

UAV Approaches to Wind Turbine Inspection
Reducing Reliance on Rope-Access

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Introduction

Unmanned aerial vehicles (UAVs) are quickly becoming the go-to method for inspection across the wind industry. Reducing the reliance on rope-access activity in hazardous environments, such as those found on offshore wind farm sites, is of interest to any owner/operator. UAV technology provides a means to reduce the risk of inspection tasks, increase the frequency of inspection and provide high-quality information for the maintenance planning process. Although UAV inspection has been adopted in the wind industry, there can be misunderstanding around the capability and application of UAV technology in the sector. This case study aims to lift the lid on the inspection process and to provide actionable, operational insight from Cyberhawk, one of the wind industry's leading inspection service providers.

Key Findings

- UAV technology provides a number of solutions to industry challenges, including:

  Safety: Offshore UAV inspections can be conducted from crew transfer vessels (CTV) and therefore require no vessel-to-turbine transfers or working at height.

  Time and Cost: UAV inspection can be up to six times quicker than traditional rope-access inspections, significantly reducing turbine downtime and inspection costs.

  Quality: Defects can be sized to ± 5mm and inspection outputs are provided to operators in interactive asset management tools.

- Interactive means of visualising inspection data, such as Cyberhawk's iHawk software, provide a valuable tool for the maintenance planning process.
- UAV inspection technology can be used from initial wind farm design (site surveys) all the way through the asset's inspection lifecycle.
- High-quality data is needed throughout the lifecycle of a wind farm. Historical inspection data is required to determine damage progression and contributes to the maintenance planning process
- Operators already convinced of the benefits offered through UAV inspection may look to develop internal departments to run more frequent inspection activities.
- Automation, regulation and advanced image processing are all being developed with the aim of faster, more accurate and standardised UAV inspections.

A note on abbreviations: throughout this case study the term UAV is used to describe aerial vehicles piloted by remote control. Similar publications may also refer to this technology using the phrase "drone" or Unmanned Aerial System (UAS).

Introduction

In the growing renewable energy sector, there is a continual drive toward cost reduction and improved safety in operations and maintenance (O&M) activities. A key O&M task is the inspection of operational assets and, common across all industries, the need for accurate and timely inspection data is crucial in the maintenance planning process. In the wind industry this is an increasingly complex task, with individual wind turbine blades set to exceed 100m in length and ambitious goals for wind farm construction in the coming decades. Although advanced inspection techniques are available, the first port-of-call is often visual inspection of the asset or component in question. This is industry-agnostic and often the inspection techniques from one industry are applicable in many others. Although this case study focuses on inspection specific to the wind industry the same technology, methods and processes described can be, and are, actively used in a range of applications in many different industries from construction and infrastructure to oil and gas.

Figure 1: UAV technology in action.

Wind industry-specific inspection methods include:

Rope-access: The conventional method of inspection. Requires a team of qualified engineers to scale a turbine, access the nacelle and abseil down each blade in turn, recording and capturing defects.

UAV: The use of a remotely-piloted UAV to inspect wind turbines both onshore and offshore. A qualified UAV pilot and inspection engineer are required for this type of inspection.

Elevated platform: A specially-designed platform is used to inspect the length of blades in-situ. The risks with this method mirror those of rope-access inspection.

Ground camera: Visual inspection of blades from static devices within a wind farm.

Rope-access and UAV inspection are the two most widely-used methods in the wind industry to date. Although possible, elevated platform and ground camera inspections are not typically utilised for large-scale inspection activities due to logistical, quality and cost limitations. For the purposes of this case study only the conventional inspection methods, rope-access and UAV, are considered.

In the wind industry, UAV technology has been used for the inspection of turbines, met masts, substations and for onshore site surveys. Although UAV technology is not yet capable of remotely carrying out maintenance or repairs, it has in many ways changed how operators are approaching operations and maintenance tasks. Early adopters of the technology have such confidence in the output of UAV inspection campaigns that they are planning the maintenance and repair of blades without the need for additional inspection by rope-access. Rather than a competitor to human intervention, UAV technology complements the tasks that are regularly carried out by technicians both onshore and offshore.

Cyberhawk

Cyberhawk is one of the service providers leading the way in the area of UAV inspection. Formed in 2008, Cyberhawk has achieved over 30 world-firsts in the oil and gas, infrastructure, utilities and wind industries. Since conducting the first UAV wind turbine inspection in 2010, followed by the first UAV offshore wind turbine inspection in 2012, Cyberhawk has established itself in the wind industry through its impressive track record and wide-ranging list of customers. Its service offering includes UAV inspection and comprehensive visual asset management assistance through its online portal, iHawk. This software solution, developed in-house by Cyberhawk and launched in 2014, has enhanced the way operators are approaching the maintenance planning process. Details of the iHawk system are provided later in this Case Study. Having experience in inspecting turbines from various original equipment manufacturers (OEMs) on behalf of several different owner/operators, there are few service providers in the industry that possess the level of insight provided for the purposes of this Case Study by Cyberhawk.

Examples of inspection campaigns conducted by Cyberhawk will be presented throughout the Case Study in order to provide specific examples of the applications of UAV technology in the wind industry.

Case Study: Onshore Wind Farm Inspection

Cyberhawk completed the inspection of 23 wind turbines across two wind farms in Turkey. The turbines were some of the oldest in the operator's fleet and the region was known for its frequent storms and lightning, so detailed information on the wind farm's condition was crucial in the maintenance planning process. Each turbine was inspected (tower, nacelle and blades), with data and inspection analysis provided via Cyberhawk's iHawk software. Simultaneously to the inspections, on-site technicians were enabled access to the turbine in order to conduct periodic maintenance tasks as the turbines were taken out of operation.

Challenges

What challenges does the wind industry face?

Before describing the details of new technology, it is useful to understand the motivations for its adoption. The incentives for the use of UAV technology can be summarised into three areas: improved safety, time and cost savings, and quality assurance [1].

Improved safety

Conventionally, rope-access teams are utilised for blade inspection and repair activities. This requires the mobilisation of at least a two-person team to access the nacelle of a turbine and abseil down each blade in turn to inspect and capture images of damage on the surface of the blades. This has inherent risks associated with working at height and in the confined and hazardous environments of turbine nacelles. Offshore, this is compounded by the added risks of CTV transit and transfer. Reducing the requirement for human presence in these environments, particularly for frequent inspection activities, is of interest to all wind farm owner/operators.

Time and cost savings

There is a balance to consider between the downtime and cost associated with inspection tasks and the savings accrued as a result of them. Although service agreements may specify an availability level - the amount of time a turbine must be up and running – the operating performance of a turbine can be overlooked. The level of performance decrease due to blade damage may seem marginal at a glance, but significant cost saving is available to forward-thinking site operators that act on the output of inspection campaigns. Even minor blade surface defects can reduce the aerodynamic efficiency of turbine blades and contribute to long-term structural damage that may be experienced by leaving damage unrepaired. Increasing the speed and frequency of inspections, using UAV technology, enables better decision-making on what repairs are needed and when.

Quality assurance

High-quality inspection images will be of particular benefit to owner/operators in the future. The balance between repair costs and production losses due to damage such as leading-edge erosion is one which is not fully understood to date. In order to make maintenance planning decisions with confidence, the historical condition of wind turbine blades will need to be understood and comparable levels of image quality and damage classification is therefore a necessity. From historical rope-access inspection reports it is evident that there is a level of ambiguity when it comes to classifying blade damage, whereas images from a UAV inspection tend to be more regular in their framing and distance from the blade. This, combined with more intelligent post-processing, can help to standardise how damage is quantified.

Inspection is required not only to identify these defects but also to evaluate the progression of damage over time and influence plans for repair. Pinholes often act as the starting point for erosion: cracks can progress to compromise the structural integrity of a blade and damage to blade modifications can lead to higher loads and reduced performance. Blade damage progression does not always show a linear pattern of behaviour over time, and so enabling timely and high-quality inspection is a concern for owner/operators.

Case Study: Offshore Wind Farm Inspection

In late 2017 Cyberhawk was tasked by Siemens Gamesa to carry out visual inspections of 27 wind turbines at an offshore wind farm [3]. Unique to this inspection campaign was the requirement to develop a bespoke app to meet specified requirements: a 25% overlap in images to ensure no blade surface was missed. In this case the images of each individual turbine were processed and uploaded on the same day as inspection.

What challenges do UAV service providers face?

One of the main barriers to widespread adoption of UAV technology is a lack of understanding of the capability and results offered from this inspection method. There are a number of UAV inspection providers but their chosen technology and the quality of their output varies significantly. This has led to misunderstanding around what is capable with regards to inspection techniques and what the outputs of inspection campaigns are. As a relatively new technology, the awareness of what UAVs are now capable of and the level of detail in the images that are captured can be limited.

UAV Inspection Process

It is common for wind farm owner/operators to require inspections at the end of warranty and, typically, every three years thereafter. This depends on the appetite of the owner/operator and the track-record of the turbines from historical inspections but in most cases it proves to be a costly, time-consuming activity. In recent years, owner/operators have transitioned from relying on rope-access teams for these inspections to utilising UAV inspection technology. Initial adoption allowed for a “first glance” at the condition of turbines, enabling areas of concern to be highlighted. Thereafter rope-access teams would be called in to perform tactile inspections and maintenance where required for these highlighted turbines. However, as confidence in the effectiveness and quality of UAV inspections has grown, rope-access has been all but removed from the inspection tasks at sites which have adopted UAV inspection technology.

Cyberhawk has a five-stage process for conducting UAV inspections. The actual inspection campaign constitutes just one of these stages, with a clear emphasis on asset management assistance and post-processing.

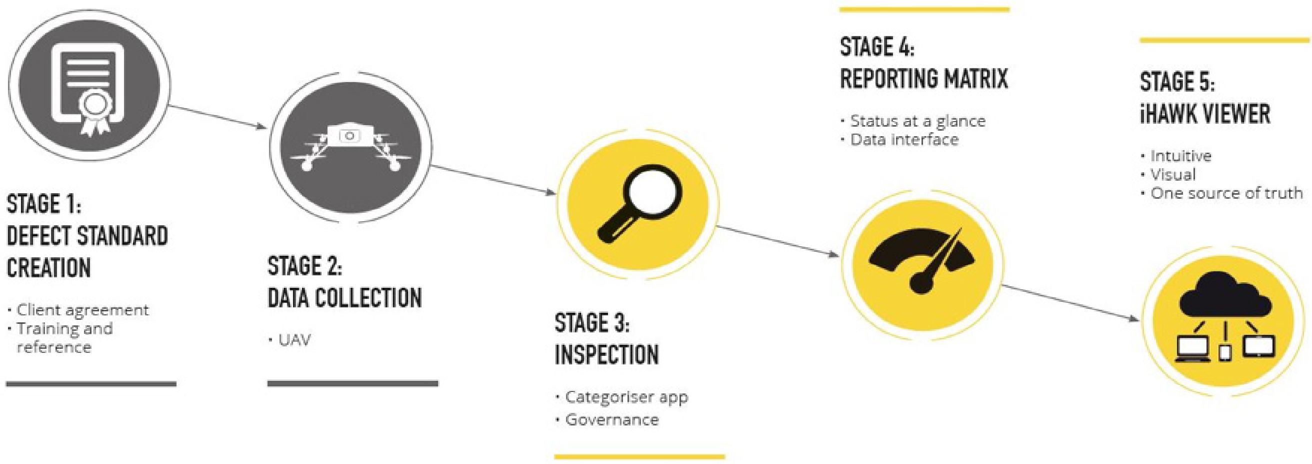


Figure 2: Cyberhawk's UAV inspection campaign process

Stage 1: Defect Standard Creation

Domain knowledge and inspection experience has enabled Cyberhawk to provide owner/operators with defect standard guidelines (a methodology for classifying blade damage) developed from scratch or from existing, operator-specific documents. This provides a condition rating scale to ensure consistency in defect classification and terminology.

Stage 2: Data Collection

Inspection campaigns are generally conducted in teams of two: one appropriately-qualified drone pilot and an industry-experienced inspection engineer. Offshore inspections are performed from the security of a crew transfer vessel (CTV), eliminating the need for turbine transfers.

A typical turbine inspection will include the inspection of each side of each blade: suction side (SS), pressure side (PS), leading edge (LE) and trailing edge (TE). The tower and nacelle are also inspected if required. Up to six turbines can be inspected per day, depending on environmental conditions.

Stage 3: Inspection

After data is acquired at site, the images are processed and inspected by engineers at an inspection centre. Reports and additional outputs are created from this analysis detailing the location, size and severity of defects in accordance with the agreed defect standard. It can take from days up to two weeks to generate the outputs from a full-scale inspection campaign, depending on the size and complexity. In some cases, raw images are provided for a desk-based inspection by the customer's internal engineering teams. All data is stored by Cyberhawk on servers, with around 5GB of data storage required per turbine, depending on the turbine dimensions and inspection requirements. Dealing with such large volumes of data presents various challenges which ultimately led to Cyberhawk's development of a cloud-based reporting and data storage solution.

Stage 4: Reporting Matrix

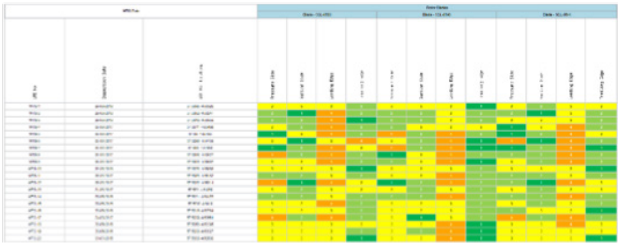


Figure 3: Cyberhawk's colour-coded reporting matrix.

In order to make sense of the thousands of images captured in an inspection campaign, Cyberhawk delivers a traffic light colour-coded reporting matrix (pictured). This enables the customer to view the condition of an entire site on one page, highlighting turbines of interest and specifics on the location and severity of the damage of individual blades.

Stage 5: iHawk Viewer

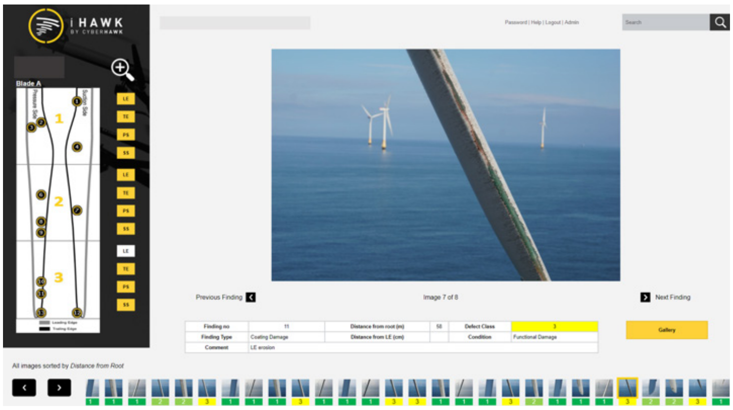


Figure 4: A view of the defects found during a blade inspection

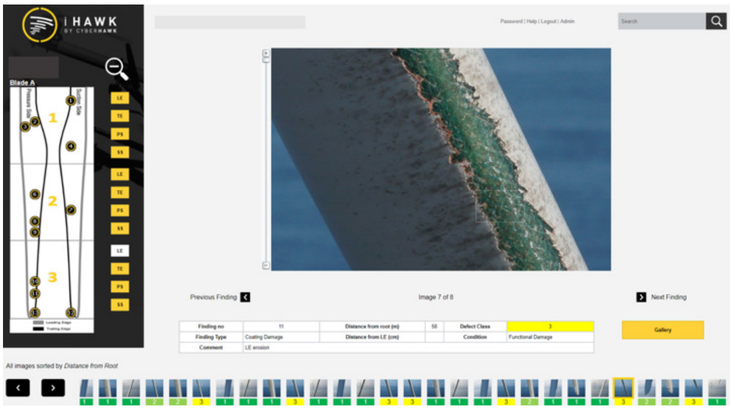


Figure 5: A magnified view of the damage

One of Cyberhawk's unique service offerings is iHawk. Launched in 2014, iHawk enables view of the output of entire inspection campaigns in an interactive asset management tool. Unique iHawk modules are available for the different industries Cyberhawk operates in, but the fundamental concept is the same: enabling the delivery of inspection data (images and engineering commentary) through an interactive, visual, online platform. iHawk users can drill down into wind farms, turbines and blades to view each individual defect identified in that operator's inspection campaign(s).

Training

As a service provider relying on the reputation of a relatively new technology, Cyberhawk has a clear emphasis on pilot and inspection engineer training in order to deliver continued success. With this in mind, the company has developed an internal training programme to ensure all their inspection teams have experienced, qualified personnel.

For pilots, a four-level training programme has been designed to ensure experience level is matched to appropriate jobs.

Level	Description	Requirements
1	Aerial photography and survey	• UK Civil Aviation Authority (CAA) qualification, or equivalent • In-house ground instruction • In-house flight training • On-site training
2	Basic industrial inspection	• In-house inspection training • In-house industrial risk awareness training • Full manual handling training • Training for flying close to structures
3	Advanced industrial inspection	• Minimum of 250 flights completed • In-house advanced inspection training • In-house confined space inspection training
4	Offshore industrial inspection	• Minimum of 500 flights completed • In-house working from vessels training • In-house and external offshore training (e.g. GWO training) • Elevated levels of training and risk awareness • Full manual flying training • High levels of flying competency

Table 1: Cyberhawk pilot training levels

Onshore wind farms can be inspected by level three pilots, requiring the experience of over 250 flights and several bespoke training packages. In an offshore environment level four pilots are required, with relevant Global Wind Organisation (GWO) training and significant flying experience. Over 500 flights must have been completed as well as additional training in risk awareness and working from vessels. Pilots are also trained in flying UAVs in full-manual mode, without the help of aids like Global Positioning System (GPS) position holding and collision avoidance sensors.

All inspection campaigns also require a qualified inspection engineer on site, who has been trained in data capture for specific asset types and understands what sort of condition, and defects, they are looking for. Office-based inspection engineers are also required to review the data after the inspection and provide engineering commentary.

Regulations and Requirements

As with conventional aircraft, UAVs are regulated for both commercial and recreational use. In the UK, this is done by the Civil Aviation Authority (CAA). Rules in other countries are managed by their own regulatory bodies.

The CAA awards permission for commercial operations (PfCO) to companies and individuals, allowing them to fly commercially. To be awarded a PfCO, companies must:

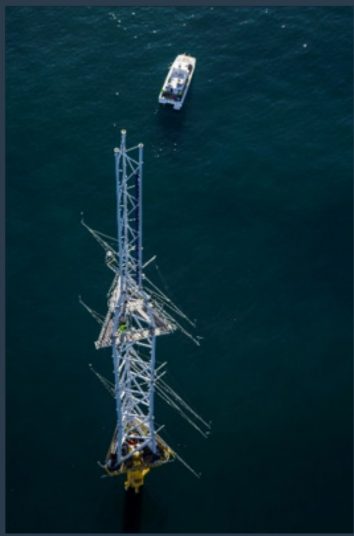
- produce an operations manual setting out the procedures for the work that will be done.
- have a UAV operator certified by a national qualified entity (NQE).
- have suitable insurance.

The standard permissions offered by the PfCO have some restrictions, however. The operator must obtain non-standard permissions to fly:

- at a height of more than 400ft (about 120m).
- within 150m of either a congested area or assembly of more than 1000 people.
- within 50m of people or property not under the control of the operator.
- beyond the visual line of sight of the operator.

To obtain these non-standard permissions, the operator must submit an operating safety case (OSC) to the CAA which details how the safety of people and property will be managed during the flight. With modern wind turbine towers often exceeding 100m in height, blades above the horizontal will exceed the height limit. This means that Cyberhawk will regularly obtain special permissions from the CAA to operate above 400ft.

Case Study
Offshore Met Mast Inspection



Sitting 150km from the coast, the Dogger Bank met mast inspections were particularly challenging [2]. Cyberhawk was tasked by Forewind to conduct the repeat inspec-tion campaign in 2016, after successfully completing the same inspection the previous year. A team of two con-ducted the inspection from the rear of a vessel. All steel lattice members and nuts and bolts on each flange joint were inspected with a duration of one day per mast. Previously, rope access inspections would have taken at least twice as long.

Case Studies

Offshore Substation Inspection

In 2016, Cyberhawk was tasked by Siemens to inspect the condition of three offshore converter stations on behalf of the transmission system operator TenneT [4]. A two-person team was mobilised to site and the inspection of all three substations was completed in seven days – less than half the time estimated for traditional rope-access inspection methods. Close liaison with the site's maintenance team ensured the full inspection campaign was completed in a single mobilisation.

Onshore Wind Farm Inspection

In 2015 Cyberhawk was tasked with inspecting over 100 wind turbines, located in Scotland and Ireland, within a short timeframe in order to meet an operator's inspection targets for the year [6]. Turbine downtime was minimised with the use of UAV technology and high-resolution images were supplied for use in the maintenance planning process. The operator wanted to schedule maintenance tasks soon after the inspection, so the specific location and size of defects were also required. Safety was highlighted as one of the key benefits of UAV inspection methods by the operator, reducing the need for rope-access technicians working at height. Also, on at least two occasions, turbines were not restarted after safety-critical defects were identified. Quicker identification of critical faults like this allow the operators to rectify problems sooner and, in some cases, before they develop into more serious problems.

Technology

UAV Platform

Cyberhawk's primary platform (device) for aerial inspection work is the Intel Falcon 8. The Falcon 8 is an octocopter (it has eight motors and propellers) which was originally developed by Ascending Technologies with support from Cyberhawk. Intel has since acquired Ascending and continues to develop the platform. The Falcon 8 has a strong background in industrial inspection, where it is considered the safest and most respected tool for the job, however as technology and hardware progresses Cyberhawk continues to trial other options to ensure the most efficient solution is being used.

Intel Falcon 8

Size	770 x 820 x 125mm
Max, take-off weight	2.3kg
Max. payload	0.8kg
Flight time with payload	12 - 22 mins
Max. range	1000m
Max. airspeed	16m/s
Max. windspeed	15m/s (GPS: 12m/s)

Figure 6: Sony α7 mounted to a Falcon 8

Payload

The UAV platform can be fitted with a variety of payloads for imaging and data capture. Cyberhawk uses Sony α6000 and α7 mirrorless DSLR cameras on stabilised gimbals to take images. The cameras are fitted with laser distance measuring equipment which, used in conjunction with flight logs, allows Cyberhawk to determine the real size of anything in the captured photos. This size measurement is an important factor in classifying the level of damage to a wind turbine blade.

Thermal and gas sensing cameras can also be used where a normal image is not enough. For example, a thermal image of electrical components can often help diagnose faults.

Benefits

The challenges of the wind industry with regards to inspection – improved safety, time and cost savings and quality assurance – can be addressed with the use of UAV technology. The ways in which UAV inspection technology have addressed these challenges are detailed below, using Cyberhawk's experience to provide specific examples.

Improved Safety

Reducing the requirement for rope-access activity is of interest to all wind farm owner/operators. This is achievable by using UAV technology for inspection and by ensuring repair activity is done in an efficient manner, as a result of well-informed maintenance planning. Cyberhawk's safety record highlights the use of UAV inspection technology as a safe alternative to rope-access inspection.

	2015	2016	2017	2018
Total working hours	60,984	70,224	79,794	78,650
Number of flights	4,526	4,239	6,032	6,000
Flight hours	618	568	823	850
Aviation-related accidents reportable to CAA	0	0	0	0
Lost time accidents/ incidents	0	0	0	0

Table 2: Cyberhawk safety statistics

Comparable statistics regarding working at height incidents within the offshore wind industry are available below, using data from the G+ global offshore wind health and safety organisation [5]. Three metrics are provided:

High-potential incidents: An incident that could have resulted in a fatality or life-changing injury.

ERME incidents: Where emergency response and/or medical evacuation is required.

Lost work day incidents: Non-fatal accidents where a person is unfit to perform any work following the occurrence of an occupational injury.

Reporting hours and total reported incidents are recorded for the industry as a whole, not specifically for working at height operations. The data clearly shows that incidents related to working at height activity are still a significant issue in the industry to date.

	2015	2016	2017
Reporting hours	21,220,000	21,726,000	26,8150,000
Total reported incidents	983	987	2200
Working at height - high-potential incidents	45	76	26
Working at height - ERME incidents	4*	2	1
Working at height - Lost work day incidents	4	4	4

Table 3: G+ incident data relating to working at height (2018 data not yet available).
**Incidents were recorded as "other" which includes working at height incidents.*

Time and cost savings

Significant cost savings are available to owner/operators in the inspection process. To demonstrate that UAV inspection technology is a means to attain these savings, the output of an O&M cost model calculation is provided below. The O&M cost model was developed internally by the Catapult.

It should be noted that these results were used to provide an idea of the cost difference between UAV and rope-access inspection activities only. Several assumptions were made, detailed below, which will differ between real-world sites. Key assumptions include the number of turbines inspected per day, the number of personnel required for each inspection method, and the time between inspections.

	Rope-Access Inspection (O&M Cost Model Inputs)	UAV Inspection (O&M Cost Model Inputs)
Turbines inspected per day	1	3
Years between inspections	5	3
Personnel required	3	2
Personnel day rate	700	700
CTV cost	2500	2500
Turbine rating	3.6 MW	
Wind farm size	83 turbines	
Wind farm capacity	300 MW	
Capacity factor	37%	
Electricity value	£140/MWh	

Table 4: O&M cost model inputs (internal ORE Catapult O&M cost model)

The annual cost of inspection was calculated for an offshore wind farm with a capacity of approximately 300 MW (83 x 3.6 MW turbines). The cost of inspection and lost production due to downtime were included in the estimated costs for both UAV and rope-access inspection. The results below show the average annual cost of inspection, for the entire wind farm, estimated for both rope-access and UAV inspection methods.

	O&M Cost Model Outputs
Average annual rope-access inspection costs	£125,000/year
Average annual UAV inspection cost	£79,000/year
Saving	36.8%

Table 5: Annual inspection costs (O&M cost model outputs)

The cost model estimated inspection savings of almost 40% when adopting UAV technology in place of conventional rope-access inspection methods. These saving are particularly impressive considering the assumed time between inspection was five years for rope-access and three years for UAV inspection. Therefore, even with more frequent turbine inspections, a further advantage to owner/operators, annual UAV costs were estimated to be almost 40% lower than annual rope-access costs for this particular wind farm.

To understand the breakdown of UAV inspection costs further, a sensitivity plot is provided. Specific metrics were varied by 25% and the output of the cost model was recalculated. The metrics varied included: inspection frequency, number of turbines, turbine rating, CTV cost and personnel day rate. A narrow spread of calculated costs suggests a low sensitivity to a particular variable (i.e. a large change in the metric will not result in a large change to annual UAV inspection costs) and vice-versa.

The results show that wind farm-specific variables (turbine number, rating and inspection frequency) are the main drivers for cost with regards to UAV inspection. Conversely, costs specific to inspection activities (personnel day rates and CTV costs) do not have a significant impact on annual inspection costs. In all cases however, the maximum annual cost of UAV inspection is well below that of the baseline cost for annual rope-access inspections.

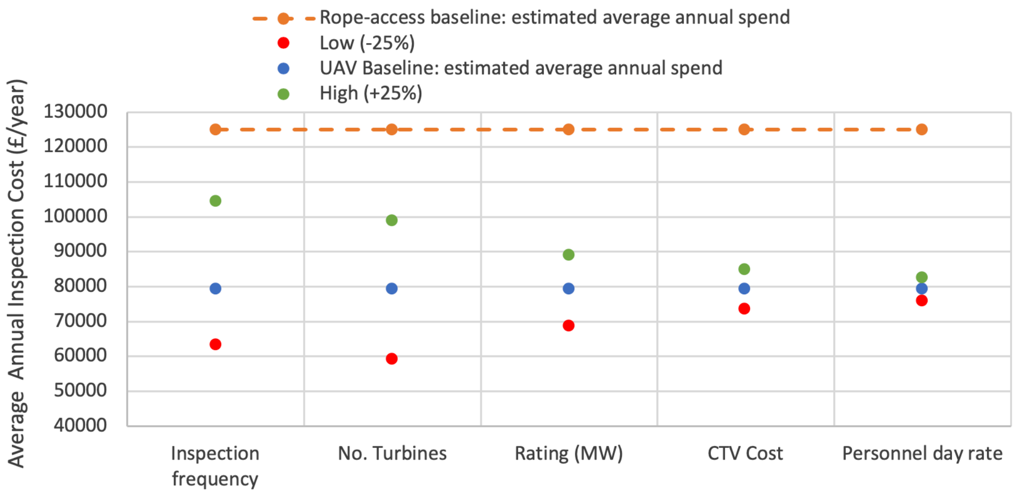


Figure 7: Sensitivity of UAV inspection cost to O&M cost model input values

Quality assurance

While the safety benefits and the time and cost savings to owner/operators in the inspection process are clear, the quality offered by UAV inspection technology is of equal importance. High-quality images where defects can be sized to ± 5 mm, alongside a means of interactively visualising the data (iHawk), provides operators with a powerful toolset for the maintenance planning process. Additionally, the quality provided in terms of pilot training and a requirement for qualified inspection engineers to direct proceedings during inspection and image analysis provides confidence in their service.

However there is still a need for guidelines on what constitutes a good inspection and what the minimum requirements for service providers should be. The Catapult is actively engaging with owner/operators, service providers and regulatory bodies to detail some of these requirements (such as image quality and scale) and to enable the industry to standardise the quality of UAV inspection. Cyberhawk have been involved in this work and have tested technology at the Catapult's 7MW demonstration turbine in Levenmouth, Scotland.

The Future of UAV Inspection

As the wider industry gains awareness around the capability and application of UAV technology, there will be pressure on UAV service providers, such as Cyberhawk, to further develop their offering. Such developments include:

- autonomous UAV technology – UAVs not requiring manual control.
- operational inspections – requiring no turbine shutdown for inspection.
- advanced image processing – using machine learning algorithms to identify and classify damage during inspection.

Cyberhawk has a range of ongoing research and development activity projects that aim to realise these goals.

Appendices

References

[1] T. Fong, "Robotics and Autonomous Systems in O&M - Removing the Barriers to BVLOS Operations," Offshore Renewable Energy Catapult, 2019.

[2] Cyberhawk, "Forewind Dogger Bank Met Mast Inspection," 2019.

[3] Cyberhawk, "Offshore Wind Farm Inspection for Siemens Gamesa," 2019.

[4] Cyberhawk, "Converter Station Inspections for Siemens," 2019.

[5] G+ Offshore Wind, "G+ Global Offshore Wind Health and Safety Organisation," 2019.

[6] Cyberhawk, "100 Turbine Inspections in Scotland and Ireland," 2019.

Recommended Reading

The CAA website contans information around the regulation which apply to the commercial use of UAVs:

CAA, "Regulations relating to the commercial use of small drones," Civil Aviation Authority, 2019.

This CAA document formally sets out the laws which govern the commercial use of UAVs:

CAA, "CAP 722: Unmanned Aircraft System Operations in UK Airspace - Guidance," Civil Aviation Authority, 2015.

Author Profiles

Craig Stout is an engineer, O&M Systems at the Offshore Renewable Energy Catapult. He has a background in mechanical engineering, receiving an MEng from Robert Gordon University, with an interest in wind turbine design. Craig's main focus is the analysis of operational data from the renewables industry. His current work includes industry benchmarking programmes, resource and performance assessment and enabling data sharing for the industry.

David Thompson is a mechanical engineer in the mechanical and balance of plant team at the Offshore Renewable Energy Catapult. He has a MEng in Mechanical Engineering and PhD in wind turbine control systems, both from the University of Strathclyde. His current work includes the development of robotics and autonomous systems in offshore renewables, wind turbine control systems and the demonstration and validation of new technology.

Contributors

Jenny Adams is Marketing Manager at Cyberhawk, where she focuses on promoting Cyberhawk and the wider field of UAV inspection, survey and data digitisation to the global energy sector. Through case studies, speaking engagements and digital content, much of her work involves highlighting the vast benefits and efficiencies provided by UAV technology.

Christopher Wilson holds MEng in Mechanical Engineering, specialising in advance materials engineering and energy systems. As Team Lead for Renewables, he is responsible for the strategic development of Cyberhawk's wind sector solutions. His remit includes ensuring field operations remain safe and efficient, the continued development of Cyberhawk's cloud-reporting solutions for renewables and working closely with technology suppliers and manufacturers.

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