SUMMARY

Background
In the Netherlands, wind turbines with the minimum tip highest level 150 metres above ground level must be equipped with aircraft warning lights to ensure aviation safety. Concerns about the potential nuisance caused by continuous illumination of aircraft warning lights on wind turbines in surrounding areas and impacts on natural assets and the landscape are a recurring theme in wind turbine project consultations. A possible solution is the use of radar detection systems that only activate the lights when it detects an aircraft flying on route towards a wind farm. However, at present there is no framework in the Netherlands for the use of such systems, which is why they are not yet permitted. To gain insight into the potential benefits offered by the use of radar detection systems for aircraft warning lights, a pilot project ('proof of concept') was launched to test the proper functioning of radar detection systems for aircraft warning lights on turbines.
The pilot project was conducted by Pondera Consult in collaboration with the National Aerospace Laboratory (NLR) and the Netherlands Organisation for Applied Scientific Research (TNO). The pilot was conducted at the behest of the Province of Groningen, the Province of Zeeland, Krammer Wind Farm and the Netherlands Enterprise Agency (RVO/Ministry of Economic Affairs and Climate Policy).

Structure of the pilot project
The pilot project comprises the three phases below. This report is the result of phases 1 and 2. Phase 3 will be elaborated on in coming months (late 2018).

- Phase 1 – Preparing an action plan
- Phase 2 – Conducting the pilot project and reporting the results
- Phase 3 – Preparing assessment and policy frameworks

The action plan describes the objective of the pilot project, how that objective will be achieved and how its practical implementation will take place. The action plan was established jointly with local authorities and the private sector before the pilot was launched (8 May 2018).

The objectives of the pilot project are:
1. To establish whether the desired aviation safety level will continue to be guaranteed when the radar-controlled aircraft warning lights are actually in operation, notwithstanding the fact that the illumination time will be limited;
2. To gather information on the basis of which national assessment and policy frameworks for the use of radar detection systems for wind projects can be prepared.

To enable these objectives to be achieved, various research questions were formulated which the pilot was intended to answer. Please see the action plan in Appendix 1 for a list of the research questions.

Conducting the pilot project
The pilot project was conducted on 23 May 2018. It comprised two parts, a flight test and an operating settings test. A Terma SCANTER radar was used to conduct the pilot. In addition to representatives from Pondera Consult and Terma, representatives from TNO, NLR, RVO and the Ministry of Economic Affairs and Climate Policy were also present on the day of the pilot.

Flight test
Prior to the flight test, a flight plan comprising eight flight routes (runs) over the wind farm was prepared jointly with TNO, Terma and NLR. The runs were designed to generate information about how the radar worked in different scenarios, with varying conditions in terms of distance, altitude and flight direction. Based on the flight plan, the aircraft flew over and around the wind farm on the day of the pilot.
A detection zone (green circle in Figure 1) and a warning zone (red circle in Figure 1) were taken as the basis for the pilot. The detection zone is the area within which an object is tracked by the radar. The lights are switched on when an aircraft enters the warning zone. A warning zone of approximately 6.2 km was taken as the basis for the pilot. The detection zone had a radius of approximately 8.2 km. The zones concerned are shown in the figure below. The white circle in the figure represents the area within which the radar can detect objects. Its radius was 18.5 km (although this varies from one type of radar to another).

Figure 1 Detection and warning zones
Source: Pondera Consult

All flights were tracked using GPS and recorded by the radar, which meant that all the situations could be simulated again at a later stage. The data was used to determine the extent to which the system worked as intended and to identify its weak points, if any. TNO used the data to verify Terma's conclusions.

Operating settings test
Terma explained and demonstrated how the radar detection system worked, focusing on several key elements, before and during the operating settings test. Among others, tests were performed to establish whether the fail-safe system worked, whether a logbook was maintained automatically, whether a test signal was issued automatically and whether electric monitoring took place (please see the report for a full overview). As far as these elements are concerned, Terma was able to demonstrate that the system worked as intended.

Results
The various runs showed the system for detecting aircraft (and other objects) worked as intended and that there were no malfunctions. The aircraft was detected in every run and the lights were switched on in accordance with the criteria. There was no interference with existing radar systems. A variety of situations were tested or simulated during the pilot and the lights were switched on in time on every occasion. Even on the runs where a malfunction was simulated, the run was again either picked up in time or the fail-safe system went into operation (leading to the lights being switched on). Details of the above may also be found in NLR's report. TNO's verification also indicated that the system worked as intended in all the scenarios tested. Additionally, the elements from the operating settings test showed that the radar elements worked as intended and would ensure an adequate level of aviation safety. Please see the full report for a comprehensive description of each aspect.

- The pilot raised a number of points for consideration that may need to be addressed, depending on which radar detection system is chosen for commissioning. These points mainly have to do with the correct positioning of the radar and will therefore need to be resolved on a location-specific basis:

- Impact of the wind turbines on coverage. Both Terma and TNO state that interference from wind turbines ('clutter') may have a limited impact on the radar's coverage behind the turbines. In practice, however, this will be so limited that it will have no impact on the correct functioning of the radar and its ability, or inability, to detect objects.
- The cone of silence. The cone of silence is an area immediately above the radar within which no objects can be detected. The pilot project revealed that a number of runs were in fact lost here and then picked up again after the cone of silence had been passed. However, this will not present a problem if the radar is positioned correctly.

- The radar's settings. The radar's settings are location-specific. This means checks will have to be made at each location to ensure that the settings allow the correct degree of filtering of other objects. The distances between the warning zone and the detection zone are also location-specific (depending on subsoil interference).
- Blind spots. In areas where there is a great deal of subsoil interference, there may be blind spots in the radar's coverage. In many cases, allowance can be made for this by positioning the radar correctly. Another option is to use in-fill radar, i.e. a small radar used to improve coverage in specific areas.

Applicability of radar detection systems
The pilot project confirmed that radar detection systems can be used effectively to guarantee aviation safety whilst reducing the duration of the illumination of the lights. However, if such systems are to be authorised, a framework will be required on the basis of which permission is given for radar detection systems to be used for aircraft warning lights. Details of the first step taken in that direction are set out below and attempts will be made to develop this step further in phase 3 with the project group concerned.

Account will need to be taken of the necessary investment and maintenance costs for the private sector associated with the implementation of the systems. On average, an investment of between €500,000 and €750,000 will be required for a fully 'installed' system. This would be a viable financial burden for large-scale wind farm projects, but it could amount to a significant portion of the total business case for smaller projects. To make such systems financially viable in the Netherlands, it might be necessary to reduce costs (e.g. with a subsidy, depreciation or joint investment).

Looking ahead to an assessment framework
Based on the pilot, a number of elements have been defined that are relevant to the decision whether or not to allow radar detection systems. Broadly speaking, we recommend dividing the assessment framework into two steps.

1. General permission (licence to operate) from the Human Environment and Transport Inspectorate (IL&T) based on an application (form) in which the location, type, safety level and settings are explained and substantiated. This could be done using product specifications, certificates, protocols, simulations and (previous) test results or authorisations at international level.
2. Further substantiation showing that the system works properly on-site and a specification/optimisation of the on-site settings based on a practical test. This could include a flight test to verify that the system was calibrated correctly. A survey report could then be presented to IL&T for approval. This would in fact serve as a verification of the authorisation given in step 1.

As stated, a framework will be prepared in phase 3 of the pilot (in the coming months), the purpose of which is to obtain permission to use radar detection systems for aircraft warning lights in the Netherlands.