VOLIRO

Voliro T
Wind turbine LPS inspection guide

Wind turbine lightning protection systems (LPS) can suffer damage from lightning strikes. Regular maintenance and inspections are vital to ensure the continued effectiveness of LPS in protecting wind turbines from lightning-related damage.

Advantages of Voliro's drone-enabled LPS wind turbine inspections

5x faster LPS inspections
Voliro's drone inspections typically take 20 to 30 minutes per turbine, reducing downtime and operational costs.

Effective data collection
Gather clear insights and immediate results on the turbine's LPS condition, with seamless reporting ready for integrity interpretation.

Small crew operation
A single pilot can operate the inspection workflow efficiently, with optional support from a technician if needed.

Ensure compliance
Voliro's inspection method adheres to IEC/EN 61400-24 standards, guaranteeing quality control and reliability.

Efficient LPS data collection with minimal turbine downtime

By eliminating the need for human access to difficult-to-reach areas, Voliro drones make inspections safer, faster, and data enhanced by empowering proactive wind turbine maintenance.

Voliro T inspection method

- 4-wire resistance measurement
- 1 person operation
- Single and multi rotor stop supported*
- Inspect up to 250 m (820 ft) in height
- No access to the hub or nacelle required (unless bridging for continuity is needed)

* Depending on the wind speeds the most efficient method is chosen. Learn more under “LPS Inspection Mission Variables” section.

Below: Evolution of wind turbine LPS inspections, showcasing how Voliro T’s drone technology offers a safer, faster, and more cost-effective alternative to traditional rope-access methods.

Voliro Equipment

❶ Voliro T	
Wind resistance	8 m/s / 17 mph for contact, 12m/s / 26 mph free flight
Temperature	-10 - 40 °C / 14 - 104 °F
Precipitation	Dry weather operation only; No rain, no snowfall
Fog	No operation in fog
❷ Needle probe payload	
❸ Cable management system	
Tether length	300 m / 984 ft
Grounding cable	40 m / 131 ft
❹ Ohmmeter	
Device type	Micro-Ohmmeter VG-BAT-150
Manufacturer	Mostec
Measurement method	4-wire measurement
Measurement current	0.30 A (for resistances <20 Ω)
Measurement range	0.001 Ω to 1000 Ω
Resolution	0.01 mΩ
Max. Voltage	24 V
Compliant with	IEC/EN 61400-24 standards

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Inspection Workflow

The Voliro T LPS workflow consists of 3 steps:

Step 1
Equipment setup

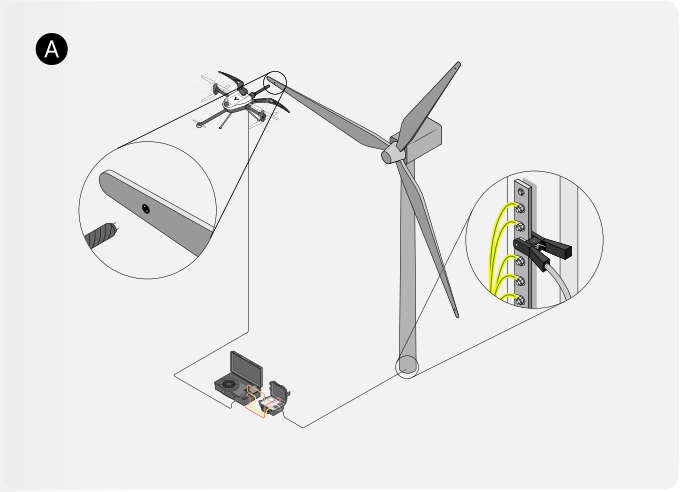
Step 2
Inspect

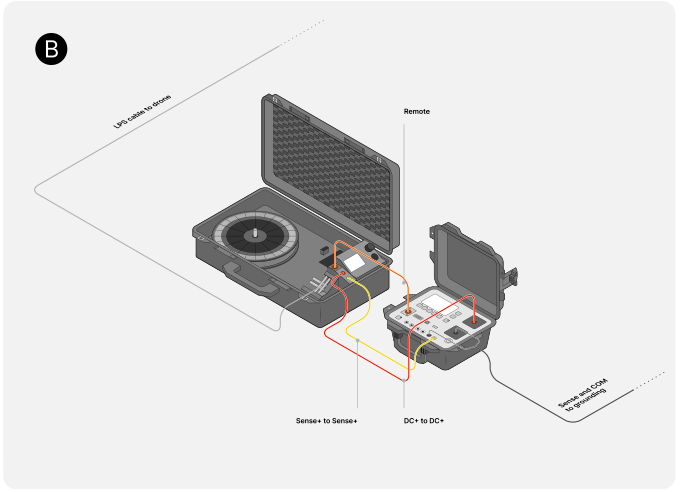
Step 3
Report

Step 1: Equipment and wind turbine setup

Equipment setup

- Place the Cable Management System (CMS) and Ohmmeter 20–30 m (65–98 ft) from the turbine tower, parallel to the rotor.
- Connect the Ohmmeter to a grounded point at the base of the turbine as seen in image A.
- Assemble the Voliro T and attach the LPS payload as well as the cable to the drone.
- Connect the CMS with the designated cables as seen in image B.
- The CMS runs on Voliro T batteries - one battery usually lasts a full day of inspections.





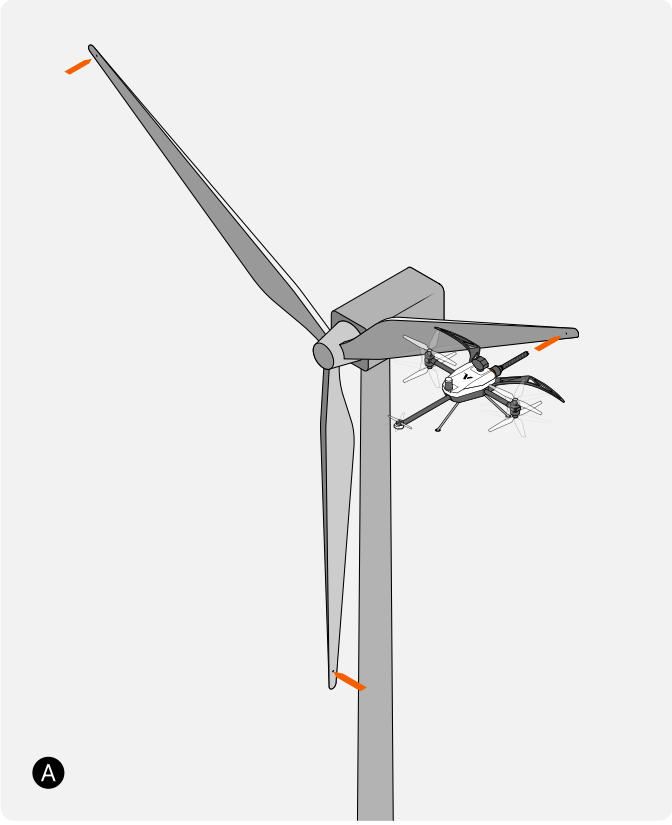
Wind turbine setup

Option A: One-stop inspection

The rotor is placed into the Y position. Blades which are not in the 6 or 12 o'clock position have to be pitched to 0°.

Option B: Three-stop inspection

Inspect each blade in the 6 o'clock position. Keep the rotor facing the wind, i.e. keep the yaw angle.



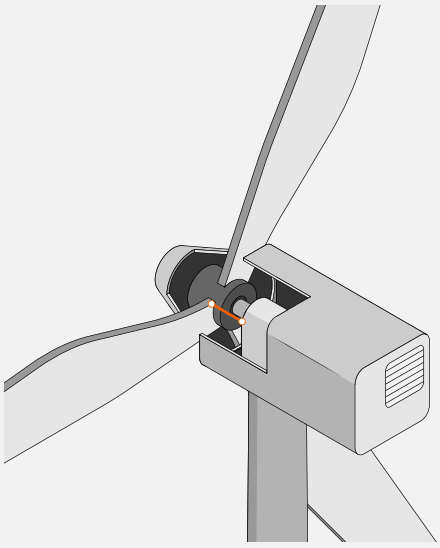
Wind turbine setup (1-stop inspection)
At low wind speeds (below 6 m/s), this method offers the fastest inspection mode. The drone is able to inspect all blades in a single flight, maximizing efficiency.

Wind turbine setup (3-stop inspection)
At higher wind speeds, this method offers a safer inspection approach. The blades are repositioned twice to always inspect the 6 o'clock blade—no blade pitching required.

Spark gap bridging

The inspection of the LPS of wind turbines using the Voliro T equipment requires continuity of the LPS from the blade to the bottom of the tower. Some wind turbines have a discontinuity of the LPS at the hub or nacelle. These can be bridged by installing a jumper cable:

- A technician needs to access the hub of the turbine
- The cable is installed between an accessible point of the LPS on the blade and an accessible point of the LPS in the hub or nacelle.
- Usually one blade is bridged at a time.
- Typically, each blade is bridged in the 6 o'clock position. If required by the turbine design, use the 3 or 9 o'clock position instead.



Step 2: Inspect

1. Contact & Inspection

- The pilot flies the drone to the blade and establishes contact with the LPS receptors, closing the electrical circuit with the wind turbine's LPS.
- This enables an electrical resistance measurement of the wind turbine's LPS.
- The Cable Management System (CMS) automatically reels the tether in and out, keeping it taut - no manual adjustments needed.

2. Flight & Alignment

- Fly in Visual Line of Sight (VLOS) until near the turbine blade.
- Switch to FPV camera for the final approach.
- Built-in sensors assist with drone alignment to the blade.
- Use the autonomous interaction mode to establish and hold contact with the blade.

3. Resistance Measurement

- Both the grounding cable and drone tether have 2 phases inside, enabling a 4-wire resistance measurement (IEC 61400-24 compliant).
- This ensures the measurement captures only the electrical resistance from the contact point on the blade to the grounding clamp at the bottom of the tower.
- A certified, third-party Ohmmeter pushes a current of 300 mA through the circuit and records the resistance.
- The resistance data is sent to the drone and stored on the on-board computer as well as redundantly on the Ohmmeter. The on-board computer links each measurement directly to the correct receptor.
- Measurements can be verified in real-time by the operator on the control tablets.

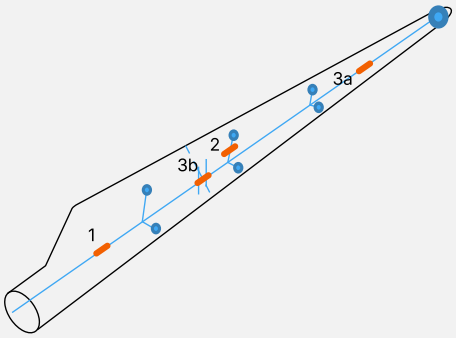
Step 3: Report

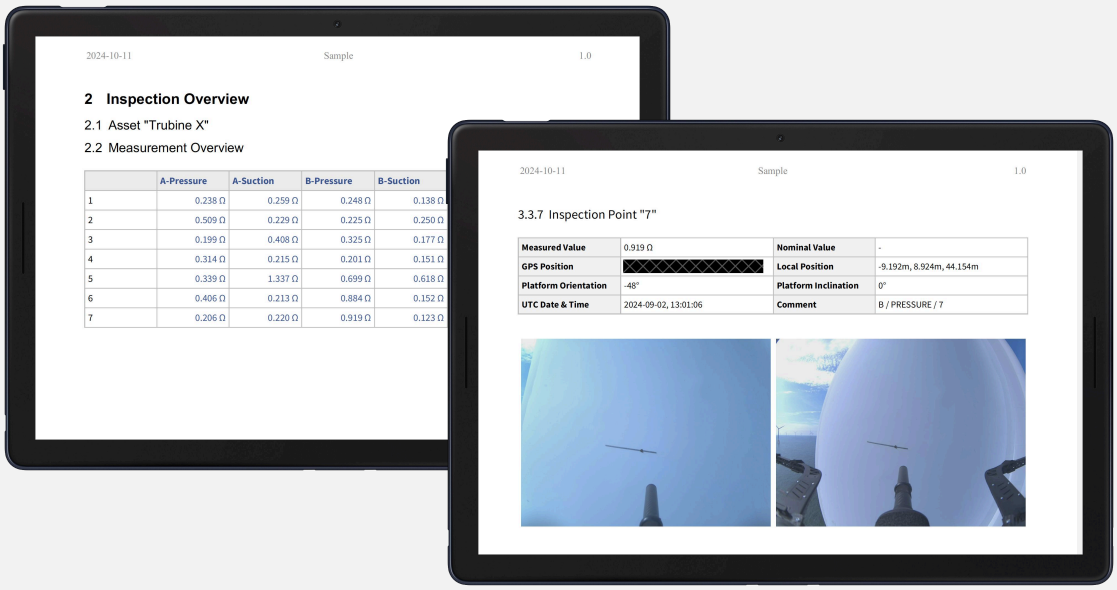
- Upload data to Voliro's reporting tool to auto-generate a PDF report including an image of every LPS receptor.
- Alternatively, export data as CSV or JSON for use in third-party tools or custom reports.

Data interpretation

Receptor measurement data provide critical insights into the integrity of the LPS system. Specific defect patterns indicate different failure modes, such as:

1. **All receptors disconnected on one blade:** Likely caused by a defect at the blade root or in the hub / nacelle.
2. **Single receptor disconnected:** Typically due to an individual receptor being disconnected or oxidation.
3. **Multiple receptors disconnected:** Damage within the down conductor, e.g. between different receptor pairs (3a) or at the connection of two separate blade parts (3b).





Preview of the auto-generated PDF inspection report. Both views are included in one single report.

LPS inspection mission variables

The following table categorizes the complexity of missions undertaken with the Voliro T drone for Lightning Protection System (LPS) inspections of wind turbines. The complexity is determined by several factors, including nacelle access requirements, wind speed, turbine location, number of receptors, and receptor type.

Mission Complexity	Low	Medium	High
Nacelle access / bridging	Not required		Bridging required
Wind speed	<5 m/s	5-8 m/s	8 m/s, gusty
Number of receptors per blade	2	4-6*	8-16*
Location	Onshore, wind farm	Onshore, individual turbines	Offshore
Receptor type	Metal tip	Standard receptor plug	Bulb, Tip winglet

* It is recommended to inspect the 2 receptors closest to the tip and only inspect the remaining receptors in case defects were found on these 2 receptors.

Mission Examples

This table provides representative mission examples from actual Voliro T operations. It is illustrative only and does not represent the full operational capacity of the technology.

Mission Complexity	Low	Medium	High
Country	United States	Austria	Germany
Turbine model	GE 2.82-127	V150-4.2	SWT-6.0-154
Nacelle access/ bridging	Not required	Not required	Bridging required
Wind speed	5 m/s	6 m/s	7-8 m/s
Numbers of receptors per blade	2	8	10
Location	Onshore, large wind farm	Onshore, small wind farms	Offshore
Receptor type	Standard receptor plug	Standard receptor plug	Standard receptor plug
Number of inspected WTGs per day	10	5	1-2

Inspected Wind Turbines Models

The following list provides an overview of wind turbine models that have been successfully inspected using the Voliro T for Lightning Protection System (LPS) assessments. However, this list is not exhaustive, and we are committed to meeting our clients' unique needs by extending our inspection services to additional turbine models upon request.

Wind Turbine Model	Manufacturer	Able to inspect	Access to nacelle needed
V90	Vestas	TRUE	TRUE
V112	Vestas	TRUE	TRUE
V117	Vestas	TRUE	TRUE
V136	Vestas	TRUE	TRUE
V150	Vestas	TRUE	TRUE
V162	Vestas	TRUE	TRUE
SWT-2.3-108	Siemens	TRUE	FALSE
SWT-2.415-108	Siemens	TRUE	FALSE
SWT-6.0-154	Siemens	TRUE	FALSE
MM100	Senvion	TRUE	FALSE
3.2 M114	Senvion	TRUE	FALSE
3.4 M114	Senvion	TRUE	FALSE
MM92	Senvion	TRUE	FALSE
6.2M 126 - Offshore	Senvion	TRUE	FALSE
N90	Nordex	TRUE	FALSE
NM52/900	NEG Micon	TRUE	FALSE
Impsa-1.5MW	IMPSA	TRUE	TRUE
GE 5.X-158	GE Wind	TRUE	FALSE
GE 1.6-100	GE Wind	TRUE	FALSE
GE 1.85	GE Wind	TRUE	FALSE
GE 2.3-116	GE Wind	TRUE	FALSE
GE 2.52-116	GE Wind	TRUE	FALSE
GE 2.75-120	GE Wind	TRUE	FALSE
GE 2.82-127	GE Wind	TRUE	FALSE
GE 3.4-140	GE Wind	TRUE	FALSE
GE 5.3-158 / GE5.5-158	GE Wind	TRUE	FALSE
GE 4.8-158	GE Wind	TRUE	FALSE
GE 5.5-158	GE Wind	TRUE	FALSE
G90	Gamesa	TRUE	FALSE
G114/2000	Gamesa	TRUE	TRUE
G132	Gamesa	TRUE	TRUE
E138	Enercon	TRUE	TRUE
E-70	Enercon	TRUE	TRUE
E-52, E-82, E-90	Enercon[1]	FALSE	TRUE

[1] On most of the older Enercon turbines it is not possible to measure the LPS continuity on the winglet receptor with a low voltage measurement. It is usually possible to measure the receptors along the blade on newer Enercon turbines.

Case Study: AssetTech

5x faster

Reduced inspection time from one day to just 30 minutes per turbine.

50% less costs

Lowered inspection expenses from approximately $1,000 per turbine to $500 per turbine.

AssetTech, a leading Brazilian inspection company specializing in wind turbine maintenance, revolutionized Lightning Protection System (LPS) inspections by adopting the Voliro T drone. This innovative technology dramatically improved efficiency and safety within Brazil's rapidly expanding wind energy sector.

By transitioning from traditional rope-access methods to drone-based inspections, AssetTech achieved a 50% reduction in inspection costs, lowering expenses from approximately $1,000 to $500 per turbine. Furthermore, the inspection time was slashed from a full day to just 30 minutes per turbine, representing a 5x acceleration. Consequently, turbine downtime was reduced by 95%, keeping turbines operational for an additional 7.5 hours, thus maximizing energy output and minimizing financial losses. The Voliro T drone eliminated the need for risky, labor-intensive manual inspections at heights exceeding 100 meters, significantly enhancing worker safety.

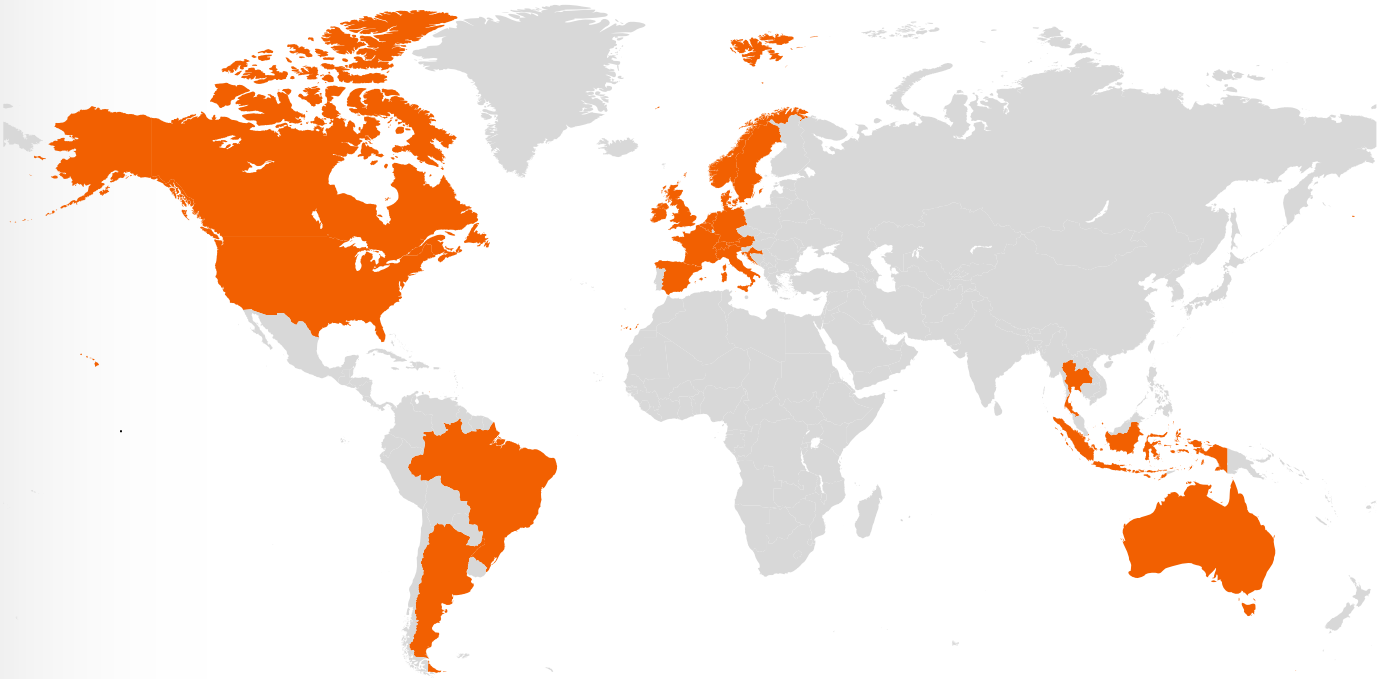
Scan to read the full case study

Trusted by leading companies

zeitview	SKYSPECS	arthwind	Clobotics
ACUREN	CALAWAY SOLUTIONS	Tidalis AERO	AssetTech
Deutsche Drohnen Inspektion	HORUS SOLUTIONS NAVIGATING FUTURE	SRG GLOBAL	AEROMEDIA
cornis	GRUPO DR1	CAPSTONE INFRASTRUCTURE	Robotics

LPS inspections are done by the Voliro T around the world

Argentina, Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, England, France, Germany, Indonesia, Ireland, Italy, Netherlands, Norway, Scotland, Spain, Sweden, Switzerland, Thailand, United States, Wales



Interested in learning more about the Voliro T? Contact us for a demo or more information:

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