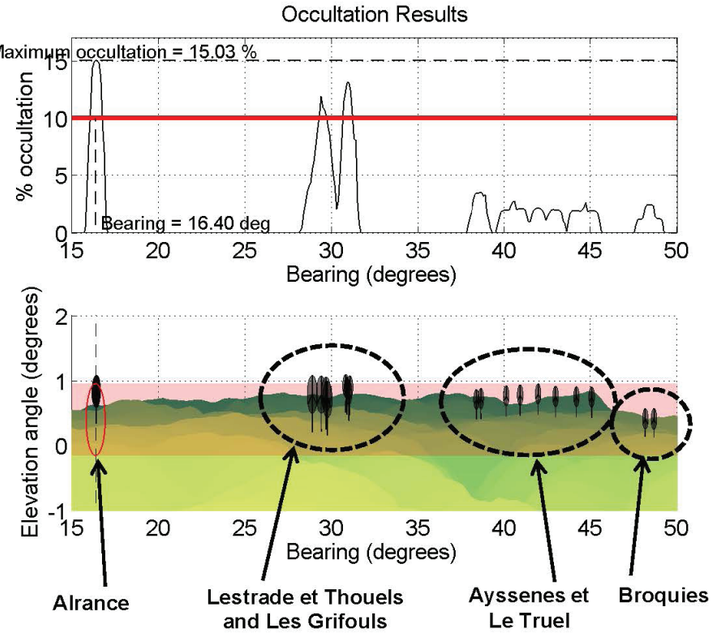

Figure 3-1: Occultation in sector containing Alrance and other operational turbines

3.2 Criteria 2 and 3: Impact zone size and interdistance

3.2.1 Composite reflectivity

In this section the reflectivity due to the Alrance wind farm is calculated, to show how strong the reflections from the turbines will be.

There are two main types of information used in meteorology, often referred to as products, which can be derived from modern weather radars; reflectivity and radial velocity. Reflectivity is a display of the echo intensity, which is measured in units of Z, and is essentially the amount of transmitted power returned back to the radar receiver. Two forms of the reflectivity data are often presented; *base* and *composite*. Base reflectivity images are typically information from the lowest elevation angle that has been scanned, and are used to detect precipitation and hailthat is closest to the ground. Composite reflectivity is the maximum echo intensity across all the layers in elevation, at all ranges from the radar, and is used to determine the highest reflectivity in all echoes. Composite reflectivity is often important for revealing storm structure features and intensity trends of storms. The data is usually presented in units of dBZ, which are decibels of Z. The decibel, or dB, is a logarithmic scale, often used by engineers to describe the signal levels in radar systems due to the large variations encountered, and is a unit of measurement that expresses the magnitude of a quantity relative to a specified or implied reference level.

Only the bottom three elevation layers are used in the calculation.

3.2.2 Impact zone

Reflections from wind turbines can result in increased clutter levels. There are two main effects of wind farm clutter: i) reduced ability of the radar to detect less reflective objects in that region, such as precipitation or hail; and ii) interference of Doppler measurements that can cause erroneous values in the velocity measurements of any precipitation in the region.

The impact zone is defined as the grid cells where, at any of the lowest three scan angles, a wind farm is predicted to cause an operationally significant impact on the raw radar data in any of the zero Doppler and non-zero Doppler channels[D]. The typical RCS)[E] is used in the calculation to show what the time-averaged impact will be. There is an impact if, in any channel, the turbine reflectivity is i) greater than 0 dBZ and ii) greater than the terrain reflectivity. The size of the impact zone is measured along the longest dimension. Only the parts of the impact zone inside the coordination area are taken into account in the calculation.

Alrance extends the size of the impact zone formed by Lestrade et Thouels, Broquies, Les Grifouls and Ayssenes et Le Truel. The impact zone is shown in Figure 3-2, and its interdistance from the other impact zone in the coordination is shown in Figure 3-3. The maximum dimension of the impact zone is 10.3 km, and so Alrance fails Criterion 2. The minimum interdistance is 20.0 km, and so Alrance passes Criterion 3.

[D] The radar uses Doppler processing to filter out unwanted returns from stationary targets, such as the ground. Any static object, such as the turbine tower, can usually be filtered out using a technique called moving target indication/detection (MTI/MTD). MTI uses the familiar Doppler effect due to an object's motion towards, or away from, the radar to discriminate moving targets from stationary clutter. MTD is a similar but more advanced form of MTI. This filtering helps to separate the returns from static and moving objects into different channels: the returns from static objects will predominantly appear in the zero- Doppler channel of the radar; whereas the returns from moving objects (such as the blades) will predominantly appear in the non-zero Doppler channels.

[E] The assumption is made that the turbine blades are moving, therefore, the turbine RCS will be changing over time. The time-averaged turbine RCS is estimated based on an analysis of turbine RCS datasets, and this is referred to as the typical RCS of the turbine.

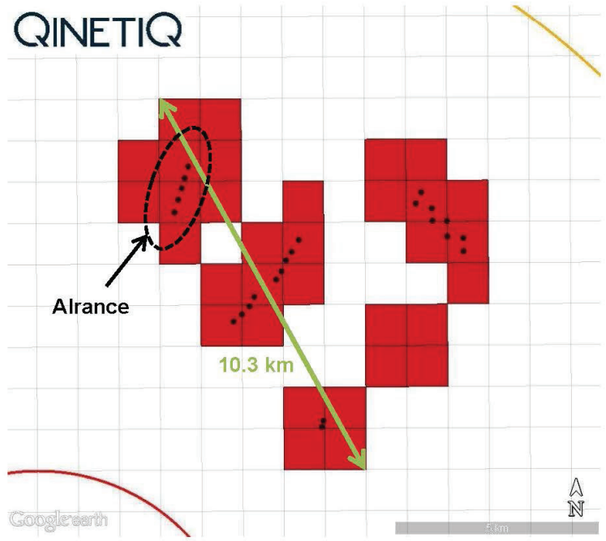

Figure 3-2: Impact zone (red cells) due to the proposed Alrance turbines and operational turbines (black dots). Red line = protection zone; orange line = coordination area

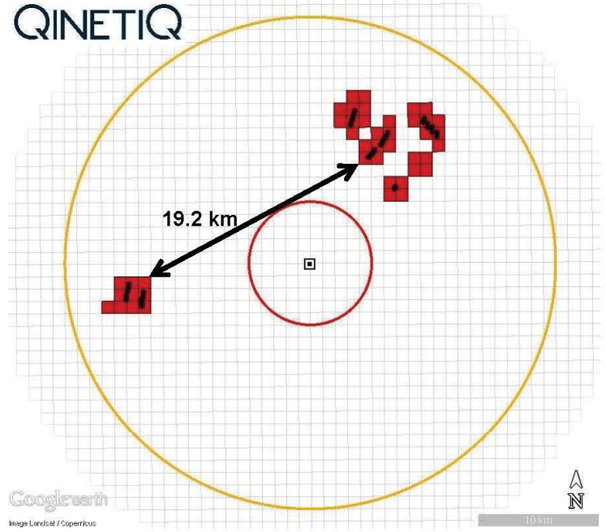

Figure 3-3: Impact zone (red cells) due to all turbines black dots) in coordination area. Red line = protection zone; orange line = coordination area

3.3 Sensitive Sites

No sensitive sites have been identified within the coordination area. Therefore, the proposed Alrance project passes Criterion 4.

4 Mitigation

4.1 Discussion

The assessment in Section 3 showed that the initial layout fails criteria 1 (occultation) and 2 (maximum size of the impact zone). Modelling tests showed thatthe occultation criterion can be met by spacing the turbines equally in angle; and the impact zone size can be reduced by avoiding the locations that have an impact on the cells to the west of the impact zone.

Various layout iterations were discussed between QinetiQ and Soleil du Midi, and other constraints (roads, streams, microlight club) were considered. The optimised layout is shown in Figure 4-1. The new turbine locations are all inside the 1st preference development areas (green circles). The modified turbine locations are listed in Table 4-1.

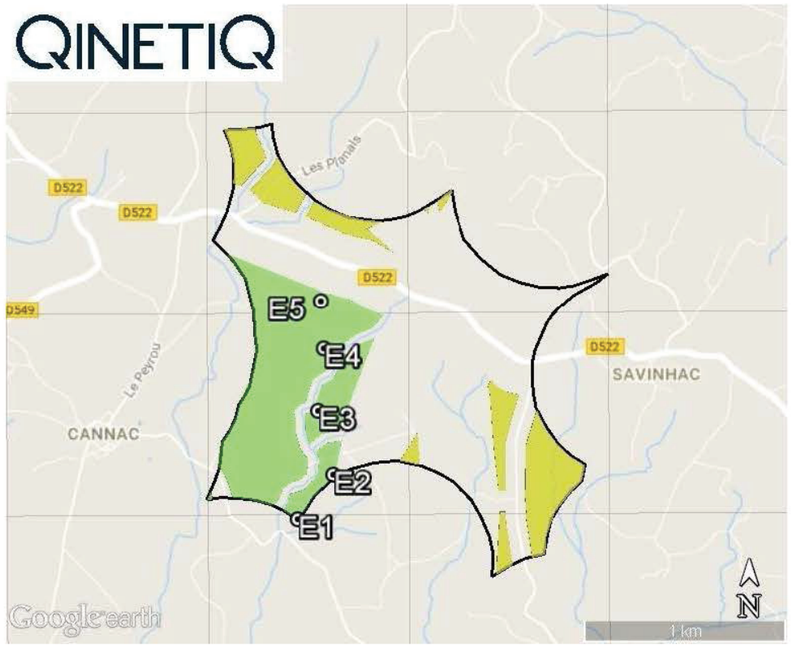

Figure 4-1: Optimised Alrance layout. White circles -= turbine locations; black polygon = development area; green areas = 1st preference areas; yellow areas = 2nd preference areas

Turbine ID	WGS 84 coordinates (degrees)	
	Latitude	Longitude
E1	44.089488	2.652010
E2	44.091476	2.654219
E3	44.094321	2.653280
E4	44.097111	2.653635
E5	44.099245	2.653457

Table 4-1: Optimised Alrance layout turbine coordinates in WGS84 latitude/longitude format

4.2 Occultation

The occultation results using the Optimised Alrance layout are shown in Figure 4-2, and should be compared with Figure 3-1. The maximum occultation from the proposed Alrance wind farm is approximately 9%. This is less than 10% and so is acceptable.

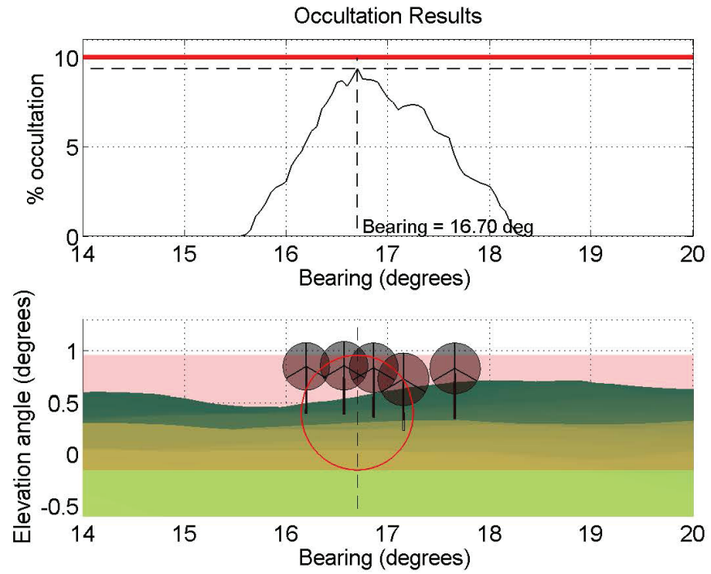

Figure 4-2: Occultation in sector containing Alrance and other operational turbines. Alrance Modified Layout A is used

4.3 Impact Zone

The impact zone for Alrance Modified Layout A is shown in Figure 4-3 and should be compared with Figure 3-2. The maximum dimension of the impact zone has reduced to 10.0 km and now passes Criterion 2. The minimum interdistance is unchanged, shown in Figure 4-4.

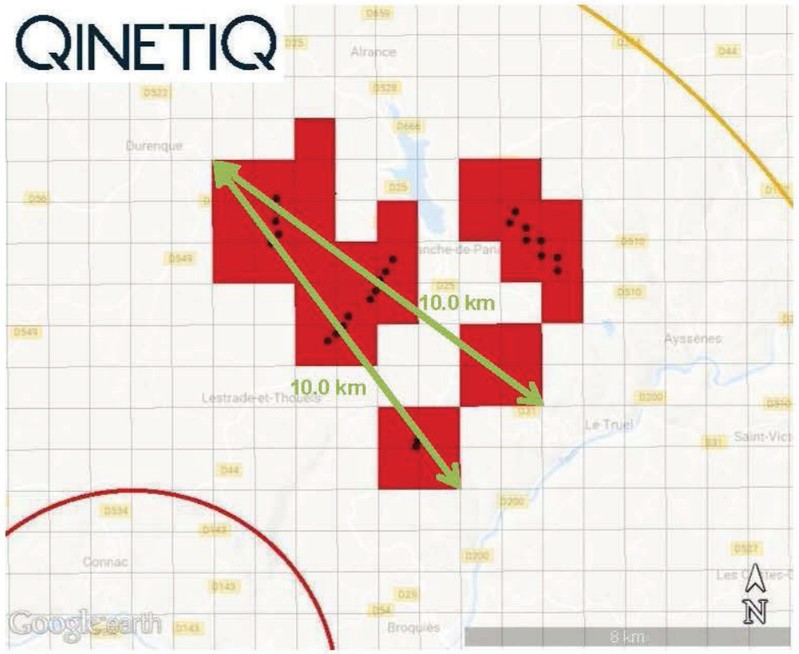

Figure 4-3: Impact zone (red cells) due to proposed Optimised Alrance layout and other turbines (black dots). Red line = protection zone; orange line = coordination area

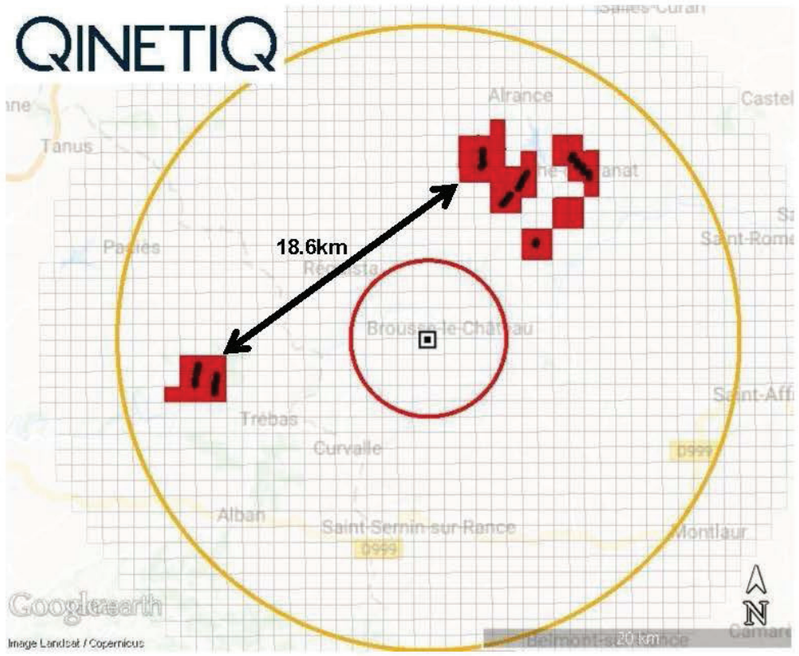

Figure 4-4: Impact zone (red cells) due to all turbines (black dots) in coordination area, using Optimised Alrance layout. Red line = protection zone; orange line = coordination area

5 April 2019, Updated Layout

5.1 Discussion

Soleil du Midi want have updated the potential Alrance-Durenque wind farm development area, shown in Figure 5-1. The proposed layout from Table 4-1 is shown on the figure for reference. Turbine E2 from Table 4-1 is now outside the development area. Soleil du Midi require an updated layout with five turbines inside the Main Zone. In addition, the potential for an additional turbine in the Optional Zone is being considered. The candidate turbine is the same as described in Section 1.2.

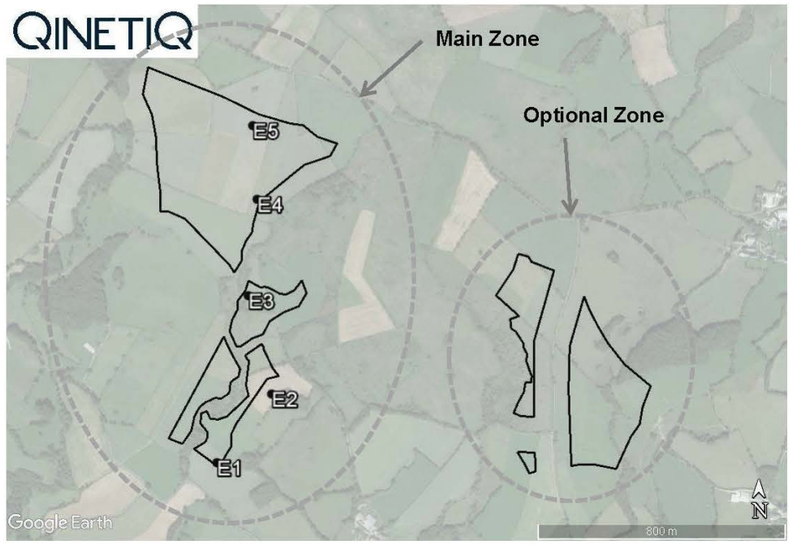

Figure 5-1: April 2019 potential development area (black polygons). The proposed layout from Table 4-1 (black dots) is shown for reference

The existing constraints are summarised in Figure 5-2. Any impacts in the green cells are acceptable with respect to Criteria 2 to 4.

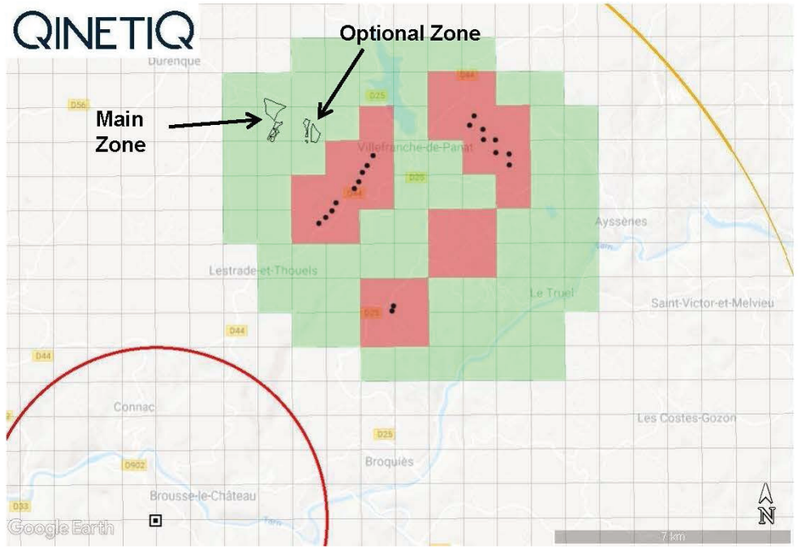

Figure 5-2: Existing constraints (red cells), existing turbines (black dots), cells where additional impact is acceptable (green polygon); radar cells (grey lines); radar (white square), protection zone (red line), coordination area (orange line); April 2019 Alrance-Durenque wind farm development area (black polygon)

5.2 Layout Alrance05_290419

QinetiQ and Soleil du Midi discussed and assessed various candidate layouts. An optimised layout Alrance05_290419 was agreed with location listed in Table 5-1.

Turbine ID	Zone	WGS 84 coordinates (degrees)	
		Latitude	Longitude
E1	Main	44.089488	2.652010
E2		44.091726	2.653810
E3		44.094321	2.653280
E4		44.096775	2.653473
E5		44.099245	2.653457
E6	Optional	44.093143	2.666944
E7		44.089865	2.667816

Table 5-1: Alrance05_290419 layout

Soleil du Midi are considering an alternate location for turbine E3 at WGS84 location 44.094421°N 2.653324°E. This location is approximately 12 m from the location of E3 listed in Table 5-1 and on the same bearing from the radar. Modellingchecks from QinetiQ in October 2019 show that the change in location will have no significant impact on the results presented in the remainder of this section.

Accordingly, all subsequent discussion and results also apply to the layout with new location E3.

5.2.1 Occultation

The occultation results using the Alrance05_290419 layout are shown in Figure 5-3. The maximum occultation from the proposed Alrance wind farm is 9.4%. This is less than 10% and so is acceptable.

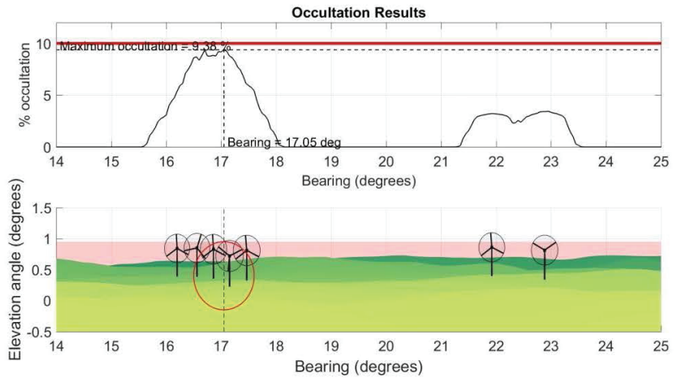

Figure 5-3: Occultation for Alrance05_290419

5.2.2 Impact Zone

The impact zone for Alrance05_290419 is shown in Figure 5-4. The maximum dimension of the impact zone has reduced to 10.0 km and now passes Criterion 2. The minimum interdistance is unchanged from Figure 4-4.

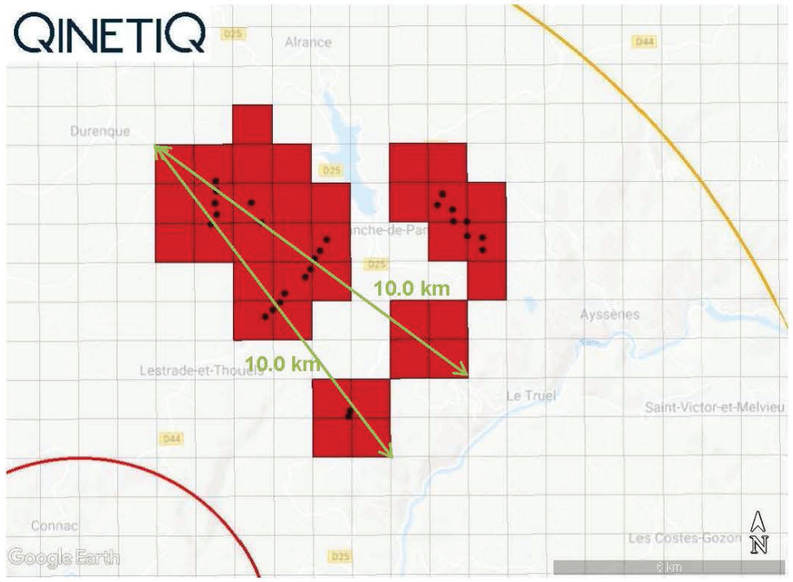

Figure 5-4: Impact zone (red cells) due to Alrance05_290419 and other turbines (black dots). Red line = protection zone; orange line = coordination area

6 Mise à jour de Janvier 2021

6.1 Définitions du projet

La définition du projet de parc éolien de Durenque a été mise à jour comme suit :

- Implantation = 4 éoliennes (identique à celle d'Alrance05_290419 avec la suppression de l'éolienne E1), listées dans le tableau 6-1 [11].
- Type d'éolienne = Nordex N117 [11].
- Hauteur du moyeu = 91 m, longueur des pales = 58,5 m [11].
- Forme de la tour, 2 segments avec des diamètres, D, aux hauteurs au-dessus du niveau du sol : à 0 m au-dessus du niveau du sol, D = 3.9m ; à 63.1 au-dessus du niveau du sol, D=3.9m ; H=93.1m, D=2.29m [12]
- Hauteur de la nacelle = 4,0 m, largeur = 4,3 m [13].

Ceci sera désigné comme la définition du projet Durenque_Jan21.

Turbine ID	WGS 84 coordinates (degrees)	
	Latitude	Longitude
E1	44.091726	2.653810
E2	44.094321	2.653280
E3	44.096775	2.653473
E4	44.099245	2.653457

Table 6-1: implantation de Durenque_Jan21

En outre, de petites corrections ont été apportées aux définitions de projet de certains parcs éoliens existants et proposés :

1. Lascombe (Broquiès) = 2 x Gamesa G58, hauteur du moyeu 65m, longueur des pales 29m [12].
2. Lespigue, 4x Enercon E82, hauteur du moyeu 85m, longueur des pales 41m [12], aux emplacements résumés dans le Tableau 6-2 [12].

Turbine ID	WGS 84 coordinates (degrees)	
	Latitude	Longitude
E1	44.070500	2.671556
E2	44.069333	2.669667
E3	44.068139	2.667778

Table 6-2: January 2021 Lespigue wind farm locations

Soleil du Midi a demandé une mise à jour de l'évaluation du parc éolien de Durenque. Cette mise à jour comprend les changements apportés à la définition du projet de parc éolien de Durenque et les petits changements apportés aux autres parcs éoliens.

6.2 Evaluation

Les occultations pour la définition du projet Durenque_Jan21 sont présentées dans la figure 6-1. L'occultation maximale du parc éolien proposé de Durenque est de 9,8 %. Ce chiffre est inférieur à 10% et est donc acceptable.

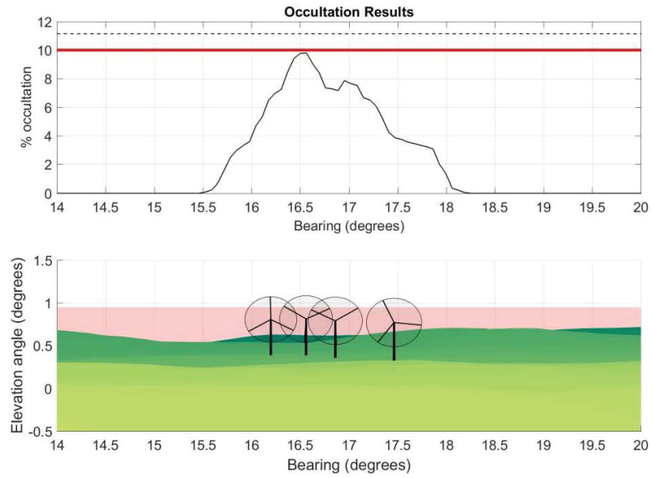

Figure 6-1: Occultation pour Durenque_Jan21

La zone d'impact de la définition du projet Durenque_Jan21 et des autres parcs éoliens est présentée dans la Figure 6-2. La dimension maximale de la zone d'impact combinée est de 10,0 km. Par conséquent, le parc éolien proposé est acceptable au regard du critère 2. Les zones d'impact dans l'ensemble de la zone de coordination radar sont présentées à la figure 6-3, montrant que l'interdistance avec la seule autre zone d'impact est de 19,2 km. Cette valeur est supérieure à celle d'Alrance05_290419 (18,6 km, examinée à la section 5.2.2) car l'éolienne la plus au sud d'Alrance05_290419 a été supprimée.

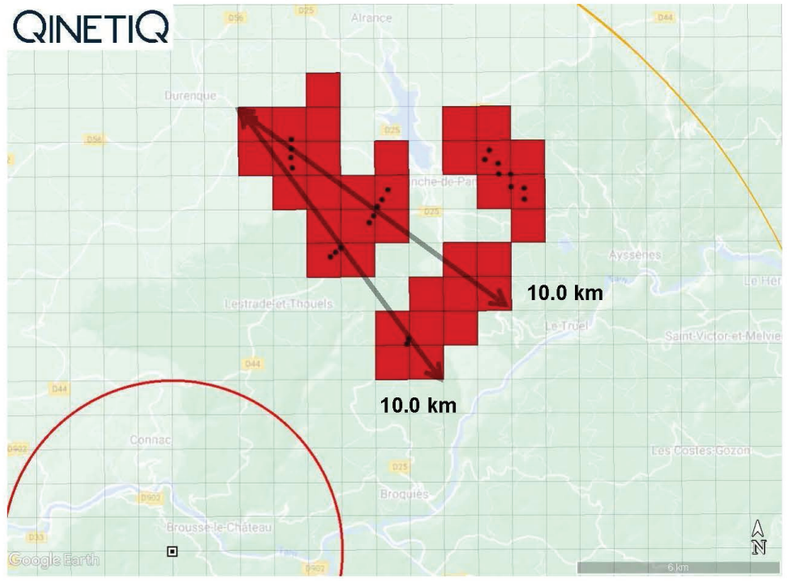

Figure 6-2: Zone d'impact (cellules rouges) due à Durenque_Jan21 et aux autres éoliennes (points noirs). Ligne rouge = zone de protection ; ligne orange = coordination ; radar = carré blanc

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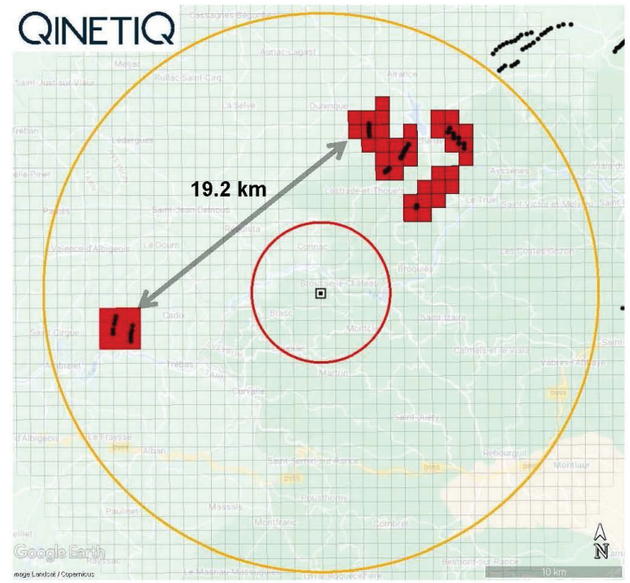

Figure 6-3: Zone d'impact (cellules rouges) due à Durenque_Jan21 et aux autres éoliennes (points noirs). Ligne rouge = zone de protection ; ligne orange = coordination ; radar = carré blanc

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7 Résumé

7.1 Evaluation initiale Octobre 2017

Soleil du Midi a l'intention de développer le parc éolien d'Alrance-Durenque. Le parc éolien se trouve dans la zone de coordination du radar météorologique de Montclar où s'appliquent les règles de sauvegarde de la DGPR.

Une étude LoS du radar a montré que tous les emplacements proposés pour les éoliennes sont visibles depuis le radar. Cela signifie qu'elles sont susceptibles d'être détectées et d'avoir une zone d'impact. Ceci est vrai pour tous les emplacements de la zone de développement du projet.

Les impacts du parc éolien proposé ont été évalués et l'acceptabilité a été calculée sur la base des critères d'acceptation du DGPR. Une évaluation de la disposition initiale proposée (tableau 1-1) a montré que les impacts sur l'occultation et la taille maximale de la zone d'impact étaient inacceptables. Des modifications ont été apportées à la disposition pour définir une disposition optimale qui soit acceptable pour les quatre critères. La disposition acceptable est appelée disposition optimisée d'Alrance (tableau 4-1).

7.2 Mise à jour d'Avril 2019

Suite aux modifications apportées à la limite de développement potentiel, un tracé actualisé Alrance05_290419 a été proposé en avril 2019. Ce tracé est acceptable au regard des quatre critères.

7.3 Mise à jour de Janvier 2021

Suite à des changements dans la définition du projet, les évaluations ont été mises à jour. La définition du projet est désignée sous le nom de Durenque_Jan21. La mise à jour comprend de petites corrections concernant d'autres turbines existantes et proposées.

7.4 Acceptabilité

Les résultats sont résumés dans le tableau 7-1.

Critères DGPR	Metric (PASS/FAIL)			
	Initial Alrance	Alrance optimisée	Alrance05 _290419	Durenque_ Jan21
Turbines	Diameter du rotor=101m; H du moyeu = 99m			N117-HH95
Layout	Table 1-1	Table 4-1	Table 5-1	Table 6-1
1. Occultation	15.0% FAIL	9.0% PASS	9.4% PASS	9.8% PASS
2: Dimension max. de la zone d'impact	10.3 km FAIL	10.0 km PASS	10.0 km PASS	10.0 km PASS
3: Interdistance mini. avec les autres zones d'impact	19.2 km PASS	18.6 km PASS	18.6 km PASS	19.2 km PASS
4: Interdistance mini. des sites sensibles	n/a PASS	n/a PASS	n/a PASS	n/a PASS

Table 7-1: Résumé des contraintes du radar d'Alrance

8 References

[1] QinetiQ, *Statement of work: Radar Impact Assessment of Proposed Alrance-Durenque Wind Farm*, reference 130517-0529, April 2017

[2] Pons, A. (Soleil du Midi), *Re: UC QinetiQ RIA assessment of two wind farms proposal document*, email to Savage, V. (QinetiQ), 3rd July 2017

[3] Météo-France, *Coordonnées de positionnement des radars météorologiques de Météo-France*, 1st April 2016

[4] OPERA II, WORK PACKAGE 1.8, *Impact of Wind Turbines on Weather Radars*, OPERA deliverable OPERA_2006_18

[5] OPERA III, WORK PACKAGE 1.5b, *Site protection (wind turbines)*, OPERA deliverable: OPERA_2010_05

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