



Introducing Lilypad

A network of resident autonomous UAVs accelerating offshore renewable energy growth by delivering data-driven dynamic inspection services

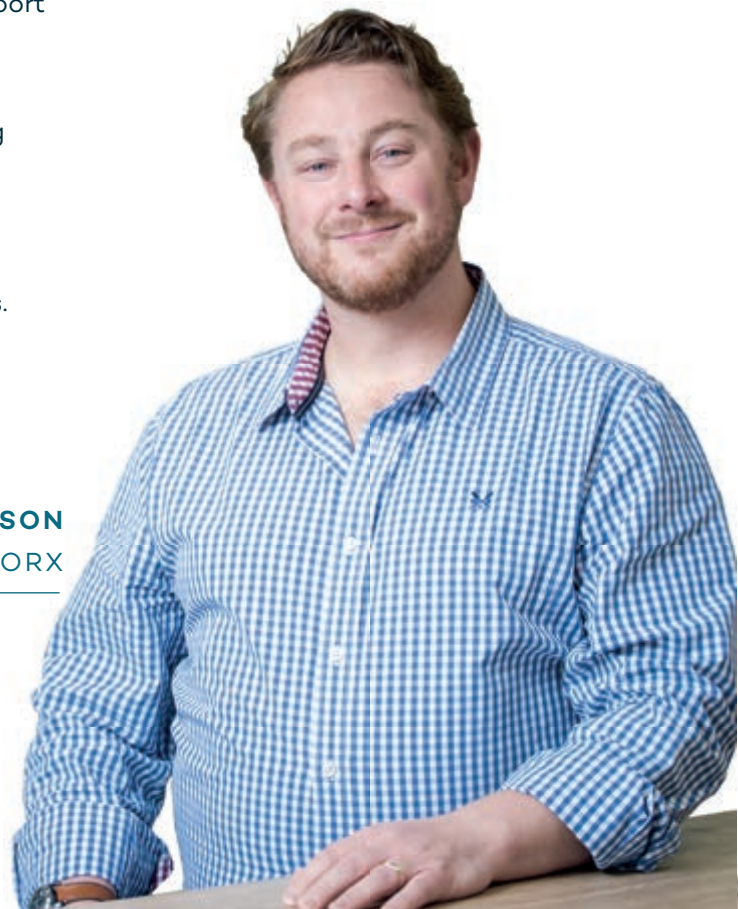
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The ever increasing demand for secure and renewable energy to power our communities has resulted in the surging need for innovative solutions to enable the installation and support of offshore wind infrastructure, right from initial construction and through the life of projects. Leveraging our demonstrated talent for integrating leading technologies and providing support services to customers operating in demanding and regulated environments, we are excited to share the first of these products – Lilypad, an offshore wind farm inspection service that provides truly scalable inspection capacity to support the significant growth and increasing remoteness of offshore wind farms.

Lilypad uses permanently resident autonomous UAVs allowing us to provide on-demand and scheduled inspections timed to minimise the economic impact on wind farm operations. Lilypad decouples the cost of inspection from sea state, distance from shore and seasonal considerations and eliminates the need for offshore personnel during inspections.

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KIEREN PATERSON
MANAGING DIRECTOR, FUTUREWORX



The Lilypad Mission

Our mission is to provide safe, efficient inspection services for offshore wind farms using resident autonomous UAVs, optimising operations and maintenance with reliable data whilst enabling sustainable industry growth.



Contact Details

For more information on Lilypad and to register interest for a customer demonstration please contact Business Development, Manager Kathryn Coogan:

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LILYPAD
OFFSHORE



The challenge

Offshore wind is a key component in the UK Government's net zero strategy and the UK's offshore wind sector is poised to step up and play an even bigger role in the energy transition. With an ambitious UK target of achieving 50 GW installed capacity by 2030 and more than 100 GW by 2050, the number of wind turbines is set to increase to over 30,000 globally with wind farms becoming further and deeper offshore to keep up with this demand. Industry must work together to navigate the challenges associated with offshore renewable energy and drive investment and innovation in this thriving sector.



Significant industry growth with **30,000** turbines globally **by 2030**

Global capacity to increase to **380GW by 2030**

More turbines require a **scalable inspection** solution



UK capacity to increase to **50GW by 2030**

UK has the **second-biggest operational** offshore wind **capacity**

UK has the **second-largest** offshore wind **pipeline**



Farms **further offshore** with **larger turbines**

Harder to reach by CTVs

Decarbonisation of **O&M** operations required to complete the energy transition



Increasing **reliance** on **offshore wind** energy

Fight climate change, **phase out** fossil fuels and **strengthen energy security**

UK **offshore wind** is **recognised** as **critical** national infrastructure



Global drive to **accelerate** the journey to **net zero by 2050**

Supporting the **transition to digital** O&M operations for **localised, real-time decision making**

Drive sustainable **sector growth** through ambitious targets and deployment of **new technology**

The Lilypad Technology

Futureworx has teamed up with state-of-the-art BVLOS software industry leader sees.ai and cutting edge UAV designer and manufacturer ISS Aerospace to deliver a ground-breaking ecosystem of autonomous beyond visual line of sight (BVLOS) UAVs. Lilypad utilises aerial intelligence and navigational sensors to create a world-leading integrated capability, providing dynamic and on-demand inspection.

Lilypad is set to accelerate data-driven, sustainable, offshore renewable energy growth through a network of resident robotics. Lilypad is reimagining inspection delivery with operational, economic, and environmental benefits to revolutionise the way operators monitor and maintain offshore assets to maximise wind farm performance.



Consistent & reliable data analytics for scalable inspections



Resident highly automated inspection UAV system



High resolution payloads including inspection camera and LiDAR with edge processing



High reliability / minimised maintenance by design



Multiple UAVs to be monitored simultaneously by a single remote pilot



Fully UK CAA certified end-to-end service integrated into operations



Task based BVLOS command and control



Automated environment recognition / navigation / avoidance



Remote deployment of software for functional updates / patches



Versatile modular technology that can be readily upgraded to support future innovations

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The modular technology that sits behind Lilypad is extremely versatile - it can be readily adapted to support future technologies and applications. Notwithstanding further technical development, a UAV permanently deployed in a wind farm could perform complimentary tasks beyond just blade inspection. Surveillance of critical national infrastructure, turbine jacket and substation structural surveys are all viable additions expected to be added in our key delivery year, along with an exploration of alternative sensor payload missions. 2023 is set to be the year of innovation for UK supply chains in offshore wind, and we are excited to be a part of it.

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CHRIS HOE

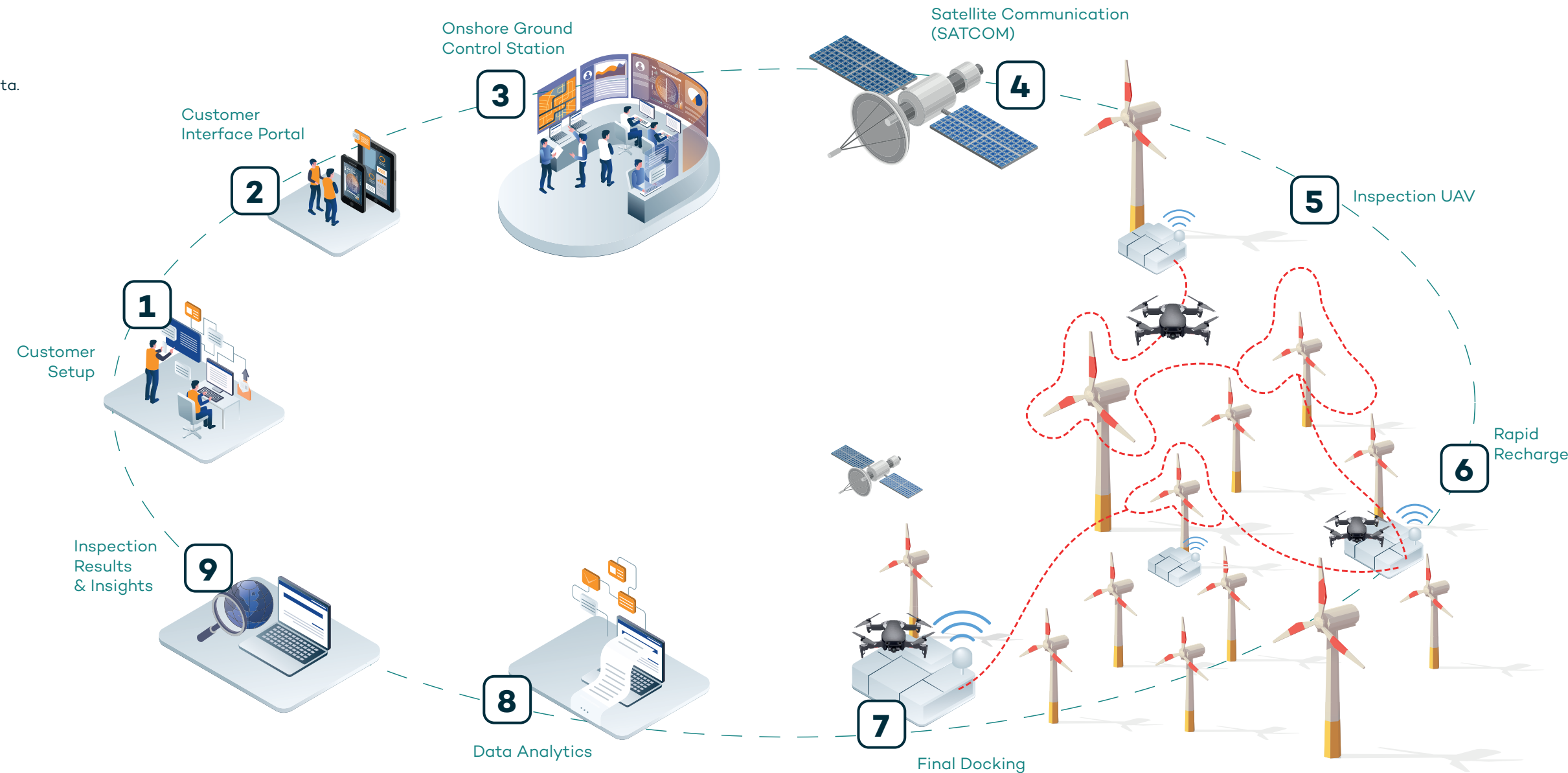
FUTUREWORX ARCHITECT & LILYPAD CONCEPT CREATOR



The Lilypad Ecosystem : How it works

Powering the offshore wind industry with cutting-edge robotics and data.

- 1 Customer Set Up**
Working collaboratively with customers, an offshore survey will be completed to determine the size of the operation and the optimum layout of the offshore infrastructure. Specialist contractors will then install and commission all equipment, ready for service.
- 2 Customer Interface Portal**
All customer inspection requirements and schedules are loaded into a Lilypad Customer Interface Portal. This is a web-based application where long-term inspection schedules can be loaded and ad-hoc requests can be submitted. Inspection status can be monitored with progress reports available to customers via the portal.
- 3 Onshore Ground Control Station**
Schedules and requests that have been loaded into the Lilypad Customer Interface Portal will be received by the Ground Control Station and used to generate the Lilypad mission plans. The dedicated Operations Team will create the mission plans based on external factors such as weather, other air users and further wind farm activities.
- 4 Satellite Communication (SATCOM)**
A secure, persistent and weatherproof SATCOM link provides continuous communication between onshore and offshore Lilypad assets, with BVLOS data links enabling command and control of the Lilypad inspection UAV and enclosure.



- 5 Inspection UAV**
The permanently deployed Lilypad inspection UAV is then launched and flown by the remote pilot to the required turbine to complete the automated inspection task. The Lilypad inspection UAV can cover a range of approximately 15km with an average flight time of 45 minutes, and will utilise GNSS LiDAR and AI to fly an optimised route for inspection completion. Safety, reliability and availability is ensured through rugged back-up systems and is recognised by CAA authorisation.
- 6 Rapid Recharge**
The Lilypad inspection UAV will hop between the installed Lilypad enclosures, where a battery swapping mechanism enables rapid recharging to complete the task. During this quick turnaround time the Lilypad inspection UAV will also offload inspection data as well as complete pre-and post-flight checks before taking off again.
- 7 Final Docking**
Upon completion of the maintenance task, the Lilypad inspection UAV will dock in the final Lilypad enclosure. Data is then downloaded within the enclosure and securely transferred back to the Ground Control Station via the secure SATCOM link.
- 8 Data Analytics**
Inspection image data is processed using a state-of-the-art, industrially proven data analytics tool which employs blade inspection experts and AI-enabled damage recognition software. Bespoke customer inspection reports are then created.
- 9 Inspection Results and Insights**
All customer inspection reports are loaded into the Customer Interface Portal (and also provided in PDF format) for the customer to access, analyse and plan next steps.

Reimagining Inspection Delivery

Innovation to advance O&M operations can provide operational, economic and environmental benefits to revolutionise the way operators monitor and maintain offshore assets to maximise wind farm performance.



Maximises wind turbine uptime to support ambitious 2030 and 2050 UK government targets

Resident UAVs exploit inspection opportunities throughout the year whilst reducing human exposure to operations

Scheduled and on-demand inspections with high-quality, consistent data analytics



Maximises wind turbine revenue generation

Reduces costs of CTVs and O&M workforce

Reduces cost of repairs and maximises through-life earnings through early identification of faults

Inspection downtime reduced to 15 minutes for all three blades



Reduces carbon emissions associated with CTV voyages

Supports a preventative rather than corrective maintenance strategy reducing environmental impact

Future capability for environmental monitoring and surveillance of critical national infrastructure

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BVLOS-based inspections result in significant cost savings (relative to costs of rope access or UAV-based inspections). The cost per inspection is greatly reduced even compared to UAV-based inspection due to eliminating the need for CTVs. The more turbines to be inspected, the more cost-effective BVLOS becomes, as more and more CTV trips are saved.

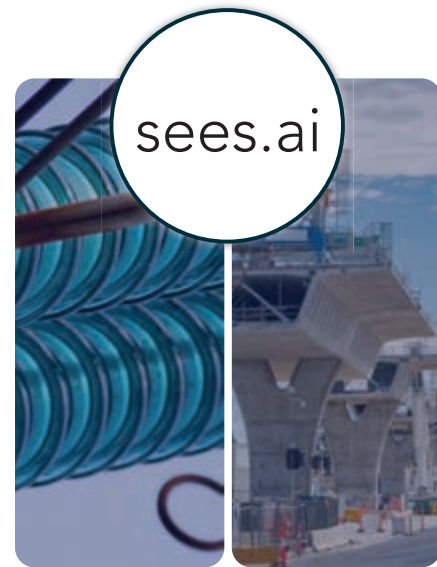
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ORE CATAPULT

(BVLOS DRONE CONSULTANCY REPORT, AUGUST 2022)

Making the Mission Possible

Offshore wind has the biggest growth potential of any renewable energy technology. To support this Futureworx has created an expert network from the UK supply chain to design, manufacture, integrate, develop and accelerate industry-leading technology into the market.



State-of-the-art BVLOS Software

- Most advanced UK CAA authorisation for BVLOS operations
- Highly autonomous navigation and collision avoidance capability
- Fully autonomous inspection capability
- Ground breaking technology pushing regulatory boundaries



World Leading System Integration

- Lilypad system architect
- Design, manufacture and testing of permanently deployed infrastructure
- System integration
- CAA authorised flight operator
- Data capture analytics

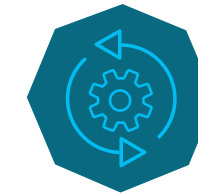


Cutting Edge UAV Design

- Designs, builds & operates UAVs
- Resilient, BVLOS capable UAV
- Onboard data processing
- UAV payload integration

Futureworx is a innovation and venture builder focussed on creating technology and enterprise solutions for developing global trends. We are a team of creative engineering talent with a goal to explore new partnerships, markets and emerging technologies and create new products and services to answer problems of practical significance. As part of the broader Marshall Group, we leverage over 100 years of aerospace and technology integration expertise and approvals to create safe, secure and cutting-edge systems.

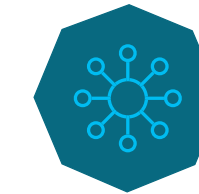
SYSTEM INTEGRATION AND LILYPAD ENCLOSURE



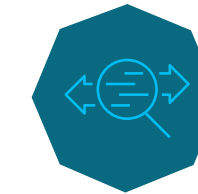
Permanently deployed infrastructure and environmentally controlled storage for inspection UAV



Battery exchange mechanism to maximise on-demand UAV availability



Integration of over-the-horizon and local area datalinks



Edge data processing to ensure streamlined and cost-effective data transfer



System integration with hardware, software and compatible with third-party data analytics platforms



Regulatory lead for CAA BVLOS approvals

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It's an exciting challenge to develop a system capable of performing in demanding situations and achieving the highest levels of safety. We tackle this task with the vision of unlocking the potential in offshore renewable energy. The whole team is coming together along with the best technologies, partners and suppliers to solve this difficult problem. Embracing a collaborative and innovative culture is key to achieving our goals.

Our ambition for Lilypad gives us the energy and drive to deliver this breakthrough system and we look forward to realising what else we believe Lilypad is capable of.

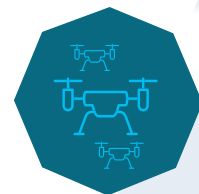
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GRAHAM WALKER
FUTUREWORX ARCHITECT & TECHNICAL LEAD



ISS Aerospace is a UK-Based UAV manufacturer, specialising in the design, development and production of high-performance UAV platforms. ISS Aerospace collaborates with leading academic institutions and research organisations to develop new technologies and to explore new applications for UAVs. The company's experienced team of engineers and technicians is working closely with Futureworx to understand the specific requirements of Lilypad to develop a customised UAV solution and remain at the forefront of the UAV industry.

INSPECTION UAV HARDWARE



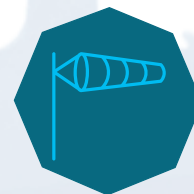
Proven UAV platform capable of operations in harsh industrial environments



Up to 50 minutes flight time



Up to 15km range



Performs inspections in winds of up to 20 knots and capable of operations in up to 40 knots



High resolution camera with LiDAR



Real-time onboard navigation, collision avoidance and inspection

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ISS Aerospace is delighted to have been appointed by Marshall Futureworx to provide a derivative of our Sensus ML8-XP UAV for the Lilypad ecosystem. The Sensus family of UAVs has seen considerable buy-in from our defence, security and energy clients and seen operations worldwide. ISS provides highly innovative, customer requirement focused solutions which deliver on-board multi-modal sensor integration to deliver intelligence solutions at the highest tempo.

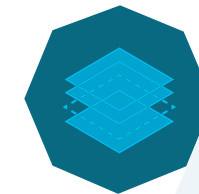
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RYAN KEMPLEY
CEO, ISS AEROSPACE



sees.ai is a UK-based aerial intelligence company who are breaking new regulatory and technical ground with their world-leading BVLOS operating system. sees.ai has the lead in facilitating remotely-piloted UAV operations with state-of-the-art navigational software that is continuously improving its efficiency, quality and safety. The commitment to safety has been recognised by the Civil Aviation Authority having secured permission to trial routine BVLOS operations. This is one of the most advanced drone permissions ever given by a developed market aviation regulator.

STATE-OF-THE-ART NAVIGATION SOFTWARE



Industry leading software stack



Able to generate real-time environment maps



Able to generate real-time environment maps for automated navigation, collision avoidance and inspections



Able to autonomously inspect the wind turbine regardless of blade angle and orientation



Completes inspection of all 3 blades within 15 minutes



Collects high-quality, repeatable inspection

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We're thrilled to be able to reveal more about this project. Not only does it involve deep collaboration with Marshall Futureworx, one of the UK's leading aerospace companies, and an exciting opportunity to develop a defensible world-leading product for a huge and rapidly-growing global market; but it also gives us the opportunity to make a substantial impact on one of the most pressing challenges of our time: the transition to net zero. With this stellar consortium we look forward to pushing the boundaries of what is possible with UAV technology.

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JOHN MCKENNA
CEO, SEES.AI



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