



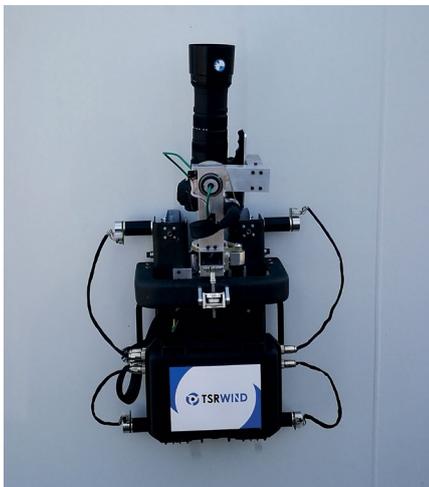
Innovative blade inspection and cleaning services

Words: Leonardo Gómez, Engineering Manager at TSR Wind

PES is excited to introduce TSR, a small Spanish engineering company that has developed technology through R&D, to provide affordable services that can compete in price, with traditional methods in the wind energy sector, solving problems that historically, would have involved risks, non-competitive stopping times and an increase in operating personnel.

With the growing number of wind turbines soon to be operating out of warranty, more frequent, minimal risk, effective and affordable services are a necessity in the industry. Maintenance often conflicts with tight budgets and down times but at the same time, high performance rates are expected from the windfarms, where one of the more critical factors is the inspection and repairing of the blades

TSR conceived its magnetic coupling robots for wind turbine maintenance, as a solution to minimise cost, reduce risks and obtain better results. The development started with the idea of a climbing, cleaning robot and



EOLOS 200 Inspection Robot

has evolved into a series of different models of robots, according to the service it provides. The first ones on offer to the public were the EOLOS series, a type of robot specifically designed for blade inspections.

TSR entered the international market with the robotic platforms from EOLOS series, a guided magnetic coupling robot, designed to move around steel or other ferrous material surfaces, metal tubes or cylinders

of more than 2m in diameter, as well as flat or uneven plates, specifically designed and constructed for inspection tasks in wind farms, therefore, the ideal operation would be in the a wind turbine tower.

Using a simple yet very powerful inspection tool, that is revolutionising how modern inspections are made, it's simple, effective, fast and so quality oriented that it has proven to facilitate the detection of 40% more damages and objects of interests, than the ground inspections and without the risks that aerial inspections services imply.

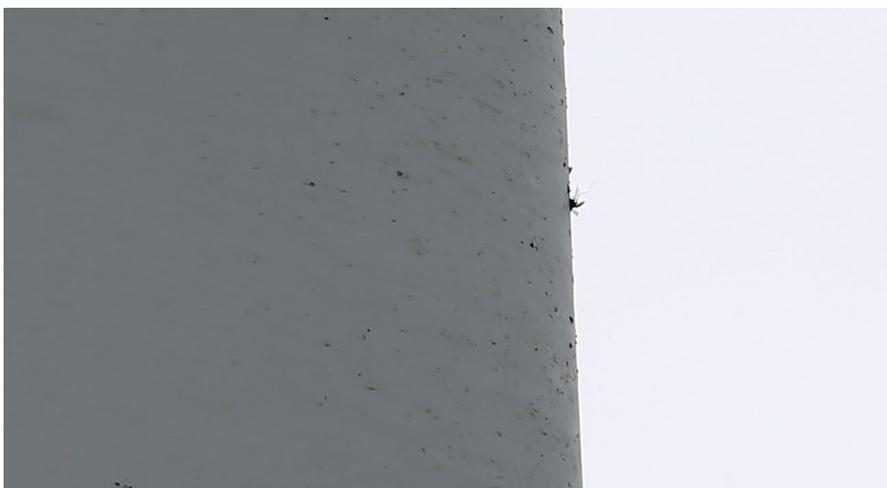
The robot weighs approximately 35 Kg, including the inspection tool and camera, and the extra rated payload for the robot is 20Kg. Therefore it can withstand a maximum weight of 55Kg whilst climbing.

Humidity in the surface doesn't prevent the traction system from working, and it can withstand water, however, images cannot be acquired under rainy conditions.

The operation centre was conceived to be portable, easy to deploy and to work with its own battery supply, not be dependent on the client's electric grid.

EOLOS is the ultimate inspection tool for wind turbine blades. The remote controlled robotic tool, is able to acquire images of the blades surfaces with unsurpassed quality, the platform is safely operated from the ground, the robot climbs the tower, where pictures are systematically taken and identified for each surface of a blade, for a total of 12 surfaces per wind turbine.

Once the images are acquired, they undergo an internal treatment process in the TSR wind offices. The files are read, the overlap, between using a cutting edge computer vision program, is adjusted to build a high-quality mosaic for each surface. Thus overcoming the problems of acquiring outdoor images, such as light variations, cloud patterns, other objects, etc.



Example of the quality of acquired images. Bug captured in the blade.



Mosaic automatically composed from 25 different images of the blade

However, high-quality images of the blades are just the tip of the iceberg, there are a lot more high-tech resources behind it, after the creation of the mosaics, TSR wind offers a personalised and protected cloud service for each client. Access is provided to the mosaics in a deep zoom environment, the user has the means to open each surface from the wind turbine and zoom in to observe in detail the status of the blade.

The client can choose between hiring their own experts or ours, in either case, the web application is accessible from anywhere in the world, with internet connection, and offers the means needed to analyse and record the damages to the blades.

There are other tools: automatic measurement of the distance from damage to the root, automatic report generation and it's possible to download mosaics, photos showing any damage and the wind farm damage summary.

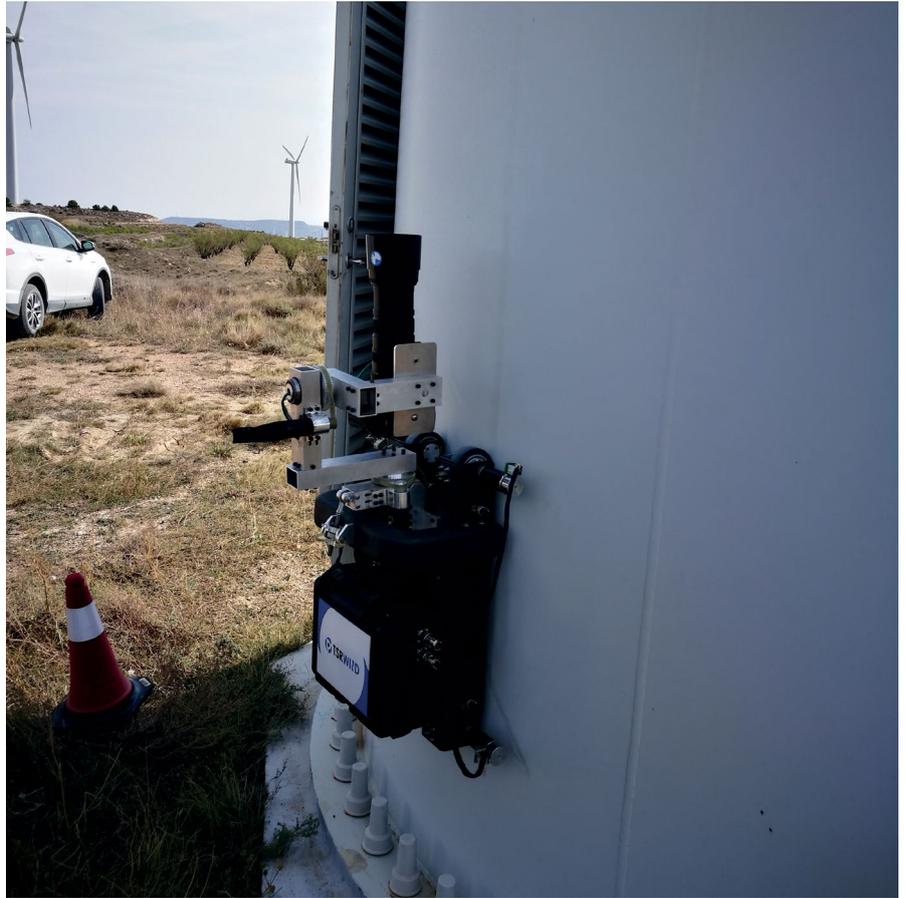
Benefits of the online system include:

The ability to track faults through time for improved decision making about maintenance, once a wind farm has repeated TSR inspections, the user can track the evolution of any damages and repairs online or with the downloadable data.

The calculation of the pixel-millimetre ratio, for the reconstruction image of the blade, in order to get a very accurate measure of the damage, repairs and any objects of interest.

A wind farm inspection summary for analysis, comparison and planning the maintenance schedule.

The typical inspection time goes from 1 to 1 and a half hours, resulting in 5 to 6 wind turbines a day, if weather conditions are favourable, dramatically shortening inspection scheduling from weeks to days, to focus on repairs and maintenance. Reconstructions are published to the



EOLOS 200 coupled to wind turbine

client's profile, in the www.tsrinspector.com web application; 3 to 4 days after receiving the images, reducing time and costs whilst augmenting the quality.

When repairs are needed, the automatically generated reports inform the client of the exact location on the blade. The detailed information also makes it easier to estimate exactly what tools and materials are needed before the engineers the climb wind

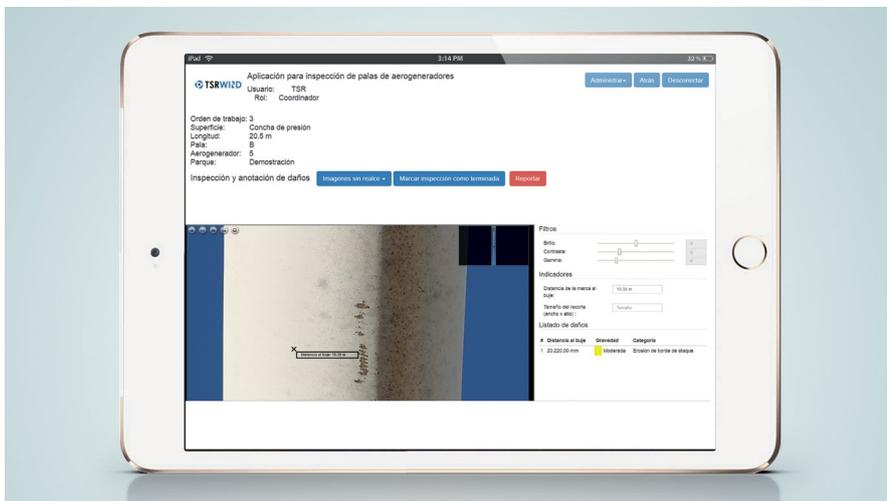
turbine. The ability to increase efficiency and to reduce the number of climbs has a beneficial effect on personnel, repair costs and safety.

'TSR started marketing the service in February with excellent results. So far, more than 250 wtg from different manufacturers between Spain, Portugal and Uruguay have been inspected and a great commercial effort is being made so that the customers get to know the company and try the service.

The feedback received is very positive and clients are very impressed with the quality of the service, which is a great point to start panning the next campaign.

In parallel TSR is continuing with the R & D. New robots are being developed to provide services, such as cleaning towers and blades, in which we aim to optimise the cleaning costs and quality, whilst avoiding the risks involved with working at height.

New services are also being developed, like UT welding inspection, inspection over moving blades. The aim of the company is to remain at the forefront of the wind sector by developing new services through R & D & I in applied robotics,' expanded Juan Rivas, TSR Wind Business Manager.



TSRinspector tool via a mobile device

www.tsrwind.com