1. **What is 3D Holographic Radar™?**

3D Holographic Radar™ is a new and advanced ‘staring array’-based radar that offers a revolutionary advance in tracking and surveillance radar capability. It provides a real-time, three-dimensional surveillance of the airspace through its use of a modular array that can be configured to match the airport requirements of range and coverage. Unlike traditional scanning radars, 3D Holographic Radar™ actually characterises, identifies and intelligently decides what to do with the returns it receives, depending upon the requirement. In the case of wind farm mitigation, it clearly identifies wind turbines and removes them from the ATC display whilst at the same time passing through aircraft returns it receives.

2. **Why is 3D Holographic Radar™ different to other surveillance radars?**

Traditional scanning radars use a rotating antenna that combines a transmitter and receiver. As they rotate, they switch between transmitting and receiving and are able to capture returns from objects for a very small period of time. They can effectively report that an object is at a certain distance from the radar head and at an approximate bearing. They provide no information on the height of the object. They spend approximately 1% of each scan ‘on target’ and so cannot differentiate between different types of moving objects and, for this reason, rotating wind turbines can cause massive confusion in the radar system.

3D Holographic Radar™ uses a totally different technology. It uses flat-panel arrays which receive radar returns from a separate transmitter that is broadcasting continuously, providing 100% time ‘on target’. This means they gather a huge amount of information on the object and so can create a ‘signature’ that can be characterised and intelligently identified by the radar system. This enables the system to select what is passed on to the displays and, in the case of wind turbine interference, the turbines themselves are removed from the display, removing a key source of distraction for air traffic controllers.

In summary, unlike traditional scanning radars which effectively provide a ‘dumb’ display, 3D Holographic Radar™ provides an intelligent picture of the airspace where unwanted returns are removed before display.

3. **Can 3D Holographic Radar™ differentiate the height of objects?**

Another key advantage of 3D Holographic Radar™ is the fact that it tracks objects in three dimensions through the coverage area. This provides another layer of information which enables intelligent characterisation and differentiation of all the returns it receives, but it also allows for the radar feed to be used in multiple primary radar installations as it enables any slant range error to be removed. Whereas the feeds from two separate 2D scanning radars cannot be combined without introducing large errors into the display, using a 3D Holographic Radar™ input actually improves the overall accuracy of the ATC display.

In a recent independent analysis of 3D Holographic Radar™ performance, it was reported that the intelligent 3D reporting of 3D Holographic Radar™ achieved much higher performance in terms of detection and accuracy than conventional radar.
4. Are there any range limitations?

The 3D Holographic Radar™ product is a completely modular solution. Transmit modules are added to increase the transmitter power and receiver modules are added to improve sensitivity and resolution. A single 360-degree installation can mitigate beyond the typical 20nm protection zone around an airport PSR.

In addition a 3D Holographic Radar™ can be deployed remotely at a wind farm site and integrated with more than one PSR feed. This is possible because the output from a 3D Holographic Radar™ is three-dimensional and there is no slant range error to account for. This ability for remote deployment means that range is NOT a limitation and 3D Holographic Radar™ can be used to provide a clear airspace feed at ANY distance from the primary radar.

5. Does HR need to be installed on the airport?!!

For the same reasons described above, the location of the 3D Holographic Radar™ is totally flexible and can be configured to suit the specific airport requirements and timescales. Individual short-range units can be initially deployed at remote locations to meet specific needs. Longer-range airport-based units can then be implemented as the need arises and the remote units transitioned out. Installations are configured exactly as the airport requires.

6. How can 3D Holographic Radar™ help when multiple PSRs need to be mitigated?

When multiple 2D radar feeds are integrated into a single display, the locational error from each radar is compounded. If no action is taken, this would create large discontinuity of tracks at display boundaries and without a consistent track the integrity of the information would be lost. A multi-sensor tracker can help to overcome some of this problem, but the inherent locational errors in the feeds are compounded.

Because 3D Holographic Radar™ is a 3D feed, the exact, accurate location of the aircraft can be computed and the correct location. This means that integration can be performed seamlessly without procuring an additional multi-sensor tracker. Where a multi-sensor tracker is already used, the improved reporting rate and accuracy of the 3D Holographic Radar™ make the tracker’s job easier offering an overall improvement in surveillance quality.

One 3D Holographic Radar™ can support feeds into multiple Primary Surveillance Radars.

7. Is 3D Holographic Radar™ only used for wind farm mitigation?

3D Holographic Radar™ is an evolutionary advance in surveillance radar technology that can be used for many applications. Wind farm mitigation is the first market area that Aveillant is addressing through its unique Data Service business model. Aveillant is also involved in advanced research for 3D surveillance radars which will result in the next generation of non-cooperative surveillance.

New application areas are constantly being evaluated and Aveillant is also working with partners to take the 3D Holographic Radar™ technology into international markets.
8. Why is HR good at differentiating wind turbines from aircraft?

3D Holographic Radar™ is unique in that it does not use any form of ‘blanking’ or ‘range gating’ to reduce the effect of wind turbines on the radar. A 2D scanning radar is effectively ‘ignoring’ the airspace over the turbine (the same effect as blanking) but the smaller the blanking area, the higher the need for RF spectrum. As RF spectrum availability is reducing, this is not a sustainable approach.

The operational mode of 3D Holographic Radar™ is quite the opposite of traditional scanning radars in that it wants to see the turbines so that it can intelligently categorise them and remove them for the radar data feed. It is able to do this because it captures the 3D information of the return as well as generating a ‘signature’ of the radar return in Doppler space. 3D Holographic Radar™ identifies and characterises ALL of the returns it receives and can therefore intelligently manage what is passed to the radar display.

9. Can 3D Holographic Radar™ integrate with any PSR?

Holographic Radar has already been integrated with both video-based and plot-extracted radars. To support video-based radars, an external video card is used which effectively patches in the area to be mitigated into the PSR video feed. The patch is seamless and the feed is synchronised with the PSR update using all the information available from the 3D Holographic Radar™ to ensure that there are no boundary effects. As 3D Holographic Radar™ samples data multiple times a second, it can be scan-synchronised to exactly match the PSR update rate.

10. What is the Spectrum Release Programme and how does HR fit in?

The UK Government plans to release at least 500 MHz of public sector spectrum below 5 GHz before 2020 to meet the demand from commercial services, such as mobile communications including broadband. The Department for Culture, Media and Sport published a consultation document, Enabling UK growth – releasing public spectrum, in which it laid down the strategy for spectrum release. The document identified the 2.7-2.9 GHz and 2.9-3.1 GHz frequency sub-bands (i.e. part of the S-Band) as priorities for further investigation, which are currently occupied by Primary Surveillance Radar (PSR) used to support aviation, maritime and military security tasks. In 2012, the Civil Aviation Authority (CAA) provided the Department for Transport (DfT) with an initial feasibility assessment of potential options for releasing spectrum in the 2.7-2.9 GHz band. On the basis of this assessment the DfT, supported by CAA recommendations, concluded that there was sufficient potential and benefits to proceed with the implementation of a spectrum release programme. However, it was recognised that before any spectrum release could be formally supported and delivered, there would need to be extensive development trials work carried out. DfT now requires the CAA to lead and manage this programme of work, which is known as the S-Band Spectrum Release Programme.

Aveillant is working closely with the CAA on the Spectrum Release Programme and have been awarded a substantial contract to work on next-generation technologies (based on 3D Holographic Radar™ operating in L-Band) that will enable the Government to meet its goals whilst ensuring that a successor to the current primary surveillance radar systems is available.
11. Who is Aveillant?

Aveillant is a UK technology company, which spun off from Cambridge Consultants in October 2011. It employs radar, technology, air traffic control, mapping and commercial experts to design, deliver and support the 3D Holographic Radar™ technology.

The core of the design team has been focused on designing radar technology that focuses on the understanding and characterisation of the radar returns rather than on identifying movement at long range. The 3D Holographic Radar™ technology enables an intelligent picture of the surveillance area to be created and managed.

12. Has performance of HR been reviewed independently?

In July 2013 Helios, an independent aviation consultancy, analysed flight trials data from a 3D Holographic Radar™ installation at Glasgow Prestwick Airport. Their analysis concluded:

- The feasibility of integrating the 3D Holographic Radar™ surveillance data with PSR data to provide a single, seamless surveillance data display was successfully demonstrated.
- The performance of 3D Holographic Radar™ was greatly improved over traditional PSR performance in the vicinity of a wind farm.
- The evidence observed in this analysis suggests the Aveillant 3D Holographic Radar™ will meet the likely performance and safety requirements for providing a surveillance separation service in the vicinity of a wind farm.
- In many cases the 3D Holographic Radar™ performance is similar to that expected from a secondary radar.

13. How does performance compare with UK CAA and Eurocontrol standards?

As part of its independent analysis of flight trials data, Helios produced the following comparison table:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>HR performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAP670, Air Traffic Service Safety Requirements, UK CAA, third issue, amendment 1/2013, 13th June 2013</td>
<td></td>
</tr>
<tr>
<td>SUR02.40 Recommendation: Probability of detection should be at least 90% for conventional radars and exceed 97% for Monopulse and Mode S radars and other co-operative techniques.</td>
<td>99%</td>
</tr>
<tr>
<td>SUR02.42 Recommendation: Within any one update, the false target count should be less than 2% of the total target count.</td>
<td>2% (overall false plot ratio)</td>
</tr>
<tr>
<td>SUR05.34 Recommendation: For en-route separation, SSR systems should have a standard deviation of 250 m for range accuracy and 0.15 degrees for azimuth accuracy. At 40NM 0.15 degrees equates to 194 metres</td>
<td>49m</td>
</tr>
</tbody>
</table>
### Eurocontrol Specification for ATM Surveillance System Performance,
Eurocontrol-SPEC-0147, Edition 1.0, 30th March 2012 – requirements for providing 3NM separation using non-cooperative surveillance systems

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3N_N-R2 Probability of update of horizontal position in accordance with selected measurement interval: Greater than 90% global. Recommended performance: Greater than or equal to 97% for 100% of the flights, any flight below 97% shall be investigated as defined in R10.</td>
<td>99%</td>
</tr>
<tr>
<td>3N_N-R3 Ratio of missed horizontal position involved in long gaps (larger than 16.5s = 3 x 5s + 10%): Less than or equal to 0.5%.</td>
<td>0%</td>
</tr>
<tr>
<td>3N_N-R4 Horizontal position RMS error: Less than or equal to 300 metres. Recommendation: Less than or equal to 210 metres.</td>
<td>104m</td>
</tr>
<tr>
<td>3N_N-R5 Ratio of target reports involved in sets of 3 consecutive horizontal position correlated errors larger than 555m - 0.3NM. Recommendation: Less than or equal to 0.03%.</td>
<td>0%</td>
</tr>
</tbody>
</table>

### 14. How much does it cost?

In the UK, for wind farm mitigation, the 3D Holographic Radar™ is mainly provided as part of a surveillance data service. This is where an airport has agreed that Aveillant will provide a comprehensive service to local wind farm developers on behalf of the airport which includes the provision of 3D Holographic Radar™ units as required to mitigate whatever wind farms are approved for the area and which affect the PSR of the airport. The wind farm developer pays an annual fee for the service which is comparable to the Community Benefit Payment that it is required to make. Aveillant in turn has a commercial agreement in place with the airport to provide the service.

### 15. How reliable is it and how is it maintained?

3D Holographic Radar™ contains no moving parts, and no components are exposed to the atmosphere. This reduces any wear and tear to a minimum and increases reliability and reduces maintenance down time.

All critical components are redundant and each array can operate to the specified level even if multiple elements fail. In addition, comprehensive built-in test and remote control and monitoring of all parts of the system allows for the early identification of any performance degradation prior to potential failure.