

~~WPD/7/2~~

Town & Country Planning Act 1990 – Section 78

Appeal by Wind Prospect Ltd against the failure by Tynedale District Council to determine an application for planning permission in respect of a wind energy development comprising construction of eighteen wind turbines with associated switchgear building and anemometer mast at Green Rigg Fell, Birtley Parish, Northumberland

Proof of Evidence of

Duncan Lennox

On behalf of Wind Prospect Developments Ltd

23rd June 2008

Local Planning Authority reference: 20060040
PINS reference: APP/R2928/A/07/2039188/NWF

Professional Qualifications and Experience

1. My name is Duncan Lennox. I served in the Royal Air Force for 32 years as an aeronautical engineer, qualified pilot, and guided weapons specialist. I attended the RAF Advanced Weapons Course from 1964 to 1966, and the RAF Staff College in 1973. My duties included the development, testing and entry into service of air-to-surface missile (ASM) and air-to-air missile (AAM) projects, including testing these systems in electronic warfare (EW) environments. From 1966 to 1969 I was in the Air Guided Weapons Directorate of the MOD Procurement Executive, responsible for the Martel ASM programme. This was a joint project with France, and included TV guided and anti-radar missile versions. I served in the British Embassy in Sweden from 1969 to 1972, covering Finland and Denmark as the Assistant Air Attache. I was awarded the OBE in 1973.
2. From 1980 to 1982 I was the Assistant Director Air Guided Weapons (Group Captain) in the MOD Procurement Executive, responsible for Sidewinder, Sparrow and Sky Flash AAM programmes. In 1983 I was awarded the RAF Diamond Jubilee Fellowship, and studied the Air Defence of the UK, which included assessments of a variety of AAM and surface-to-air missile (SAM) systems. From 1984 to 1985 I was Staff Officer Engineering at HQ 11 Group, responsible for the day-to-day engineering aspects of the complete UK air defence system. This included special assessments of the Bloodhound and Rapier SAM, as well as the performance of Sidewinder, Sparrow and Sky Flash AAM. From 1980 to 1985 I was involved in numerous ground and flight trials, as well as simulations, associated with the performance of AAM and SAM. The Falklands War in 1982 demonstrated the use of Sidewinder (AAM), Rapier, Seawolf, Sea Cat, Sea Dart, Blowpipe and Stinger

(SAM) against aircraft targets. This provided valuable insights into the use of AAM and SAM in wartime.

3. On leaving the RAF in 1987 I set up a small consultancy business, Duncan Lennox Associates. This work has included studies into numerous missile systems being developed and in use in countries around the world. From 1987 to 2007 I provided consultancy services to the US Department of Defense, Missile Defense Agency (MDA). The MDA has been developing a ballistic missile defence system that is global in nature, and has to be capable of operating in an EW environment. I participated in several studies examining how to identify and overcome the use of EW by a potential enemy. I have authored two reference books for Jane's and written numerous articles about missile systems, and have broadcast interviews on TV and radio. My consultancy work has included the study of surface-to-air missiles developed and used around the world, and I maintain records on over 90 such systems. I have briefed the House of Commons Defence Committee on missile issues, and was a Special Advisor to the Committee from 2002 to 2005. I have spent over 20 years building a network of contacts, using people that I can trust to provide an accurate and honest assessment of events being reported. This has enabled me to provide a service to government organisations and industry, illuminating the international trade in weapons and their related technologies.

Scope of the Evidence

4. I have been retained by Wind Prospect Developments Ltd (WPD) to assist them with their proposal for a wind farm at Green Rigg, in relation to the objections raised by the Ministry of Defence (MOD) concerning the threat systems used by RAF Spadeadam. My evidence will be restricted to the objections to the planning application as they relate to WPD and the Green Rigg site. My evidence will consider the objections and will seek to prove that the

Green Rigg wind farm does not affect the realism or efficacy of training provided by the RAF Spadeadam range. In my proof of evidence I will deal with the following issues:

- Electronic warfare, a brief unclassified explanation
- Open source information, its sources and relevance
- Intercept ranges, interpreting manufacturers' figures
- EWTR at RAF Spadeadam
- SA-6 performance
- SA-8 performance
- Skyguard performance
- Wind farm effects on the EWTR

Electronic Warfare

5. Electronic Warfare (EW) has played a crucial role in recent air operations, such as the allied attacks on Iraq in 1991 and 2003, as well as on Kosovo and Serbia in the late 1990s. The Israeli attacks on Iraq and the Bekaa Valley in 1982, and in Syria in 2007 were further examples when EW was used successfully to negate hostile air defence systems. EW is a broad term, and is usually considered to include the use of both electronic (radar and radio) and optronic (visual and infra-red) systems, as well as aircrew tactics.
6. There are a number of aspects to EW, and it is a sensitive subject with many issues classified. Basically, intelligence is needed about an enemies' air defence system, which includes radars, surface-to-air missiles (SAM), air defence fighters and their air-to-air missiles (AAM), communications, organisation and training. This tends to be collected by signals intelligence (SIGINT) satellites, aircraft and ground stations monitoring and recording enemy radar and radio transmissions. Data from SIGINT sources and equipment is

analysed, and used to design and develop EW systems to protect our own aircraft.

7. The suppression of enemy air defences (SEAD) is another part of EW. This involves the use of several techniques, including jamming, deception, decoys and the use of anti-radar missiles (ARM) or bombs to destroy enemy assets. Jamming is achieved by broadcasting strong signals that overwhelm the enemy radars and radio communications. Deception is a more subtle approach, whereby the location of the attacking aircraft appears to be in a different position, and the enemy may not realise that he is being deceived. In addition, deception could include feeding false signals and data into an enemy air defence system. Decoys use unmanned air vehicles or drones, which appear to be attacking aircraft, to force the enemy to switch on their radar, and give away their positions. This can then be followed by the use of anti-radar missiles (ARM), which home onto the enemy radar transmissions and destroy the equipment. Once the radar has been knocked out, friendly aircraft can attack the SAM sites with guided bombs or missiles.
8. Most modern aircraft carry their own Defensive Aids Suite (DAS), which alerts the aircrew to threats, providing the direction and identification of the threat. This may include warning of a radar signal or the approach of a hostile missile (SAM or AAM). The DAS or the aircrew may select a response, depending on the particular system in use. The responses may include jamming or deception, or the activation of a towed decoy. The DAS or aircrew may decide to eject chaff (small strips of metallic material to confuse a SAM radar or radar guided missile), or a flare (a brightly burning cartridge to confuse a visual or infra-red seeker in a missile). Bright light sources, such as high power lamps or laser beams, can also be used to deceive visual or infra-red guided missiles. SAM and AAM operate in similar ways, posing a threat to aircraft, and the responses by the aircrew are similar. As well as the

EW responses above, aircrew can manoeuvre their aircraft to stress the ground or missile radar tracking, and present the incoming missile with a rapidly changing target aspect, resulting in a missed intercept. In addition, the aircrew might use tactics to avoid known SAM sites, such as flying low and fast behind a hill, flying in a loose formation, or selecting a route outside the range of the air defence's missile and gun systems. Whilst modern SAM and AAM have ranges measured in tens of kilometres, even modern anti-aircraft (AAA) gun systems have much shorter ranges, less than 5 km.

9. EW is constantly changing, with both offensive and defensive systems improving all the time. It is essential to train operational aircrew in as realistic an environment as possible, ensuring that they are fully aware of the tactics and equipment that might be used against them. The MOD evidence provided for the Public Inquiry into the proposed wind farm at Blinkbonny Heights in 1996 (MOD/3/11) provided useful background information about the EW tactics and facilities in use at the RAF Spadeadam range.

Open Source Information

10. Using open source information, which means in effect information that has not been classified as sensitive, needs explanation. The information is received from a wide variety of sources, including manufacturers' brochures, journals, magazine articles, reference books (such as Jane's), air shows, exhibitions, conferences, and discussions with people who have operated these equipments. In the case of the SA-6 and SA-8 SAM systems, these were widely exported by the former Soviet Union, and several of these systems were captured and examined in detail to assess their performance. In addition, several former Warsaw Pact SAM crews came forward, following the collapse of the Soviet Union, and explained how these systems had been used. SA-6 and SA-8 have been used in several conflicts from 1970 to 2007, and the strengths and

weaknesses reported afterwards. The Skyguard system was developed in the 1970s by Oerlikon Contraves in Switzerland. The manufacturers have promoted this system widely over the intervening years, and state that over 600 systems have been sold. The extent to which you can rely on open source information depends on the quality and reliability of the originator, and the understanding of the analyst.

Intercept Ranges

11. A typical SAM, such as the Russian SA-6 Kub or SA-8 Osa, is only powered at the beginning of its flight, and it then coasts towards the target aircraft. The maximum speed of the missile is achieved at the end of the powered flight phase, and from then on it loses speed. If the missile has to manoeuvre (change direction) then it will lose speed more rapidly. As the speed of the missile reduces, then it cannot manoeuvre as well. The SAM will slow more quickly if it is climbing in height, and accelerate if it is diving. Aircrew understand these characteristics, and a common tactic is to manoeuvre the aircraft as the missile approaches. This causes the missile to have to out-manoeuve the aircraft to achieve a kill. If the intercept has been planned to occur at maximum SAM range, then the SAM may not be able to respond sufficiently and will lose the aircraft. The missile manufacturers will quote a maximum range, but this can be misleading.
12. As a generalisation, the best results for a SAM are achieved within a region from a quarter to three-quarters maximum range, when the missile has sufficient speed to counter aircraft manoeuvres. This was referred to by Sqn Ldr Coleman in his POE (para 16), when he stated that 'users of the range sometimes request that they not be engaged until they are well within the envelope'. Manufacturers use SAM engagement diagrams (called envelopes) to demonstrate the range and altitude at which an engagement can be achieved. Unfortunately, these diagrams are sometimes misunderstood, as

one diagram only refers to one particular set of variables. The SAM probability of kill varies as the intercept point (where the missile intercepts the aircraft) moves around the envelope, with the probability reducing as the intercept point approaches the edge of the envelope. During missile flight trials and evaluation a system simulation is developed and validated, so that a complete family (typically 30 to 50) of engagement diagrams can be produced covering the major variables.

13. If the aircraft is flying at medium altitude, say between 15,000 feet (4.5 km) and 35,000 feet (10 km) then the SAM probably has the best chance of a successful intercept, but only if there is no EW. If the aircraft is flying at low level, at 250 feet (75 metres) then the SAM will climb up and then dive down onto the aircraft for the intercept. However, this presents another problem for the SAM, as it is then looking down on the target aircraft and straight into ground clutter. Early generation SAM, the SA-6 and SA-8 were designed some 40 years ago, tended to suffer from ground clutter and reflections from the ground (multi-paths). However, it must not be assumed that low level flying is the safest approach, as the presence of shoulder-launched short range SAM and anti-aircraft artillery (AAA) make the low level (usually defined as up to 10,000 feet) a very dangerous zone to use. The RAF Spadeadam range uses unguided 'Smokey SAM' to simulate the use of short range SAM, to give the aircrew some experience against these threats.
14. The acquisition (surveillance) and tracking (engagement) radars used with the SA-6, SA-8 and Skyguard systems have their maximum ranges and altitudes stated by Sqn Ldr Coleman in his POE (para 7). The maximum radar range is affected by many variables. These include the aspect and radar cross section (RCS) of the target, the height of the target, the height of the radar, the weather, the operating frequency of the radar (wavelength), and radar design. Maximum radar range can be as misleading as

maximum missile range. The maximum radar range at medium altitude (15,000 to 35,000 feet) will usually be greater than the maximum range at low altitude. This means that the range at which any wind farm effects will be present on a threat radar display will be less than that radar's maximum range at medium altitude. In addition there is a difference in operation between the SAM radars used for acquisition and those used for tracking. Sqn Ldr Coleman explains these differences in his POE (paras 10 to 14). In general, the acquisition (surveillance) radars have a longer range with less accuracy. The tracking (engagement) radars have a shorter range, usually matched to the missile range, and provide greater accuracy.

Electronic Warfare Tactics Range (EWTR) at RAF Spadeadam

15. The EWTR is a unique facility in the UK, and has a total of 16 declared threat radar emitter systems (POE by Sqn Ldr Coleman para 7). The MOD is most concerned about the effects of the proposed wind farm on the SA-6 Straight Flush and SA-8 Land Roll radars (MOD Statement of Case Addendum MOD/0/10 dated 14th March 2008 para 3 [1]). The next most vulnerable radars are stated to be those associated with the Skyguard systems (MOD/0/14 para 2). The emulators are believed to operate as real radars, in that they transmit and receive radar signals to and from the target aircraft. The simulators have no receivers, and it is believed that they would provide no evidence of radar lock-on or tracking, and would not indicate any effects of clutter.
16. In evaluating the operational training provided by the range, it is necessary to consider not only the performance of the threat emitters, but to look at the value of the training to the aircrew. Indeed the sole purpose of the threat emitters is to provide training to aircrew. If the value of aircrew training is not affected, then any effect of the proposed wind farm development on the threat emitters or their operators does not impact upon the purpose of RAF Spadeadam. The POE by Sqn Ldr Coleman (para 14 to 27)

explains the mode of operation of the threat emitters, but does not address the possible wind farm effects on the realism or efficacy of training (raised in the MOD Statement of Case Addendum para 5 [1]). MOD stated (letter from Mr Julian Chafer dated 3rd May 2008) in answer to question 4 that 'there is no calculation as to the value of training that will be affected'.

17. There is no evidence to support the MOD allegation on realism and efficacy stated in the Addendum, nor any evidence of any harm to aircrew training. The objective for the RAF Spadeadam range is to provide operational aircrew with practical experience of flying in a hostile environment (MOD/3/11 Statement by the MOD on Blinkbonny Height application in 1996 paras 2 to 5). The hostile environment is provided by the range, which has threat radars to illuminate the aircraft and activate DAS or missile warning receivers. The aircrew or DAS then select an appropriate action, which they expect will result in breaking the lock-on by the threat radar. The range does not fire real missiles, and so the success of a SAM engagement is judged by a computer simulation. The Post Mission Report (PMR) is a print out of the training sortie, and indicates when the aircrew either successfully broke-lock on the threat emitter, or the simulator indicated a hit by a SAM. The PMR is sent to the aircrew immediately after the sortie, so that they may see the results of the training. Mr Coppel explained at the Inquiry on 8th May 2008 that the PMR is the only document produced, and that the aircrew can use a classified link to RAF Spadeadam to discuss any issues or to seek clarification of the PMR results.
18. The aircrew would test the DAS and missile warning equipment on the ground prior to the sortie, and after the sortie could have a read out of their cockpit displays. This total process provides a basic understanding of the realism and efficacy of the training provided by the range. The issue is whether and, if so, how the proposed wind farm would affect this process.

SA-6 Performance

19. The SA-6 Kub SAM system was built by the former Soviet Union and entered service in 1970. This SAM was widely exported, to over 20 countries. Some SA-6 systems were improved by the Soviet Union as a result of operational experience, and since the break-up of the Soviet Union several companies have offered upgrade kits including digital electronics, improved EW, optical sensors and more reliable components. It is not possible to understand the performance of the particular SA-6 systems used at RAF Spadeadam without knowing their individual modification states. As this information was not provided by MOD, it has been necessary to use open source data to make a general assessment.
20. The SA-6 missile weighs 600 kg, and has a solid propellant boost motor with a ramjet sustainer motor. The boost motor burns for 4 seconds, and the sustainer for 23 seconds. The missile is guided initially by commands from the ground. A launcher vehicle carries three missiles, with a separate vehicle fitted with the fire control system and sensors. A tracking/engagement radar tracks both the aircraft target and the missile, and the fire control system calculates any course corrections required by the missile and transmits this data up to the missile in flight. As the missile approaches the target aircraft, a semi-active radar receiver in the missile is switched on, and the missile calculates its own corrections by following the reflected radar energy of the tracking radar off the aircraft. This process was used in early SAM designs, as a command guidance system becomes less accurate as the range increases. General Soviet practise was to fire two or three missiles in salvo at each aircraft target, to increase the probability of kill. Bearing in mind the different modification states that exist, open sources suggest that a representative missile maximum range would be 25 km. The minimum range is stated to be 4 km.

21. The acquisition (surveillance) radar with the SA-6 'Straight Flush' sensor system has a range of 50 km (SqN Ldr Coleman POE para 7e). However, the range depends on many variables, and it should be noted that this radar is not usually switched on in combat until as late as possible, so as not to give away the radar's position. The acquisition radar hands the aircraft target parameters to the tracking (engagement) radar, which locks-on to the target aircraft so that the fire control system can calculate when and in which direction to launch the missiles. The tracking radar was noted to be the weak link in the SA-6 system, and has been targeted by aircrew and EW systems in subsequent combat situations. If the tracking radar lost lock, then the missile could not be fired until lock-on was re-established. If the missile had already been launched when lock was lost, then the missile would fly free. The maximum range of the tracking radar in most SAM systems is less than the range of the acquisition radar, and is usually more closely related to the maximum range of the missile. From open sources the range of the tracking radar is 28 km. The SA-6 tracking emulators (specially built radars to imitate the signals produced by real tracking radars) used at RAF Spadeadam are stated to have a range of 50 km (SqN Ldr Coleman POE para 7c). This suggests that they have been designed to provide greater cover than the actual systems, presumably for training purposes.
22. The SA-6 'Straight Flush' sensor system included a TV tracker for use when the tracking radar was being jammed or there was a threat from anti-radar missiles, and this is believed to have had a range of 30 km. Later systems have added a laser rangefinder and improved optical trackers. The SA-6 was not a successful SAM system, and by 1982 was beginning to be replaced in the Soviet Union by the SA-11. In 1999 for example, as stated in MOD/0/15 (article on the Multinational Aircrew Electronic Warfare Training Facility at Grostenquin, France), over 260 SA-6 missiles were fired by Serbian forces against allied aircraft. The total number of Serbian SAM launched exceeded 800, with only two allied aircraft

lost. The success of this campaign was attributed to the EW training carried out by the allied aircrew.

SA-8 Performance

23. The SA-8 Osa SAM system was designed in the early 1960s, initially for the Soviet Navy, but later introduced into the Army as the first land-based low level air defence system. The system entered naval service in 1968, and land service in 1974. SA-8 has been exported to around 20 countries, and is still in use today. The SA-8 'Land Roll' system was the first to introduce the concept of a single fire control, sensor and launcher vehicle carrying four missiles, known as a transporter-erector-launcher and radar (TELAR) vehicle. An improved TELAR was introduced in 1980 carrying six missiles. There have been several major upgrades made to the SA-8 system, including increased missile range, digital electronics, and additional sensors. The modification state of the SA-8 systems at RAF Spadeadam was not provided by MOD, and so it was necessary to rely on open source documents.
24. The SA-8 missile has a weight of just under 130 kg, and has solid propellant boost and sustainer motors. The boost motor burns for 2 seconds, and the sustainer for 15 seconds. The missile then coasts towards its target. Guidance is provided by the tracking (engagement) radar following the target aircraft and the missile trackers following the missile. The fire control system calculates any correction needed for the missile to intercept the target aircraft, and sends commands up to the missile. As this is a shorter range system than SA-6, the missile remains under command guidance for the whole of its flight. Two missiles can be guided to the same target in salvo, and it became general practise for the Soviets to launch two missiles to improve the probability of kill. The minimum missile range is stated to be 1.5 km, and the maximum range is 10 km.

25. There are six radar antennas on the TELAR vehicle. The acquisition (surveillance) radar looks for the targets, and has a range of 28 km (Sqn Ldr Coleman POE para 7f). This radar will not normally be used at maximum range, so as not to alert the aircrew or give away the position of the TELAR vehicle. The RAF Spadeadam web site quotes a maximum range of 28 km for the tracking (engagement) radar, whilst open sources suggest that the tracking (engagement) radar has a range of 25 km. When the tracking radar has locked-on to the target aircraft the fire control system calculates when and in which direction to launch the missile. If the tracking radar signal loses the aircraft (the tracking is broken), then the tracking radar has to re-lock before the missile can be fired. If the missile is in flight when the tracking radar signal is lost, the SAM will go into free flight and will miss the aircraft. The SA-8 tracking radar emulator (which imitates the real radar signals) has a range of 28 km (Sqn Ldr Coleman POE para 7d). Two antennas on the TELAR vehicle are used to track two missiles when they are in flight, if a salvo of two missiles has been launched. The remaining two antennas are used to send command updates to the two missiles in flight. A TV tracker is also fitted to the TELAR, for use when the radars are being jammed or when anti-radar missiles might be launched against the TELAR vehicle. The TV tracker has a range of 6.5 km.

Skyguard Performance

26. The Skyguard Anti-Aircraft Artillery (AAA) system has two towed 35 mm guns, with sensors and a fire control system mounted in a separate vehicle or cabin. Developed by Oerlikon Contraves in Switzerland in the 1970s, this system was used by Argentina in 1982 in the Falklands War. The Skyguard system has been exported to around 12 countries. The modification state of the Skyguard systems used at RAF Spadeadam were not provided by MOD, and it has been necessary to use open source information. The guns have a maximum range of 4 km, and a maximum altitude

of around 3 km (10,000 feet). Improved shells have been developed for the guns, with the latest version called AHEAD, which contains 150 small tungsten cylinders. The cylinders fan out in front of the aircraft target, increasing the chance of a kill.

27. Skyguard sensors comprise an acquisition (surveillance) radar and a tracking (engagement) radar, with a TV camera. The acquisition radar has a range of 16 km (Sqn Ldr Coleman POE para 7g), and this has a moving target indicator (MTI) filter (MOD/3/9 RAFSEE report annex D1). The tracking radar has a range of 15 km and also has an MTI filter (MOD/3/9 same reference). The TV tracker has a range of 15 km according to an open source report. More recent upgrades have included improved EW protection, laser rangefinder, and low light level TV. The modification state of the Skyguard sensors used by RAF Spadeadam was not provided by the MOD.

Wind Farm Effects on RAF Spadeadam EWTR

28. The MOD Statement of Case Addendum (MOD/0/10 dated 14th March 2008) states at paragraph 5 (1) that the training will be reduced in realism and efficacy by the wind farm's effects on the threat emitters. The reason given is that the threat system will be less able to 'shoot down' a target aircraft. The RAF Spadeadam range does not launch any SAM or fire any AAA at the aircraft during training, and the phrase 'shoot down' simply refers to a computer generated simulation that results in a notional intercept of the aircraft. The aircraft using the range transmit their identification friend or foe (IFF) code, which is the military equivalent of the secondary surveillance radar (SSR) code, so that the range controller knows who and where they are. The range controller alerts the threat radar systems giving them the direction that the aircraft is flying (Sqn Ldr Coleman POE paras 17 and 18).
29. The Soviet SA-6 and SA-8 systems were linked to a higher command level with longer range surveillance radars, that were

used to alert the SAM operators when enemy aircraft were approaching their positions. The SAM operators would then look for the approaching aircraft using their acquisition radars. There are then two distinct phases in the process of 'shooting down' a target aircraft. In the first phase the tracking radar has to track the aircraft for sufficient time to enable the fire control system to determine the time and direction for the SAM to be launched. If the aircraft can break the tracking lock, then the process has to restart. This first phase, up to but not including SAM launch, is carried out for real on the range. For the second phase a simulated SAM launch takes place, and if the tracking radar loses lock the missile will fly free and miss its target. The height of an aircraft over a wind farm would affect the amount of clutter received by the tracking radars. MOD/3/9 (RAFSEE/2191/11351/SNS para 13) states that when Hawk aircraft were flying at 750 feet (230 metres) over the wind farm there was no affect on the Skyguard tracking radar, as at this height the tracking radar was not seeing any clutter due to its narrow beamwidth. The SA-6, SA-8 and Skyguard tracking radars measure height to within 10 metres (33 feet) (Sqn Ldr Coleman POE para 14). The post mission report (PMR) details the distance and bearing of the target aircraft to the threat system, and the aircraft height. It is my understanding that clutter would only be a problem for the tracking radars when the aircraft were flying low over or close to the wind farm. The MOD evidence did not provide any answer to how low or how close the aircraft have to be for the threat radar operators to have a problem.

30. MOD/0/17, a PMR for mission 0832 flown on 22nd April 2008, was provided in evidence by MOD. This referred to two F-16 aircraft flying at heights between a minimum of 1,417 feet (430 m) and a maximum of 18,287 feet (5,575 m) (using regional pressure settings). The aircraft were being engaged by various threat emitters, and the maximum range between the threat emitters and aircraft did not exceed 14 km. There were some quite dramatic changes in height recorded in this evidence, the greatest change

was from 3,694 feet (1,125 m) up to 18,287 feet (5,575 m) in 11 seconds.

31. The MOD Addendum para 5 (2) states that some of the positions at which the threat systems are located could be rendered unusable. This is affected by the distance of the wind farm from the threat radar system, as well as the height and direction that the aircraft are flying. A wind farm is located at Kirkheaton, which is only 10 km from the site of the proposed Green Rigg wind farm. The MOD POEs do not mention any problems having been detected from the Kirkheaton site. The sensitive elements in the process are the tracking radars. By examining the distances from the wind farm to the original range site (within the danger area D510) and the 20 dispersed sites detailed in MOD/0/20, any effects on the tracking radars can be estimated.
32. Taking the SA-6 'Straight Flush' first, the tracking radar has a range of 28 km (para 21 above), and the missile has a maximum range of 25 km (para 20 above). The optimum range for the missile would be between 6 and 19 km (paras 12 and 20 above). The dispersed sites that are within 30 km of the proposed wind farm are Albermarle Barracks, Bell Craggs, Bolts Law, Monkside, Peat Hill and Otterburn. Of these six sites only Albermarle Barracks, Bell Craggs and Bolts Law are within 25 km, and only Albermarle Barracks and Bell Craggs are within 20 km. If the SA-6 radars were located at the 7 dispersed sites on the original range or at the 7 dispersed sites not listed above, they would all be further than 30 km from the wind farm. If radar tracking on its own is considered, then positioning the SA-6 radars on the original range or at the other 7 sites would be an effective mitigation process. Considering tracking and simulated missile interceptions together, then the only dispersed sites likely to be affected would be Albermarle Barracks and Bell Craggs. The other 18 dispersed sites would not be affected.

33. Considering SA-8 'Land Roll', the tracking radar has a maximum range of either 25 or 28 km (para 25 above). The missile has a maximum range of 10 km (para 24 above), and its optimum range would be between 2.5 km and 8 km (paras 12 and 24 above). The only sites within 25 km are Albermarle Barracks, Bell Craggs and Bolts Law, and there are no sites within 8 km. Considering radar tracking on its own, then the only dispersed sites that might be affected would be Albermarle Barracks, Bell Craggs and Bolts Law. Mitigation could be achieved by siting the SA-8 TELAR on one of the 7 sites on the original range, rather than at these three dispersed sites. Considering tracking and a simulated missile interception, there would be no problems at any of the 20 dispersed sites.
34. For the Skyguard system the tracking radar has a range of 15 km (para 27 above), and the guns have a range of 4 km (para 26 above). There are no dispersed sites within 15 km of the wind farm, and so there would be no problems with Skyguard at any of the 20 dispersed sites.
35. The effect of any additional clutter from the wind farm on the threat systems radar displays, could be mitigated by altering the computer software that produces the PMR. A distance and bearing of the wind farm from each threat site could be established. The computer print out (PMR) could indicate if a track was broken by the aircraft flying at very low level over or close to the wind farm, and this need not be counted as a successful evasion by the aircrew. This process could be applied to both the real first tracking phase, and the simulated second SAM interception phase. The training value to the aircrew is to practice using EW tactics and techniques to break-lock on the tracking radars. The aircrew would know where the wind farm is located, and could programme the aircraft navigation system to avoid flying over or close to the wind farm. The problems encountered by the threat radar operators are part of

- their daily routine, and would not have any effect on the value of aircrew training.
36. It is suggested that the approach used above represents a possible worst case scenario regarding clutter, and the possibility of threat systems not being able to conduct a successful tracking or simulated 'shoot down' of their target. In most instances the actual radar tracking process will occur with the target aircraft in front of the wind farm. This would reduce the effect of wind farm clutter, as the radar return signal from the aircraft would be stronger and would be received before any returns from the wind farm. The aircraft would also be flying at a height above the wind farm, at the very minimum 250 feet (75 m) above the blade tips, as this is the minimum separation distance (MSD) from ground obstructions outside the range danger area (D510). To fly at low level (below 10,000 feet), would expose the aircraft to AAA or shoulder-launched short range SAM threats.
 37. In the case of the simulated 'shoot down' of the aircraft by the missiles or guns, all of the tracking takes place with the target aircraft in front of the wind farm. The only exceptions might be if an SA-6 is located at the Albermarle Barracks, Bell Craggs or Bolts Law dispersed sites. The SA-8 and Skyguard would not be affected at any of the 20 dispersed sites. However, it should be noted that these limitations would only apply when aircraft were approaching the range from the north-east, using the Otterburn-Newcastle corridor. There would be no effects from the wind farm if the aircraft approached from any other direction.
 38. The MOD Addendum para 5 (3) states that the Otterburn-Newcastle corridor might have to be abandoned for training purposes. This assumes that the wind farm effects on clutter are spread over such a large area that aircraft could not fly within this corridor. The size of the corridor was shown in the John Taylor POE (WPD/5/3 appendix F), which showed that there was space

available for aircraft to pass either north or south of the wind farm when approaching the range from the north-east. The distance between the proposed Green Rigg wind farm and the Newcastle airport control zone is around 10 km, and from the wind farm to the eastern Otterburn range danger area D512 is also around 10 km. If the western Otterburn danger zone is activated, D512A, then this distance would be reduced to 5 km. The aircrew can programme their navigation computers to avoid the wind farm. The minimum separation distance in this area is 250 feet (75 m). As a former qualified pilot I can say without hesitation that I could have flown comfortably through a 5 km (2.7 nautical miles) gap. With modern aids such as inertial navigation and global positioning systems (GPS) the positional accuracy should be considerably better. In answer to the questions posed by Green Rigg to MOD, answer 2 (dated 23rd April 2008) from the MOD stated that 'aircraft are free to plan their line of attack based on tactical principles and the objective involved'. This suggests that aircrew can select any direction to approach the range.

39. During the 1996 Blinkbonny Heights Public Inquiry the MOD Statement (MOD/3/11 dated 9 Aug 96 at para 10) included the words 'aircraft converge on the range from all directions. The concentration of population centres in the Tyne and Eden valleys in the southern area of the range mean that approaches from the north are favoured.' The MOD has not produced any evidence to suggest that this has changed.

Conclusions

40. I have addressed the concerns expressed by MOD in their Statement of Case Addendum (MOD/0/10). My understanding of the evidence produced by MOD is that while it suggests, without any proof, that the threat radar operators might have more difficulty, it does not provide evidence of, still less establish, any

diminution in the value of the aircrew training provided by RAF Spadeadam.

41. The first MOD allegation (Statement of Case Addendum para 5 [1]) is that the wind farm will cause a diminution in the realism and efficacy of the training, as the circumstances in which a threat system will be able to 'shoot-down' a target aircraft will be materially reduced. I have demonstrated that this would not occur in this case, even assuming that the wind turbines could in particular circumstances interfere with the threat systems' radars.
 - (i) The use of the SA-8 and Skyguard threat radars would not be affected by the wind farm.
 - (ii) At worst, any impact is limited to the SA-6 threat radars at a limited number of sites in particular circumstances.
 - (iii) By using the SA-6 threat radars at selected dispersed sites, any problems would be overcome.
 - (iv) Even in the case of the dispersed sites where there may be potential for an impact, that would only occur if the aircraft were approaching the range from the north-east direction.
 - (v) In the very limited circumstances where there is potential for an impact, it could be addressed by modification to the software producing the PMR. The PMR could indicate if SA-6 radar lock was lost due to an aircraft flying directly over the wind farm.

42. When real life performance capabilities are used for the threat systems, the evidence suggests that the aircrew training is unaffected by the proposed wind farm. If training emulators are used then aircrew still receive valuable experience, but it is not true to life. In this instance, it is suggested that if mitigation is needed then the threat radars can be re-positioned, and the computer scoring system and post mission report can be suitably annotated to indicate when a lost-lock was due to turbine clutter rather than aircrew actions. The work load of the range staff might be increased in some instances, but the aircrew training would not be affected.

43. The second MOD allegation (Statement of case Addendum para 5 [2]), is that the wind farm would render some of the dispersed sites unusable for all practical purposes, thereby further diminishing the value of training. This is similar to the first allegation, and has been shown to be incorrect. All the dispersed sites could be used by the SA-8 and Skyguard threat systems. Only three of the dispersed sites would possibly be affected, but they would not be rendered unusable by the SA-6 threat systems. If the aircraft routed around the wind farm, these dispersed sites would remain usable as well.
44. The third MOD allegation (Statement of Case Addendum para 5 [3]) is that the effects of the wind farm on the threat radars could extend over a significant geographic area within the Otterburn-Newcastle corridor, that approach may have to be abandoned for training purposes. The evidence presented by MOD does not support this allegation. The Otterburn-Newcastle corridor need not be closed, and the aircraft can continue to approach the range from all directions.