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TO: Janet Filbin, Senior Planning Officer
Preston City Council

Sent via email: J.Filbin@preston.gov.uk
COPY: Devcon@preston.gov.uk

26 November 2012

Dear Ms Filbin,

Almonds_Farm LPA Ref: 06/2012/0357 -- NATS REF: W(F)14493

I write to you in relation to the development above.

Objections to wind turbines, raised by NATS on grounds of an impact to Air-Ground-Air ("AGA") stations are very rare. Currently they represent a rate of approximately 0.3% of all assessed applications, it is anticipated that the total number of applications received in 2012 will exceed 3500 in number.

Interference to an AGA station is an important area of concern for NATS because interference can lead to NATS losing the ability to communicate with aircraft. Losing contact with an aircraft that is under the belief that they are receiving air traffic control is clearly is a serious safety concern for everyone.

However, it is recognised, that unlike objections based on radar, the technical rationale and operational reasons for objecting are not always as clearly understood as one may like. The reasons for NATS's objections are often challenged by developers and applicants as they are often misconstrued as not being based on sound technical grounds.

The fact sheet attached, has been prepared in order to address a number of specific queries raised by a number of applicants through their planning authorities. However it has been expanded and is being promulgated in order to provide some clarity and background to all planning authorities currently facing a NATS objection based on AGA communications and to dispel the sometimes held but incorrect perception, of objections being based solely on a NATS opinion. Importantly the fact sheet does not contain any new information.

In this specific case, while we acknowledge the applicant's disappointment and the Aardvark report submitted, we have to uphold our objection. As the FAQ details, the guidance documents used for the assessment (CAP764/670), are indeed guidance, and are more appropriate for airport installations and the impact of fixed obstacles.

While on generic terms the CAP documentation can be applied to wind turbines, the criteria it is based on is not specifically aimed at this scenario, the main issue being the interaction of moving turbines and AGA En-Route sites.

While NATS does consider these guidelines in its assessments, if its deems a development to present a risk, it can and will object, despite the proposal being outside CAP guidelines.

As explained in the attachment, NATS is in the process of commissioning further studies which, in partnership with industry stakeholders, will be aimed at producing some industry-wide agreed guidelines. These will allow all wind energy stakeholders to define suitable and unsuitable locations in respect of all aeronautical radio sites.

While we appreciate that this statement will not be the answer the applicant would have liked, we trust it explains our position.

Regards,

Sacha Rossi

Mr Sacha Rossi

NATS Safeguarding Office

FAQ1. What is the rationale behind a NATS AGA planning objection?

NATS policy is to presume in favour of renewable energy developments whenever possible with the proviso that safety and service provision are not compromised. Planning objections will be raised whenever it is judged that potential risks to our operations may exist.

FAQ2. Does a NATS objection effectively preclude any planning consent?

No, however, should a planning authority choose to not follow NATS's advice, the process in the Safeguarding Direction 2002 must then be followed. This requires the planning authority to notify the Civil Aviation Authority as well as the consultee (NATS) prior to granting any permission.

FAQ3. What criteria is used when objecting to a development?

There are no scientific or documented technical criteria that can be used for assessing the impact of turbines on AGA communications. NATS however, uses the available research material, together with recommended guidelines, as well as data it has obtained from its own trials and experience.

NATS's position is based on the information that is available, together with its own experience of operating different services under a variety of different technical and environmental conditions and with a wide range of equipment.

FAQ4. Are NATS's objections insurmountable?

It should also be noted that challenges to NATS's position in respect of safeguarding Air-Ground Air (AGA) communications infrastructure sites in the vicinity of proposed wind turbine developments have previously been commonly due to two principle factors:

- inadequacy and only partial relevance of the published safeguarding guidelines (CAP 670, ICAO doc Eur 015 etc)
- lack of published research material

Current safeguarding guidelines define 'building restricted areas' only and in the case of CAP670 are specifically applicable to aerodromes installation. These guidelines were never intended to safeguard against wind turbines.

NATS has commissioned and undertaken at its own expense, scientific field studies which demonstrated and provided evidence of a credible turbine interference mechanism at both VHF and UHF communications frequencies. The studies produced a quantity of high quality data and recordings of audible corruption, however this work is currently incomplete and much still remains to be done.

Based on the findings of this work, the CAA updated publications CAP 670 & CAP 764 to highlight the potential for turbine related interference in the context of AGA installations.

The NATS position on turbine related AGA interference has the backing of domain experts from CAA, QinetiQ, MOD and other key industry stakeholders.

NATS is always willing to consider any new evidence presented to it. However, this should be based on sound technical and scientific proof. Where this scientifically credible evidence provided sufficient assurance for the safe co-existence of its infrastructure and the proposed development, NATS would consider withdrawing an AGA objection.

FAQ5. Why does NATS object to developments outside CAP670/CAP764 criteria?

The diagrams and slopes described in CAP670 and CAP764 are intended to be used as guidelines for gauging the impact of obstructions and development, on AGA installations at airports.

These are not black and white rules, and are aimed at fixed obstructions in an airport environment. This can differ markedly from the en-route environment (distance between Receiver and Transmitter, signal levels and equipment).

In NATS's experience, in certain circumstances, they are deemed to provide insufficient risk mitigation to its operations.

While NATS does consider these guidelines in its assessments, if its deems a development to present a risk, it can and will object, despite the proposal being outside CAP guidelines.

FAQ6. Can it be demonstrated that a turbine has no impact on AGA communications?

No. NATS provides a variety of services to very different aircraft types/operators, these include:-

- Airliners descending or climbing from airports, a few miles away
- Helicopters at very low level operating to offshore oil platforms, over 100km away
- General aviation traffic, including student pilots, in noisy and workload intensive conditions (IFR, exams etc)
- Oceanic airline traffic over 250km away
- Military air traffic undertaking operational or training sorties

The variables involved are numerous, and there are many factors which can all directly affect the severity of the impact any interference can have: radio equipment/installation used, aircraft background noise, controller/pilot perception and workload, specific situation/stress, distance and weather factors together with received signal levels.

Any form of interference can have an immediate and detrimental impact upon safety, as such NATS will not accept any risk which may compromise the safety of its provision of air traffic control.

FAQ7. Can any of my experience or experiments be used to mitigate a risk?

While NATS is willing to evaluate scientific evidence, simple field trials cannot be considered. Operating a transceiver in a wind farm with no interference being received is not evidence of a turbine being acceptable.

Air band radio uses AM modulation and is used in a range of conditions which cannot be simply replicated. FM radio such as commercial transceivers, broadcast radio etc is not as susceptible to interference. Likewise a small transceiver may still be transmitting or receiving a power level that is much stronger than an aircraft 250km away.

NATS's experimental work and trials have demonstrated an impact on AGA comms due to turbines. In the absence of evidence to the contrary, NATS will continue to raise AGA objections.

These are based on the current knowledge and understanding until the turbine interference mechanism is adequately understood and the principle of safe co-existence can be established and updated development guidelines are published.

FAQ8. Where can I learn more about the reasons for the objection?

The supply of directly relevant research material is very limited. This is mainly due to the specialist nature of the AGA systems and the practical difficulties associated with acquiring sufficiently high quality data. Most turbine related research data relates to broadcast transmissions and surveillance technologies or other short range radio navigation aids etc, all systems that utilise a relatively high signal level and that often employ frequency modulation (FM) techniques.

The following public domain publications provide some of the most relevant background information:-

CAA Paper 99022
'Provision of guidelines for the installation of wind turbines near aeronautical radio stations'

ERA 2008-0568 (Issue 3)
'RF Measurement Assessment of Potential Wind Farm Interference to Fixed Links and Scanning Telemetry Devices'

AGA represents a different challenge when compared to RADAR and a broadcast service etc, the interference physics is identical but the impact is very different. AGA is relatively unusual in using AM modulation and often working at very low signal levels due to long range operation where a single radio site provides unique signal coverage e.g. in oceanic transition sectors or in the North Sea etc.

The table below illustrates in general terms why there is very little correlation to the requirements of AGA services with existing published research material :-

Service type	***Interference susceptibility***		***Signal Levels***
	Tolerant	***Intolerant***	
RADAR Broadcast Marine radio etc	Amplitude variation (Fast Fading)	Frequency variation (Doppler)	Relatively High
Aeronautical / AGA	Frequency variation (Doppler)	Amplitude variation (Fast Fading)	Low / Very Low

FAQ9. Are all of the issues known and understood?

No. A significant body of work remains to be done before the turbine interference issues are fully understood. NATS is currently working with other stakeholders in order to define and secure funding for additional research.

The aim of this research is to allow some scientifically based guidelines to be defined. These would enable processes to be put in place allowing objections to be made based on these accepted guidelines. It would also then be possible to grant consent or to withdraw objections to developments falling outside of the accepted guidelines.

Initial impact studies were first undertaken by NATS in 2005. The position at the time was that any turbine related interference impact on AGA systems would probably be relatively insignificant but a recommendation was made that field work should be undertaken to validate that position.

Field studies were conducted in 2007-9 based upon the earlier work and the methodology contained in CAA paper 99022. Both studies were conducted using VHF and UHF aeronautical communications frequencies – the findings corroborated the earlier work from 99022 and provided evidence of relatively high level turbine interference potential.

This work has provided some good quality data but it is incomplete.

The requirements for further research are very simply stated, however the practical difficulties associated with the large number of complex variables to be factored makes the acquisition of scientifically valid data very difficult and hence very costly to achieve in practice.

Worst-case interference levels are now known to be high under specific conditions; this implies that a wide variety of disparate ground and airborne radio equipment types and air traffic control systems must be validated for susceptibility to interference before the overall level of technical impact can be determined.

NATS's concern is simply to ensure the delivery of a safe air traffic control service. Where uncertainty prevails we must continue to adopt a conservative and 'safety first' approach.

ERA 2008-0568 is an independent body of work carried out by ERA / Aegis on behalf of OFCOM – the field study utilised a similar methodology to the NATS studies – findings for 436MHz fixed links correlate well with data obtained by NATS for the UHF communications frequency band.

Due to achieving closer to optimum geometry in the chosen field measurement sites, this study has provided evidence of higher interference levels than those measured during the NATS trials.

FAQ10. What data has been obtained from previous studies

- Audio interference demonstrated practically (similar to broken mobile phone call)
- Video / Audio recordings produced
- Interference impact probably higher on en-route service provision – effect more significant at low signal levels
- Interference levels proportional to turbine size but with apparently complex relationship
- Worst case interference levels can be very high (Fades > 20dB have been observed)
- Prediction not straightforward – highly lobed and resonant characteristics identified
- Worst case interference potential not currently identified
- Scalability of interference effect not yet determined – number of turbines, spacing, separation etc
- Technical impact not determined – effect on ground systems, avionics etc
- Operational impact subjective and difficult to quantify, dependency on: situation, stress/workload, equipment and ultimately the Air Traffic Controller.

Due to the wide range of ground based and airborne radio equipment in use it is considered improbable that any technical mitigation solution can ever be identified for AGA communications systems.

Therefore the only feasible option for co-existence is believed to be the determination of safe physical separation limits between AGA infrastructure sites and any nearby wind turbines.

Given the massive difference in scale between small single turbine developments and multiple turbine arrays it is intuitively obvious that a 'one size fits all' approach cannot be either appropriate to the large scale projects or fair to the smaller developer.

Any future 'safe development' guidelines must therefore be based upon a known level of interference potential for a given turbine or group of turbines, and the level of susceptibility of the affected radio systems.

NATS position on turbine related AGA interference is shared and endorsed by domain technical experts within the regulator and across the industry.

Claims by any party to be able to provide a viable mitigation solution for an AGA related planning objection, could only be considered where supported by scientific and credible evidence which is acceptable to NATS, until industry-wide guidelines have been defined and agreed. This would allow NATS to provide assurance to its regulator (CAA SRG) that its service provision is safe.

A package of work has been defined and agreed by a group of major stakeholders including CAA, NATS, MOD, QinetiQ and other industry partners which would enable the development of suitable development guidelines. This work package involves the development of a turbine interference model, the assessment of a wide range of airborne and ground based radio equipment types for interference susceptibility, the evaluation of operational impact, and the establishment of safe interference thresholds – hence safe development limits.

Funding for this work is currently being sought from interested industry parties.

FAQ11. Is there any evidence of turbine interference on radio signals?

Yes. The following waveforms, which were acquired from operational wind farms, illustrate typical interference effects.

Depending on specific Transmitter/turbine/Receiver geometry, the level of received interference will vary somewhere between zero and a very high level for any given point in time and position in space.

The precise level of interference is extremely complex to predict being dependent upon many variables.

Deep fades (> 20db) in signal level have been recorded and this may not represent the worst case. Audio and Video recordings have illustrated the effect of turbine interference in correlation with blade rotation.

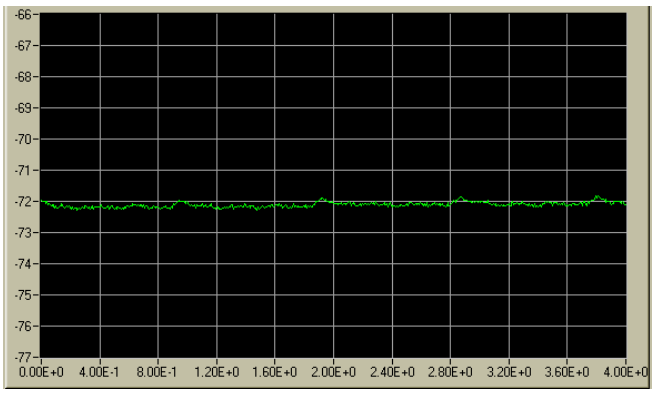

Figure 1. RF carrier signal showing no turbine interference
(waveform captured during NATS field study – Shooters Bottom Farm -2009)

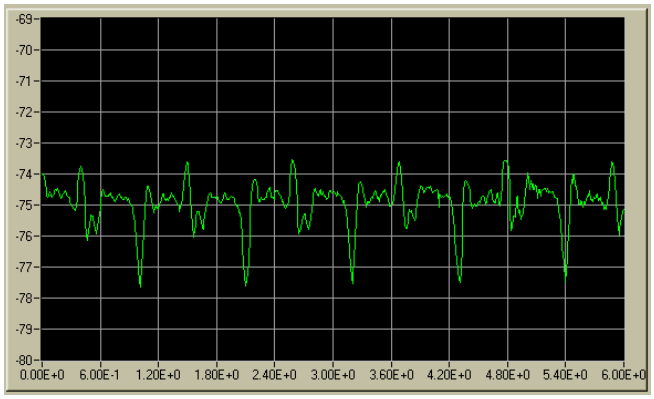

Figure 2. RF carrier signal showing classic turbine interference signature

(note spikes as blade passes through vertical. Interval between 4 successive negative spikes is 1 rotor revolution)

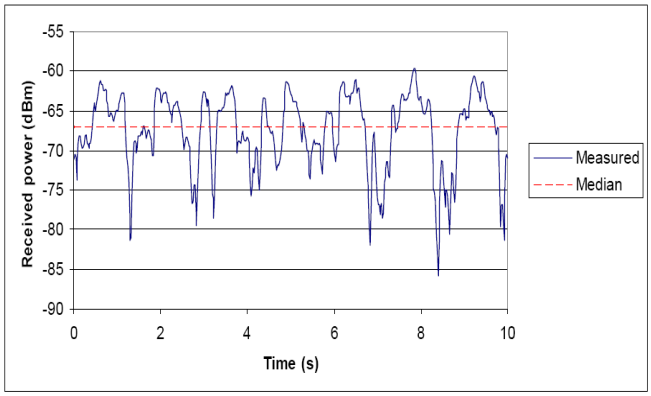

Figure 3. RF carrier signal showing a high level of turbine interference

(waveform extracted from ERA report 008-0568 Issue 3)

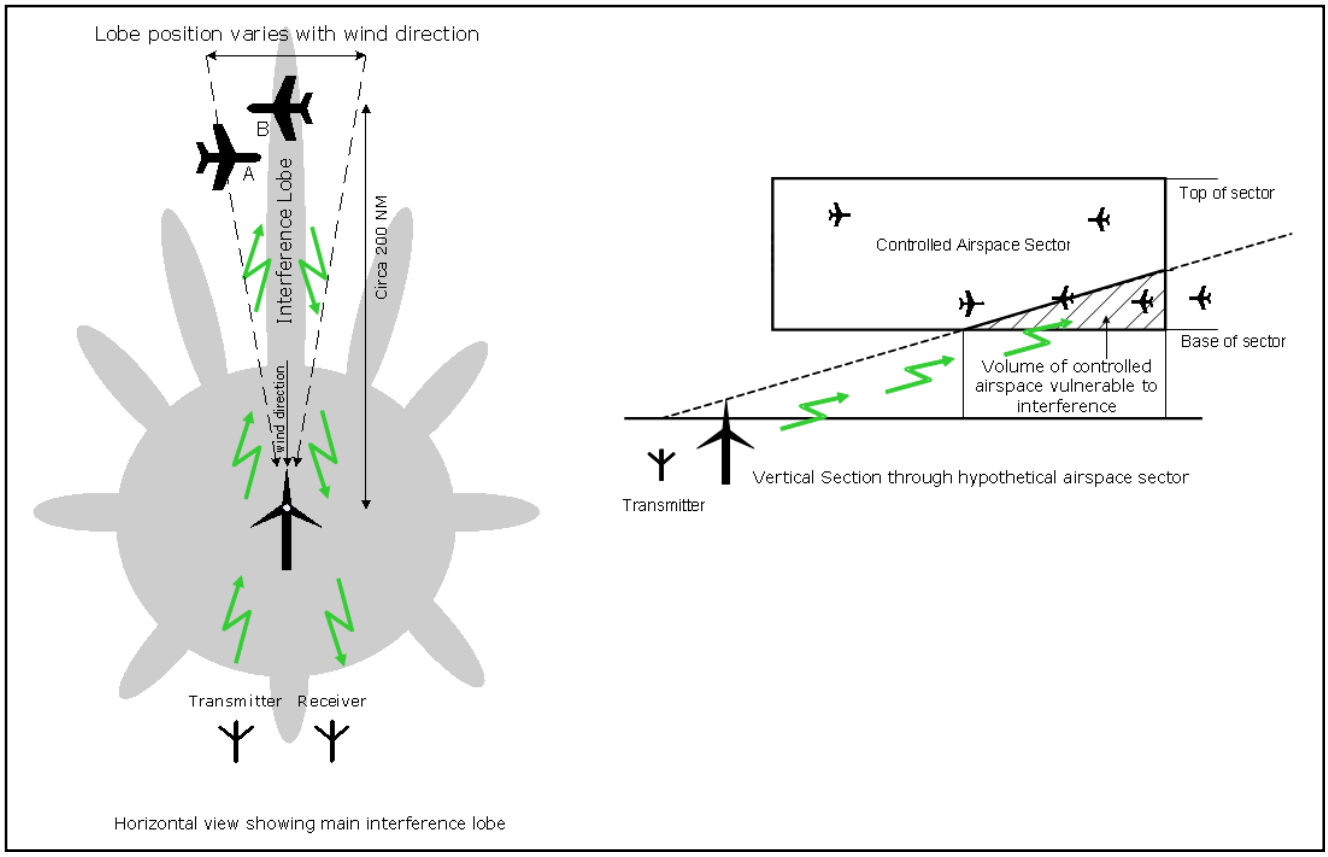

Figure 4. Effect of interference

Note. The diagrams above are not scientifically accurate and are for the illustration of concepts only.

FAQ12. What effect can interference have on NATS' air traffic control operation?

FAQ12.1. The interference area and its effects

Air traffic control exists to enable aircraft to maintain safe distances from each other ('separation'). Where NATS is unable to communicate air traffic control instructions to one or more aircraft this separation may be lost.

Interference to NATS' AGA communication sites may mean that NATS loses the ability to provide air traffic control instructions to aircraft in the affected area.

The affected area of interference due to a wind turbine, may move and have varying effects depending on the turbine's orientation, wind speed and direction and other variable factors such as weather.

FAQ12.2. Transfer of ATC control and interference

NATS en-route air traffic control services are provided on a sector basis. Each sector comprises a 3-Dimensional volume of airspace operated by a team of ATCOs. Each sector is assigned a dedicated radio frequency. Air traffic flies through different sectors and is transferred from one controller to another.

Any interference or loss of communication would have an increased impact on safety should it occur in traffic handover situations.

FAQ13. Is there any viable way to mitigate an AGA objection?

Currently there are only three options; physical separation, terrain shielding and site relocation.

FAQ13.1. Physical separation

Simply stated the greater the physical separation between turbine and radio site, the greater the chance of approval. Decisions are made on the basis of subjective assessment using 'best engineering judgement' and accumulated experience.

A consequence of the rise in turbines is also that many prime sites have now been taken up and hence new developments are being pushed closer to our infrastructure.

The NATS assessment takes into account factors such as the surrounding terrain, size and quantity of turbines, distance from the AGA infrastructure site etc.

To date, NATS policy of physical separation has been effective in safeguarding civil and military aviation operational services.

FAQ13.2. Terrain Shielding

If the proposed development is shielded by terrain and cannot be seen from the top of an aerial tower (typically 25m high), as shown in Figure 5, NATS will not raise an objection.

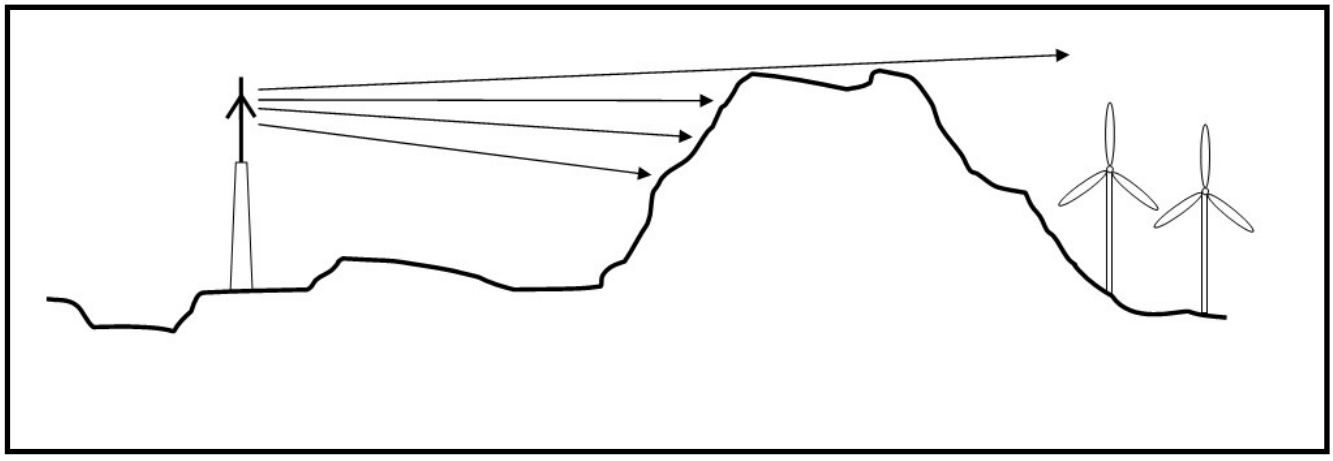

Figure 5. Terrain blocking the line of sight between turbine and radio site

FAQ13.3. Site Relocation

This is a potential but complex option for large developments only. Where deemed feasible, NATS would consider relocation of the AGA infrastructure site(s) at the developer's expense and subject to certain stringent conditions being met. Assuming the availability of suitable alternative site(s) this will be a multi-million pound commitment on the part of the developer and timescales of less than two years from contract let are unlikely.

It is important to note that the best sites for a wind farm development also tend to be the best sites for a radio station. Most of NATS AGA infrastructure sites occupy hilltop sites in order to provide optimum radio coverage beyond a 250km radius.

Identification of alternative locations with appropriate levels of coverage and supporting infrastructure, together with securing the purchase/lease and planning permissions presents a significant challenge.

REFERENCE DOCUMENTATION AND EXTRACTS

ICAO DOC EUR 015

'EUROPEAN GUIDANCE MATERIAL ON MANAGING BUILDING RESTRICTED AREAS'. Paragraph 7.7

"It is recommended that buildings such as windmills, skyscrapers, large excavating works, TV towers and other high towers should be assessed at all times even outside the BRA (Buildings Restricted Area) for omni-directional facilities. Particular attention should be paid to clusters of buildings such as wind-farms and overhead power lines."

Note that the ICAO Omni-directional BRA extends to 2000 metres from the radio site.

CAP 670 – 'Air Traffic Services Safety Requirements'

Part B, Section 4, Generic Requirements and Guidance – General

Paragraph 4 .1

"Windfarms (Wind powered Turbine Generators) have the potential to adversely affect the ability to provide air traffic services in several ways, not least because of degradation of radio signals emitted by aeronautical radio stations due to multi-path inference caused by reflection from the static elements (i.e. nacelles and masts) or signal modulation effects due to rotating turbine blades."

Paragraph 4 .3

"The CAA has been made aware of research that indicates the possibility of wind turbines adversely affecting the quality of radio communication between air traffic controllers and aircraft under their control. Further work is being undertaken to establish the extent, likelihood and severity of the problem and until further information is available, issues concerning wind turbines and VHF communications should be dealt with on a case by case basis. ANSPs are advised to include the radiation pattern of their antenna systems and the radio horizon in their considerations."

"NOTE: A wind farm whose blade tips, at their maximum height, are below the visual horizon when viewed from a point situated 25 metres above an aeronautical radio station site may be acceptable to an ANSP."

CAP764 – 'CAA Policy and Guidelines on Wind Turbines'

Chapter 2, Paragraph 4.1, Aeronautical Navigation Aids and Communication Systems

"A wide range of systems, including aids such as ILS, VOR/DME, and Direction Finders, together with air-ground communications facilities, could potentially be affected by wind turbine developments. Wind turbines can affect the propagation of the radiated signal from these navigation and communication facilities because of their physical characteristics such as their situation and orientation in relation to the facility. As a result, the integrity and performance of these systems can, potentially, be degraded. Further research is required to fully understand the potential issues; therefore, a cautious approach and case-by-case analysis is required."

Chapter 3, Paragraph 4.1, Safeguarding of Technical Sites

"There is a statutory process to safeguard certain ATC sites which are integral to the provision of en-route ATS. Radar and radio stations, navigation beacons and some microwave communications links are subject to such arrangements1. LPAs have an obligation to consult the operators of such sites as defined in official safeguarding maps. Developers may also request discussion with site operators in order to provide necessary mitigation. ICAO Eur Doc 015 and CAP 670 are sources of guidance to provide a basis for such discussion."

CAA Paper 99022 - 'Provision of guidelines for the installation of wind turbines near aeronautical radio stations'

Extract from executive summary:-

"Wind turbines affect electromagnetic signals incident upon them causing multi-path interference effects. The level of interference can cause incorrect information to be received. Additionally the blades' rotation modulates the signals and this modulation may degrade the performance of aeronautical radio systems"

ERA Report 2008-0568 -
'RF Measurement Assessment of Potential Wind Farm Interference to Fixed Links and Scanning Telemetry Devices'

Wind turbine array comprising 17 - Vestas V80 turbines
Hub height 60m
Tip height 100m

Extracts from summary:-

"A wind farm (with seventeen turbines) can produce measured fades as large as 10 to 15 dB for 1% of the time when the wind farm is lying on the transmitter-receiver path and where the wanted link suffers loss in excess of free space. These fades can be as large as 15 to 20 dB for 0.1% of the time, thus reducing the wanted signal by this margin."

"It is proposed that the most satisfactory method for predicting the impact of wind turbines on radio systems is to characterise turbines in terms of their radar cross section (RCS), and to apply the bi-static radar equation, taking full account of diffraction and clutter losses on both wanted and reflected paths. This method has the advantage that it is quite general, and can also take full account of radio system parameters such as antenna directivity and required system carrier-to-interference (C/I) ratio.
The primary problem in the application of such a method is that there is little data on the RCS of wind turbines. It is to be expected that the energy reflected from individual turbines will be a function of incidence and scatter angles, the relative yaw of the turbine, the pitch of the blades, and of the frequency"

NATS internal report – July 2007 - Goonhilly Field Trial

Wind turbine array comprising 14 – Windane 34 turbines
Hub height 30m
Tip height 47m

Extract from executive summary:-

"It may appear extraordinary given the recent interest in wind farms, but the measurements reported are believed to be the first serious on site scientific investigation of the influence of a wind farm on a radio system. Problems have been highlighted in the past, but given the momentum of wind energy there is no commitment to look at problems and they have been by-passed. Where the safety of life is involved this is potentially dangerous."

Extract from conclusions:-

"To date wind farm planning applications that possibly conflict with NATS systems have either been so obviously unacceptable that they were readily rejected or so far away that they raised no concerns. NATS are receiving more applications that do not fit into either of these categories and are difficult to deal with on a rational basis. Therefore, a more scientifically based, yet easy to apply technical tool to determine the degree and range of threat that can be imposed by the existence of such wind farm is urgently required."

NATS internal report – December 2009 – Shooters Bottom Farm Field Trial

Single Enercon E70 wind turbine

Hub height 65m

Tip height 100m

Extracts from the executive summary:-

"The RCS values measured were generally higher than expected"……

"Basic electromagnetic scattering considerations, based upon treating the wind turbine's rotor as a disc indicate four directions of potentially high-level scattering. A series of measurements were made in the forward scattering, one of these directions, and generally high levels of scattering measured. Significant variation may arise between measurements directly attributable to the highly lobed structure of the scattering pattern. The peak values are of interest. The peak RCS values measured at Shooters Bottom, in the forward direction, are 54.9dBm2 at VHF and 60.1 dBm2 at UHF. These represent very large areas.

Comparable back scattering lobes gave RCS values of 48.6 dBm2 at VHF and 51.6 dBm2 at UHF. These are the numbers that a conventional mono-static radar operating frequencies would measure. They are significantly less than the forward scatter values.

Measurements were made in other directions in an attempt to characterise the other two lobes, but the illumination angle chosen seems also to have excited a partial resonance, of the open resonator type between a blade and the tower. This assignment is tentative, but the measured RCS values were much greater than expected or measured in other directions. The peak RCS values measured in this situation is 55.3 dBm2 at VHF and 64.7 dBm2 at UHF. The manner in which these high levels values was captured and the magnitudes raise concerns that there may be other resonances not characterised. Consistently in all measurements the major interaction seems to occur as a blade passes the tower so this gives some comfort that the maximum may have been found."

"Measurements at Shooters Bottom are required to ensure that the peak scattering conditions were captured and at Red Tile to investigate the projection of individual machine parameters to multiple machine wind farms. The large RCS values measured raises concerns that interactions between machines an issue generally previously discounted may be more important."

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