# Sulzer & Schmid Laboratories AG

## Overview Presentation

Spring, 2020

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Data Capture
Drone Operations

Data Processing
Damage Annotations

3DX™
INSPECTION
PLATFORM

Data Analysis
Time Series
Benchmarks

High Quality Images

Data Exploration
Fleet Wide Reporting

# Sulzer & Schmid Mission – Enabling Unprecedented Transparency of Blade Health

- Incorporated and headquartered in Switzerland
- Founded in 2016 and privately funded
- Highly qualified team of software developers and hardware specialists

| **Tom Sulzer** | **Christof Schmid** | **Rea Meisinger** | **Ulrich Moor** | **Stefan Zeiger** |
|---|---|---|---|---|
| CEO Co-Founder | COO Co-Founder | CFO & Investor Relations | VP Business Development | CTO Software Architect |
| Serial entrepreneur | Serial entrepreneur | 6yrs+ experience | 10yrs+ experience | 15yrs+ experience |

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# Sulzer & Schmid Track Record -
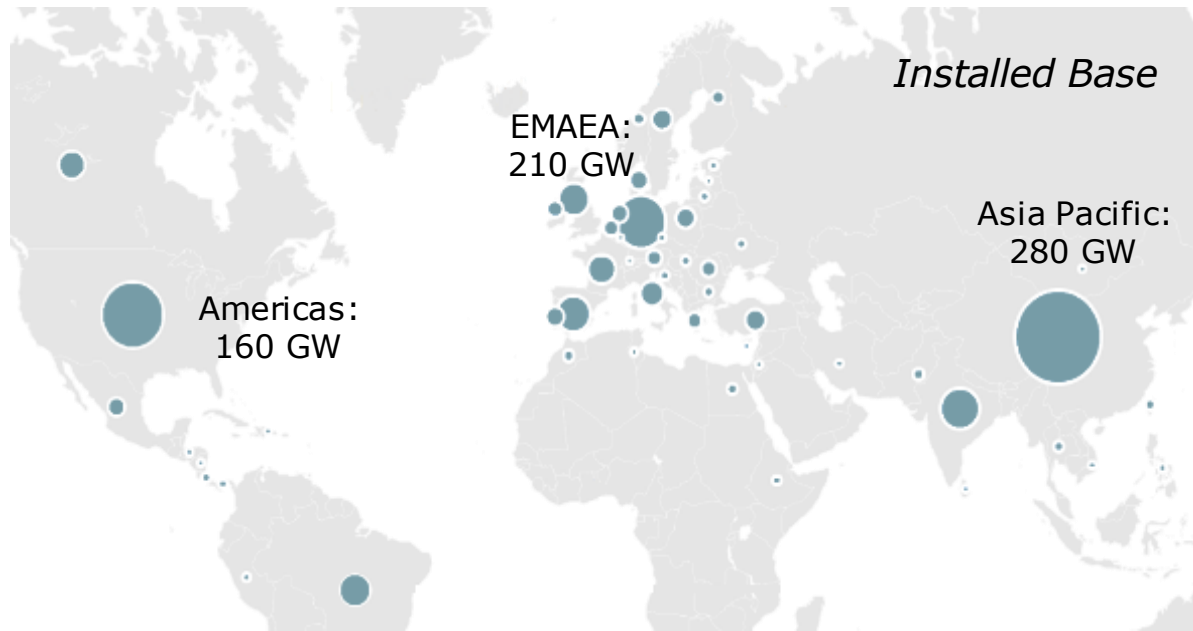# More Than 5'000 Inspections Carried Out Across four Continents
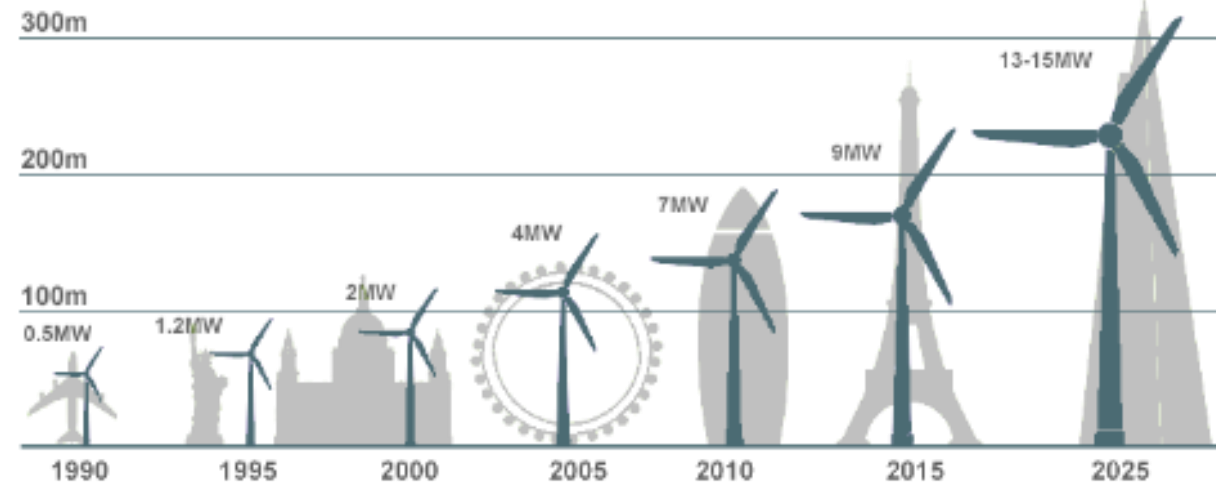
**Global Coverage**
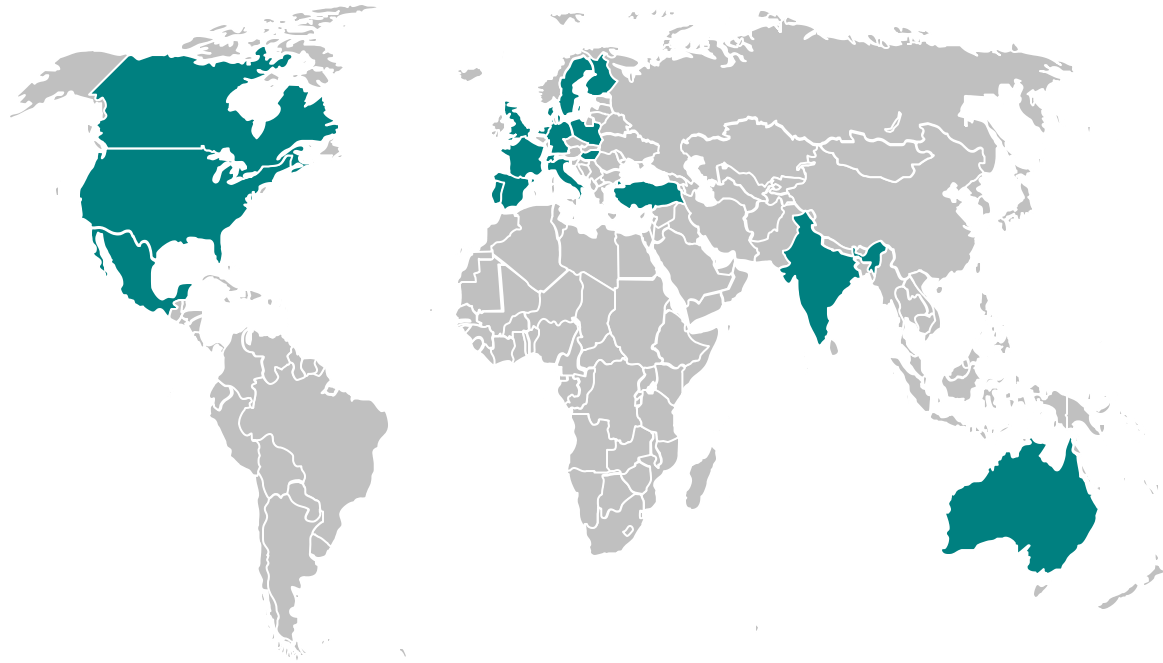


- Close to 5'000 inspections worldwide
- Customers include OEMs, large wind asset operators and energy companies
- Growing network of partnerships for global coverage
- 3DX™ Blade Health Platform for ultimate transparency

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# 1'000'000 Rotor Blades Need to be Inspected Worldwide

## Wind Power is to Double within next 10 Years

*Installed Base*

EMAEA:
210 GW

Asia Pacific:
280 GW

Americas:
160 GW

## Rising Challenge for Inspections and Repairs

300m

200m

100m

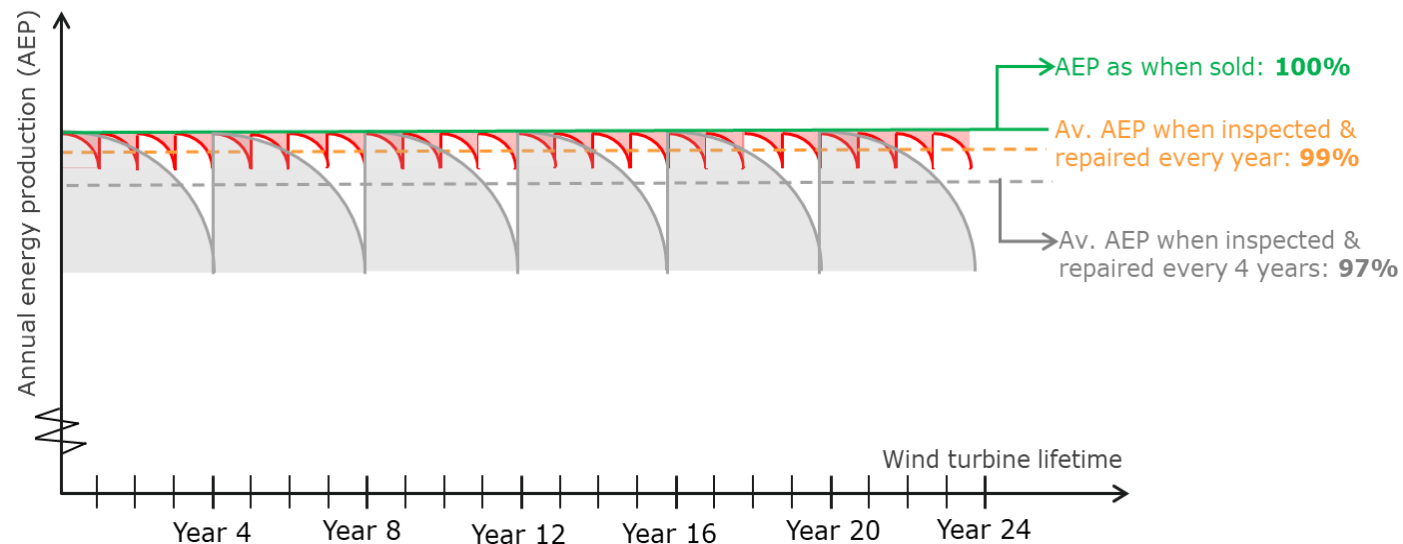0.5MW 1.2MW 2MW 4MW 7MW 9MW 13-15MW

1990 1995 2000 2005 2010 2015 2025

source: GWEC

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# Why Inspect Rotor Blades

- Optimize AEP

- Reduce unplanned repair work

- Increase asset availability

- Minimize O&M cost

- Reduce risk of asset failure

**Reduced loss of power production with ongoing repair work**



AEP as when sold: **100%**

Av. AEP when inspected & repaired every year: **99%**

Av. AEP when inspected & repaired every 4 years: **97%**

Annual energy production (AEP)

Wind turbine lifetime

Year 4   Year 8   Year 12   Year 16   Year 20   Year 24

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# 3DX™ – the Platform for Rotor Blade Inspections 4.0

**Workflow / Data Flow**



## 3DX™ Data Capture

## 3DX™ Blade Health Platform

**High Quality Images**

**Damage Annotations**

**Knowledge**

**Drone Operations**

**Data Processing**
Inspection Reports

**Data Exploration**
Fleet Analysis
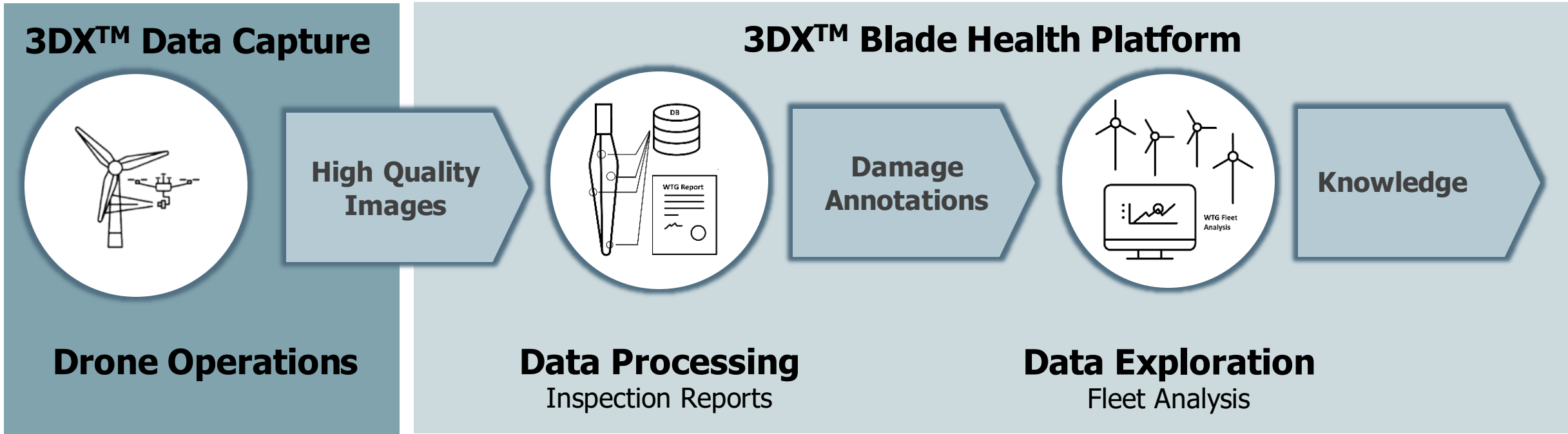
**Benefits:**

- High Quality
- Strong Economics

- Efficiency
- All Digital
- Safety

- Track Damage Progression
- Full Transparency on Blade Condition
- Data Vault for Predictive Maintenance

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# Meaningful Inspections Start With High Quality Data

- Repeatable results, uniform hi-definition data

- High degree of automation

- 100% blade coverage

- All digital

- Globally deployable, scalable

- Cost-effective & safe

## Data Capture

Sulzer Schmid offers **autonomous drone inspections**, however our 3DX Inspection platform is open and can process data from 3rd party sources such as **automated ground inspection** as well

# High Quality Image Capture: An Investment Into The Future

## The New World of Rotor Blade Inspection:

- Inspections serve as basis to manage repair campaigns
- Damage progression analysis will unlock new O&M optimization opportunities
- Data capture is an investment into data that will be used for many years

## Guidelines for Image Capture:

- Clearly defined image resolution (better than 1 pixel/mm)
- 4 Paths (orthogonal or angular) 15-30+ images per path
- Repeatable process: Best achieved with autonomous drones or mechanized ground inspection (motorized camera with high power lens)

- Collect accurate meta data for:
  - Camera location
  - View angles
  - Observation distance

**Data Capture**

Orthogonal: SS, TE, LE, PS

Angular: TE-SS, LE-SS, TE-PS, LE-PS

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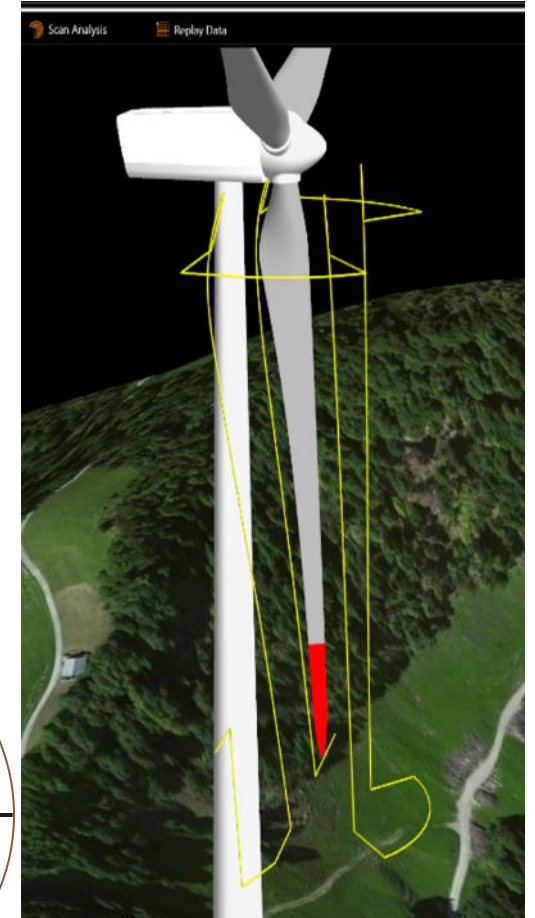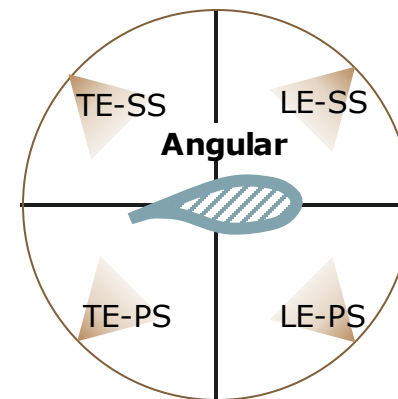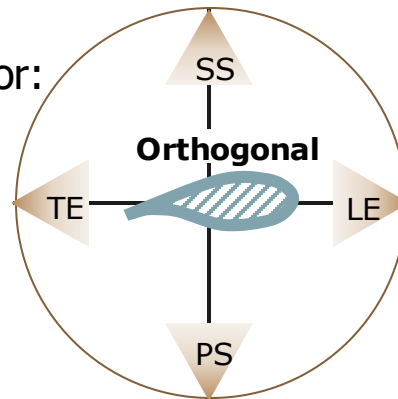
# Large Data Volumes Are Challenging To Process

**Data Processing**
Inspection Reports



5 million Images

500'000 Images

50'000 Images

500+ Images

5 GB

500 GB

5 TB

50 TB

1 WTG

100 WTG

1'000 WTG

10'000 WTG
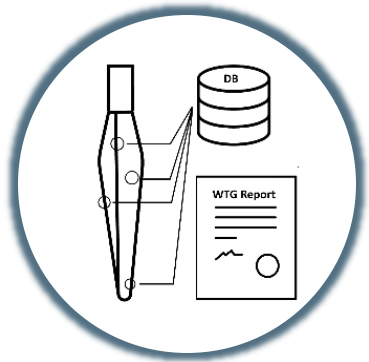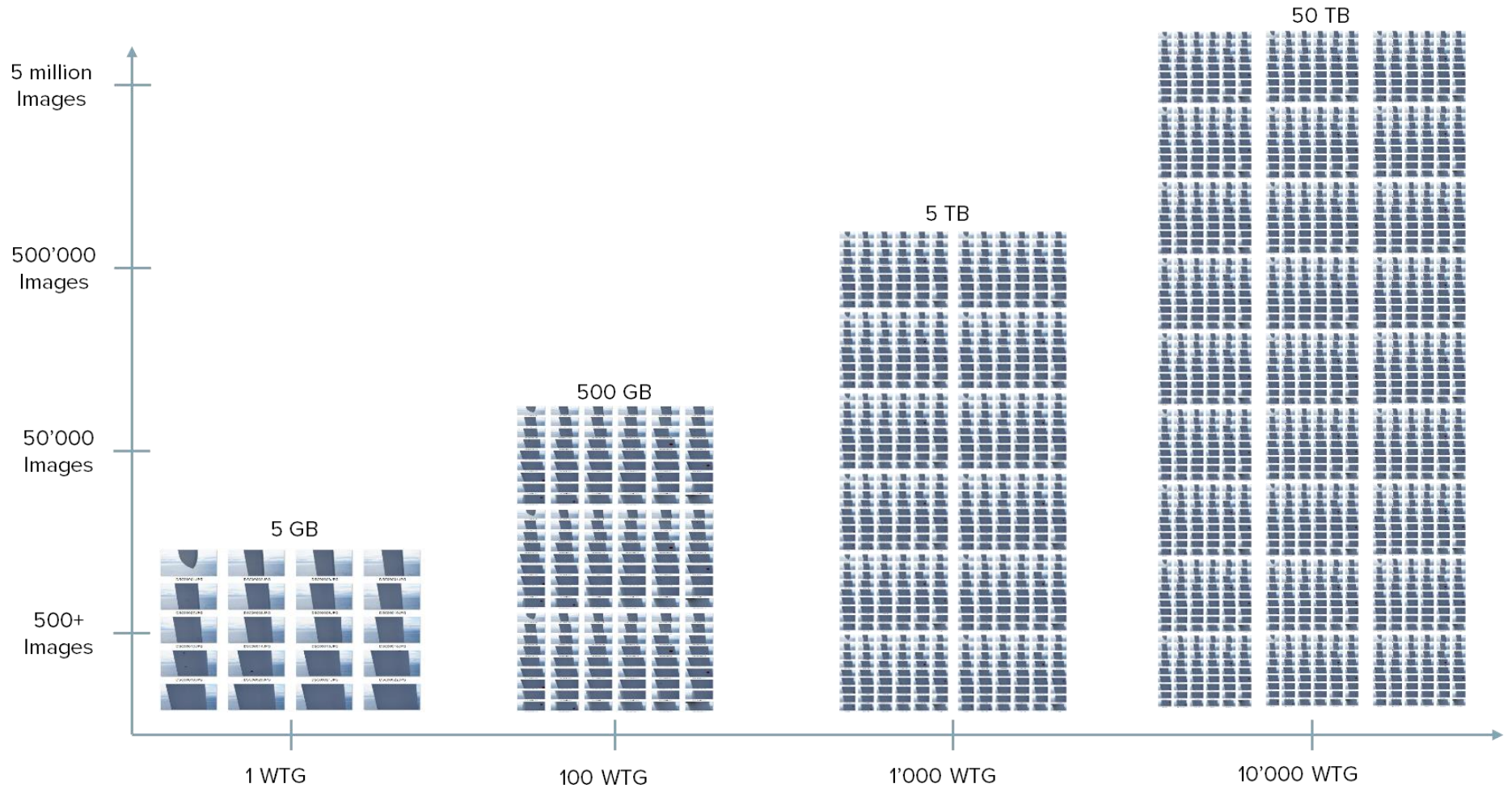
# Efficient Annotations via AI Support



**Data Processing**
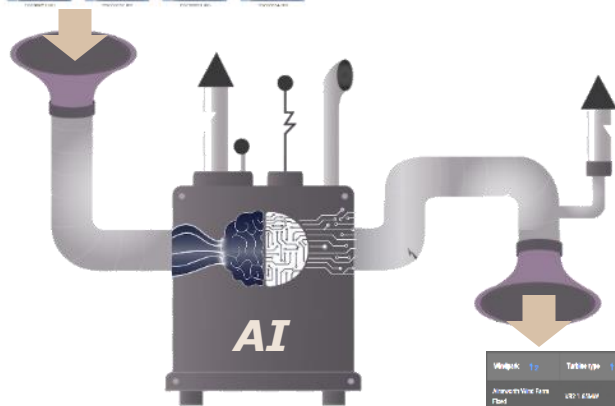Inspection Reports

**Step 1:**
**Areas of Concern**

**AI Engine**

**Step 2:**
**Annotation**
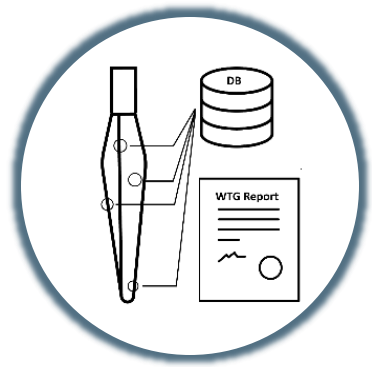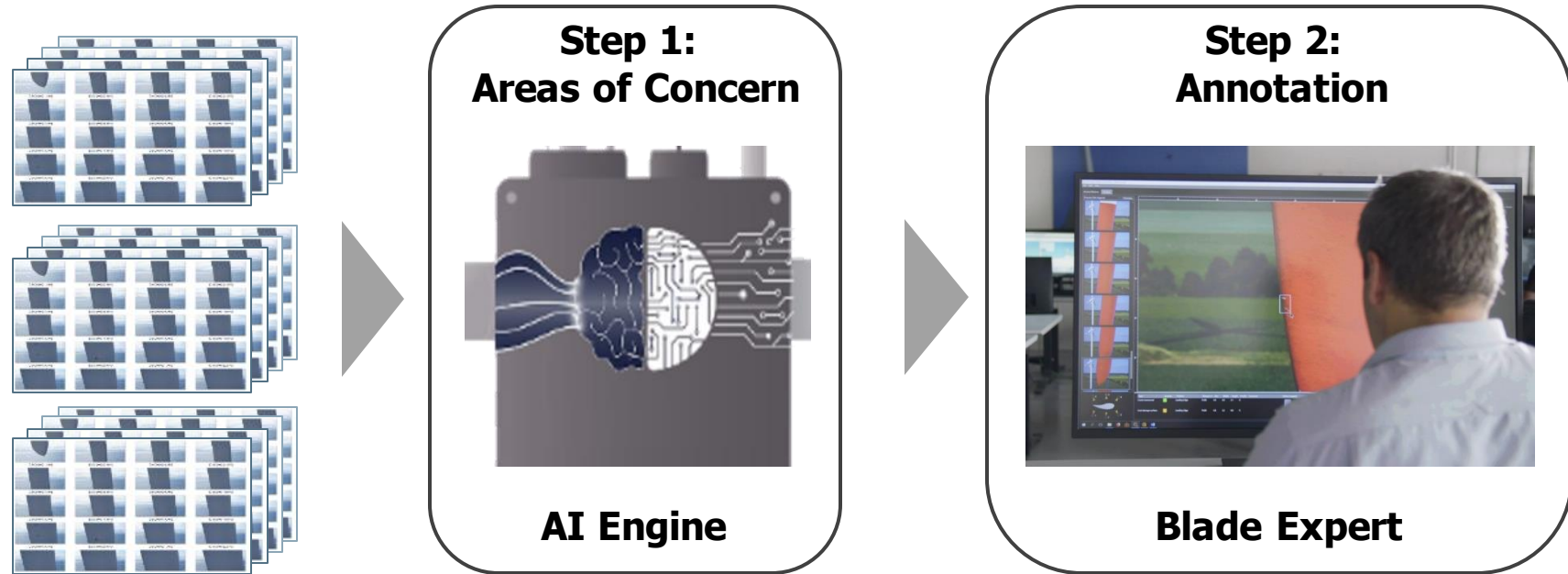
**Blade Expert**

- Use AI for laborious pre-annotation (8-10 minutes of GPU processing time per WTG)
- Final annotation and quality assurance by blade experts (Blade Station)
- All annotations are in machine-readable form (cloud database)
- Blade expert time is **15-20 minutes per WTG**

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# Uniform Data for Reliable AI Results
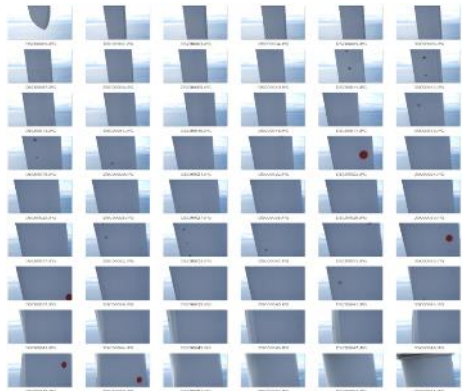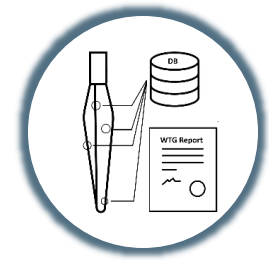
**Input:**
Uniform, high quality images and accurate, informative meta data.
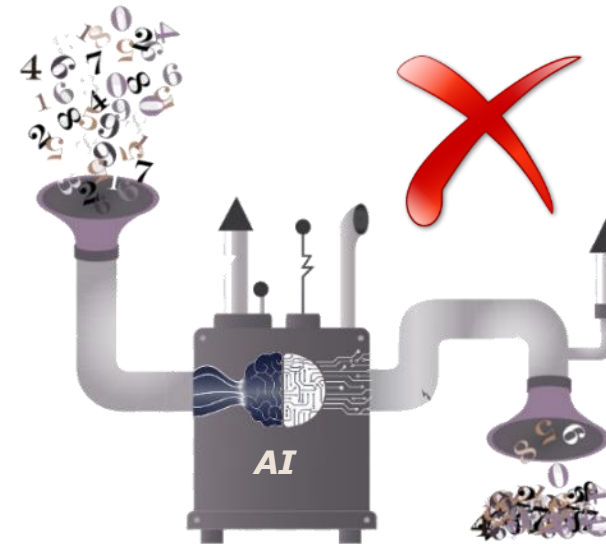
AI cannot fix poor data!
GIGO: Garbage In, Garbage Out

**Output:**
Reliable damage detection with information about location and size.
Each finding is served with a confidence index.
Expert can review and fine-tune results

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**Data Exploration**
Fleet Analysis

# Drill-downs - Annualized Statistics[1]

**Wind Park A**

Pie chart legend:
- Coat damage surface — 51%
- Erosion — 35%
- Cracks diagonal — 3%
- Cracks longitudinal — 3%
- Cracks transversal — 2%
- Lightning damage — 4%
- Open LE/TE — 1%

Class 4 and 5 Defects

- Lightning Strikes (Park A)
- Lightning Strikes (Park B)
- Lightning Strikes, Cracks (Park C)
- Lightning Strikes, Laminate (Park D)
- Lightning Strikes (Park E)
- Cracks (Park F)
- Lightning Strikes (Park G)
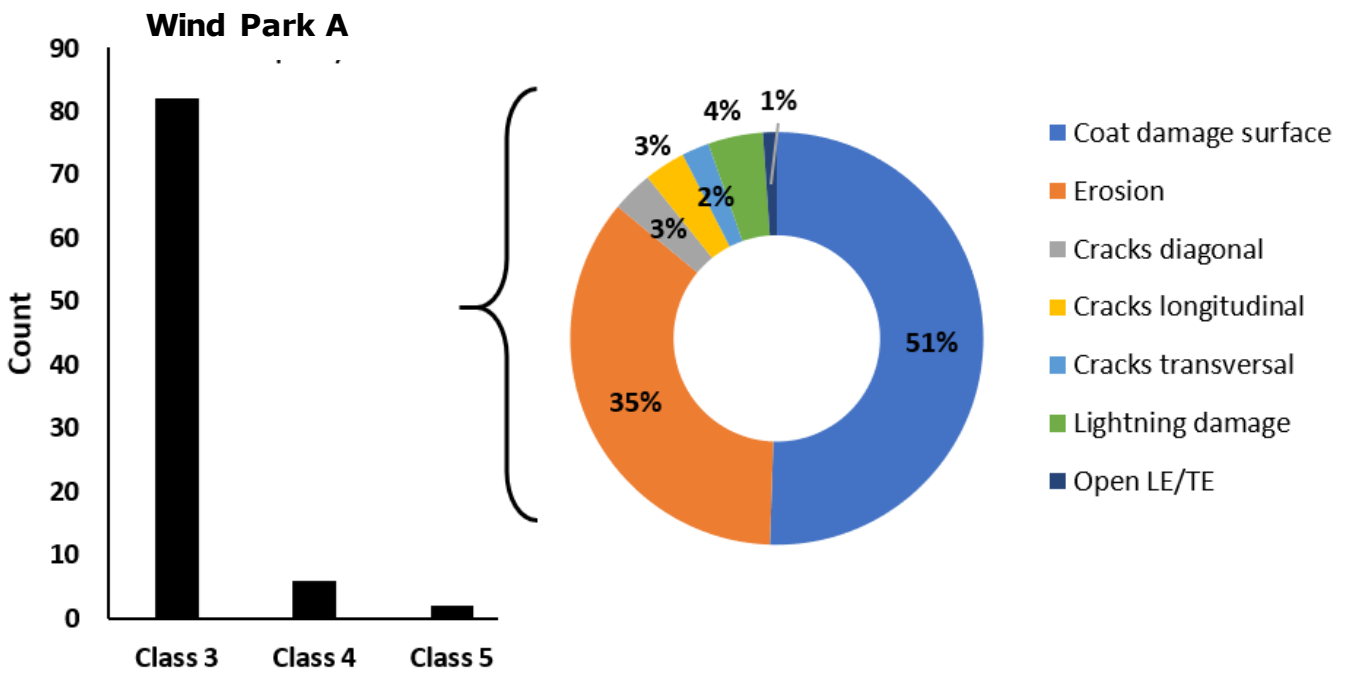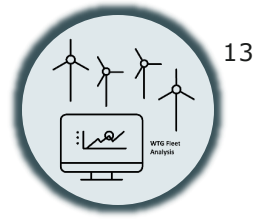
- All Class 5 are longitudinal cracks
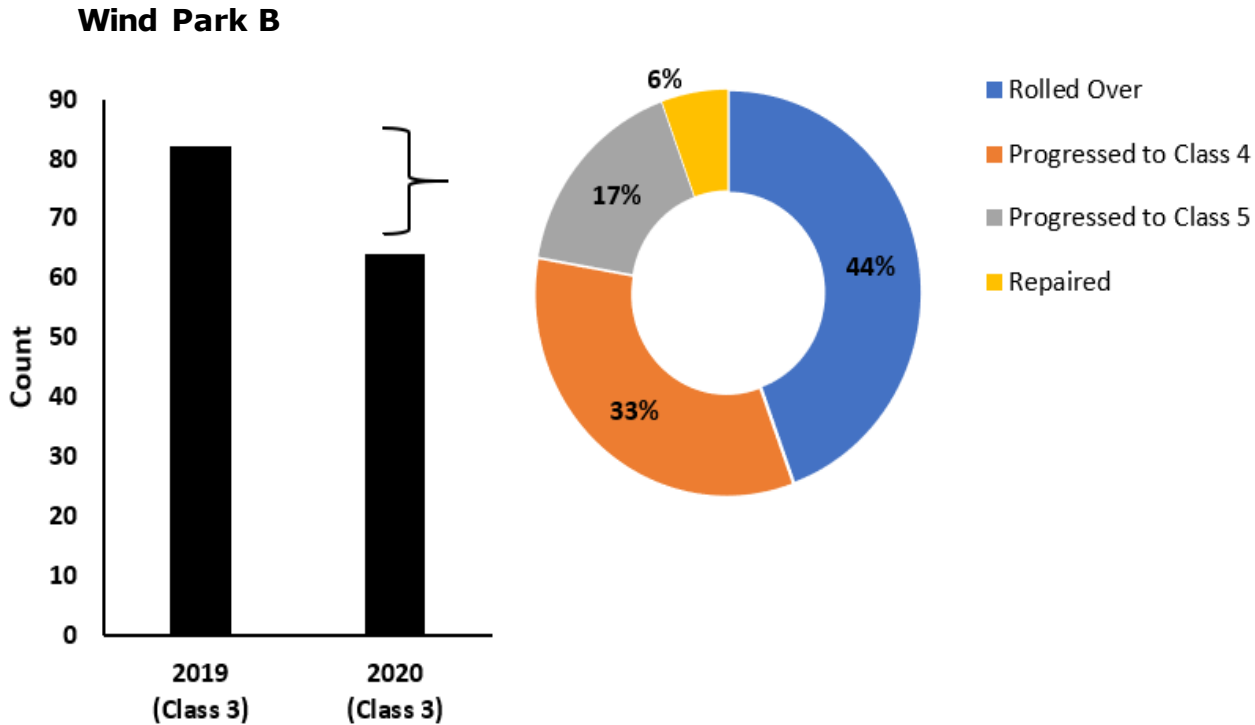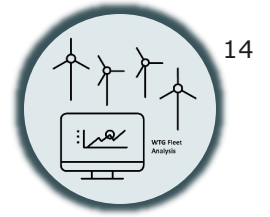- Coat and laminate damage are the most common issues

1) under development
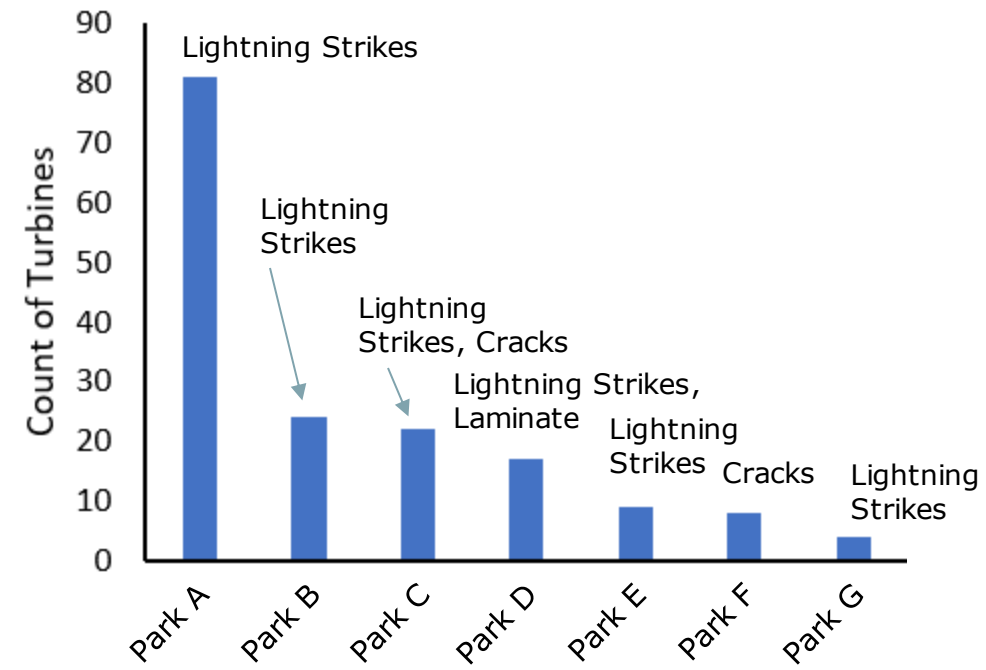
- Lightning Strike is the most common Class 4/5 issue
- Park A recorded the most instances, likely because of location
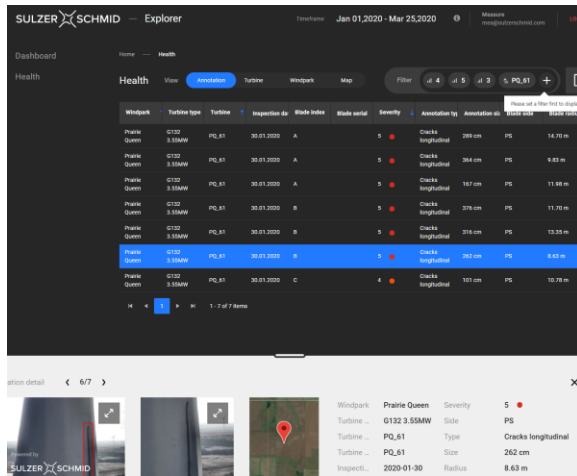
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# Damage Progression Analytics[1]

**Wind Park B**



Legend:
- Rolled Over
- Progressed to Class 4
- Progressed to Class 5
- Repaired

Pie chart values: 44%, 33%, 17%, 6%



- Majority of Class 3 were LE issues
- 50% of Class 3 defects progressed to Class 4 and 5

1) under development
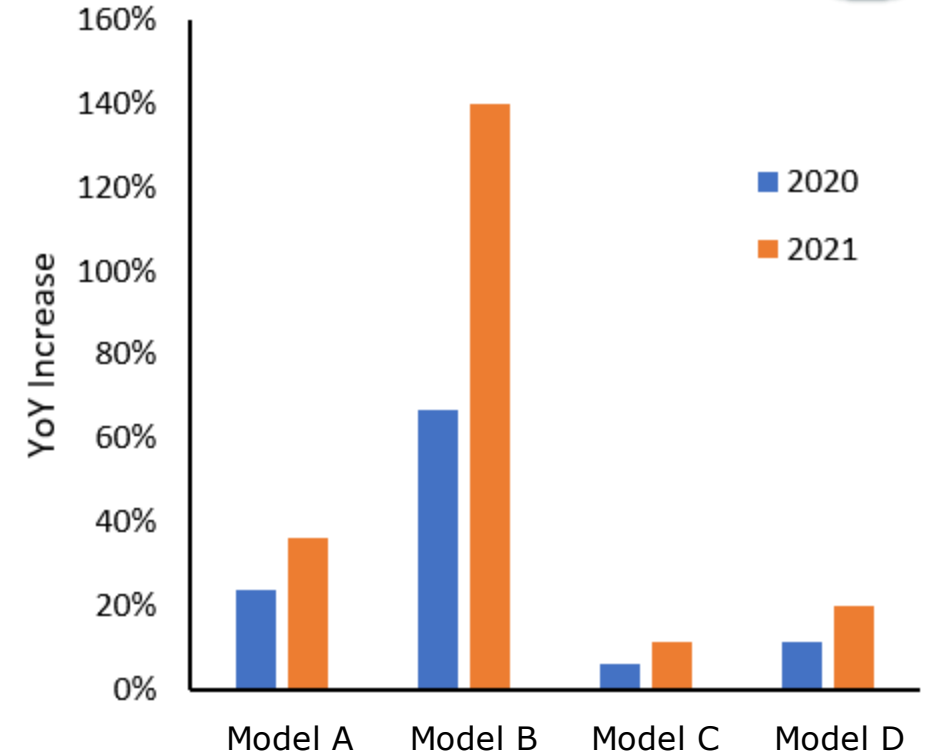
- With ageing turbines, Model B shows the fastest degradation of blades
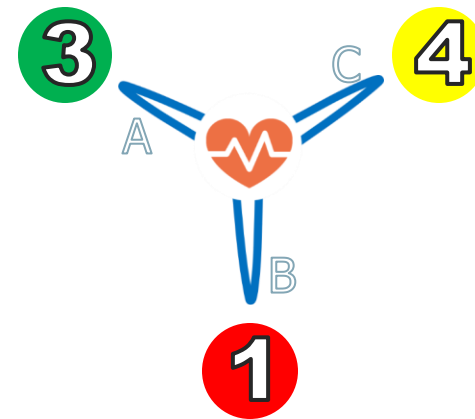- Model C seems most resistant to degradation under similar ambient conditions

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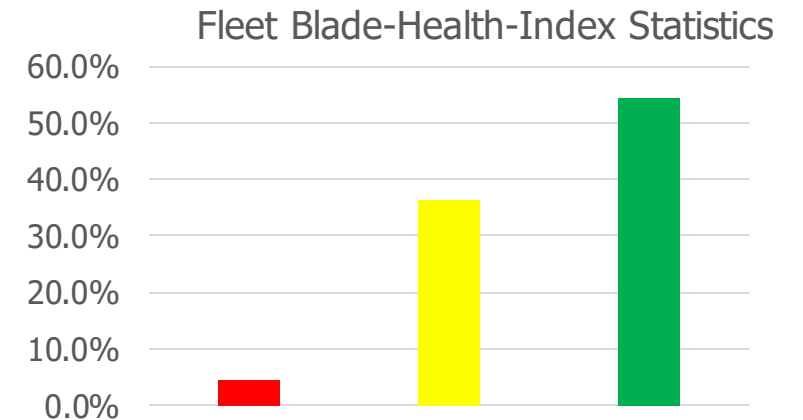
# From Individual Annotations to Feet-Wide Blade Health[1]



**Damage Annotations**

**WTG Blade Health Index (BHI)**

Fleet Blade-Health-Index Statistics
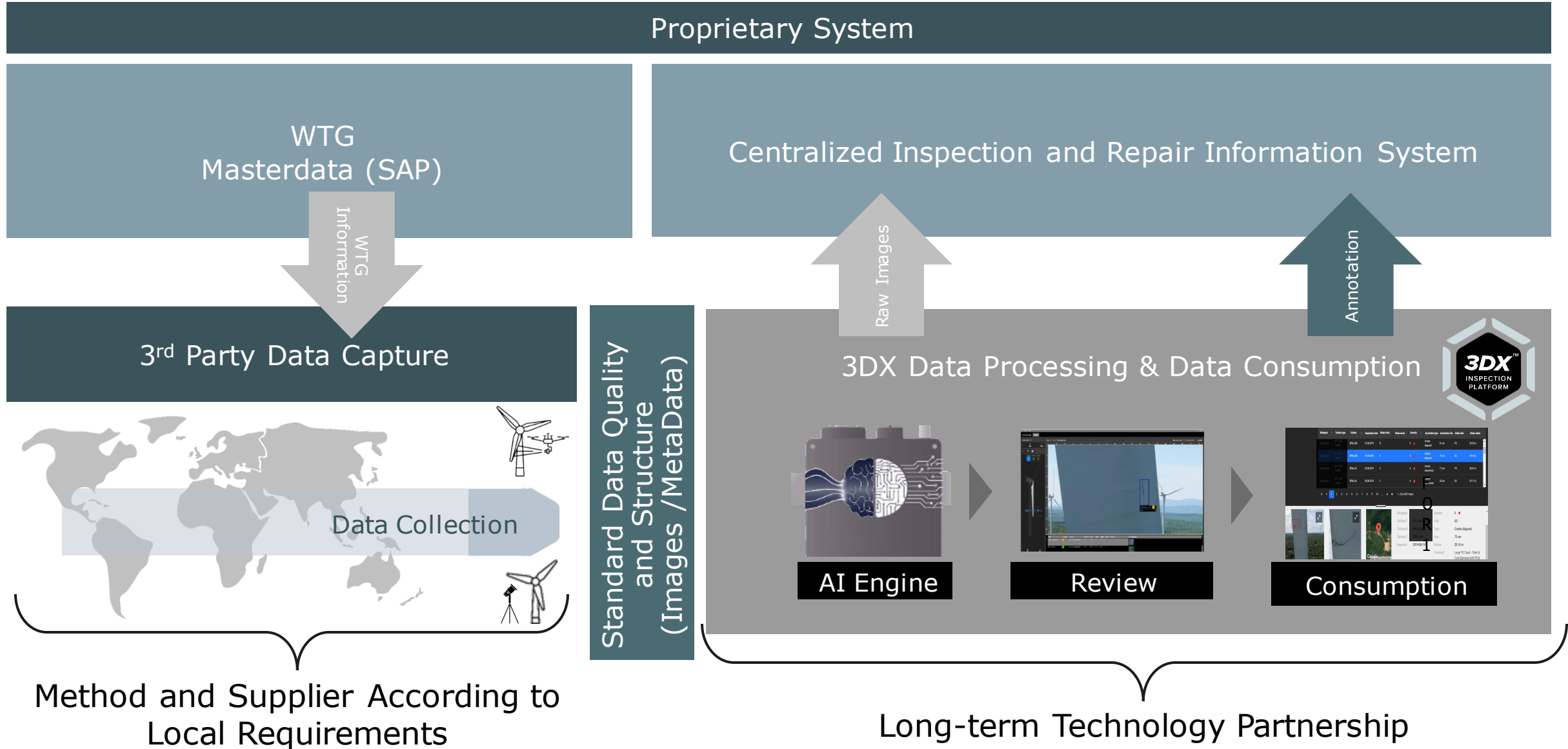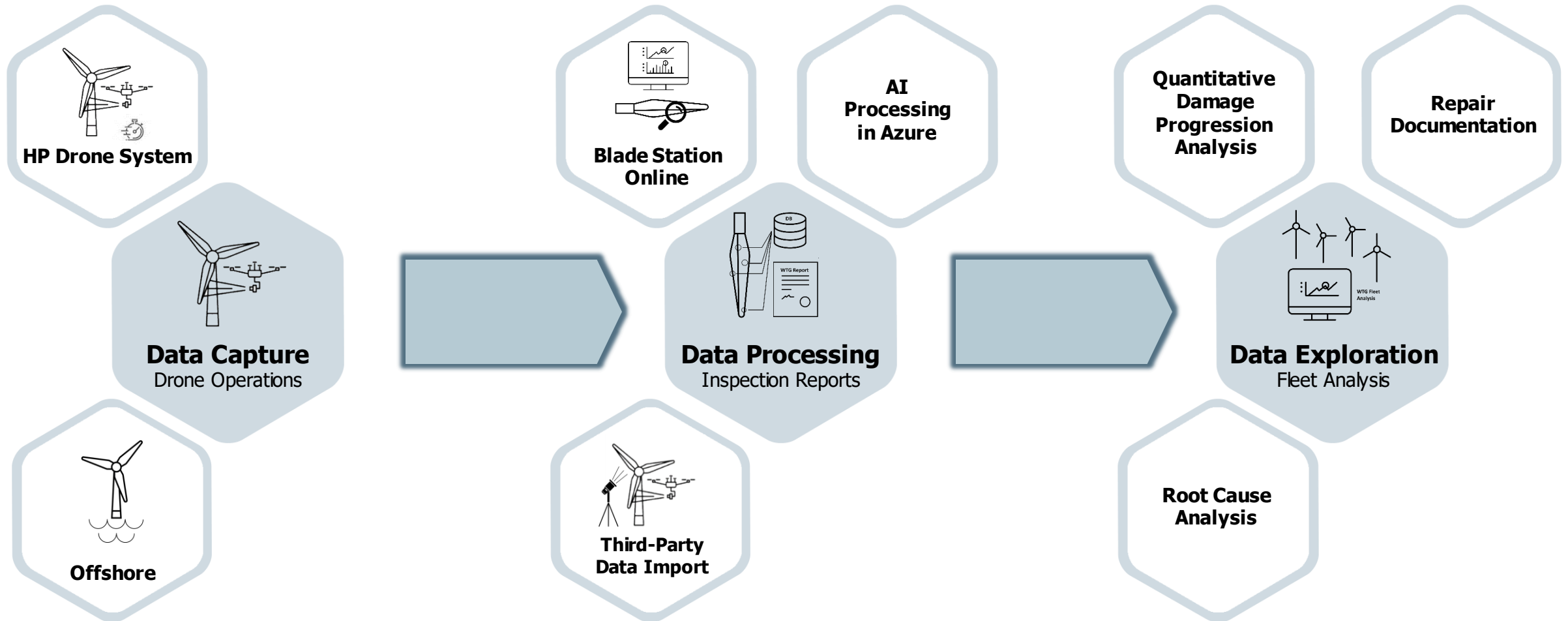
**Fleet-wide Blade Health**

- BHI is computed based on the quantifiable condition of the blade (collection of damages)
- Each defect that goes into BHI computation is characterized by type, location, size and severity
- BHI algorithm encapsulates the knowledge of leading blade experts
- BHI correlates with the expected maintenance and repair cost

1) future concept

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# Sulzer & Schmid Integration in Customer System Environment

**Proprietary System**

**WTG Masterdata (SAP)**

**Centralized Inspection and Repair Information System**

WTG Information

**3rd Party Data Capture**

Raw Images

Annotation

**3DX Data Processing & Data Consumption**

3DX INSPECTION PLATFORM

Standard Data Quality and Structure (Images /MetaData)

Data Collection

AI Engine → Review → Consumption

**Method and Supplier According to Local Requirements**

**Long-term Technology Partnership**

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# Technology Roadmap of Sulzer & Schmid

**HP Drone System**

**Blade Station Online**

**AI Processing in Azure**

**Quantitative Damage Progression Analysis**

**Repair Documentation**

**Data Capture**
Drone Operations

**Data Processing**
Inspection Reports

**Data Exploration**
Fleet Analysis
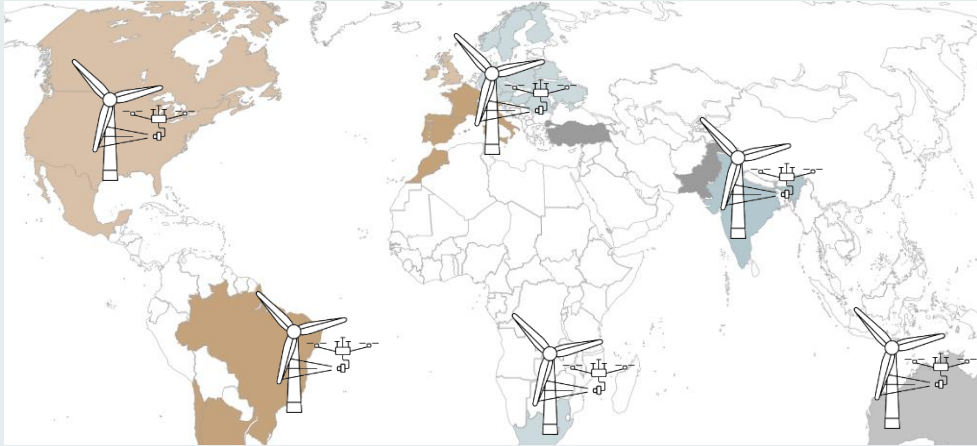
**Offshore**

**Third-Party Data Import**

**Root Cause Analysis**

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# 3DX™ Partner Network

## 3DX™ Field Operator Network



- ➤ 3DX™ Drone operations can be carried out by customer staff or by independent service providers (Sulzer & Schmid Field Operation Partner Network)

- ➤ Customers can choose who they want to use for drone operations in different territories

- ➤ Drone operators are trained and supported by Sulzer & Schmid

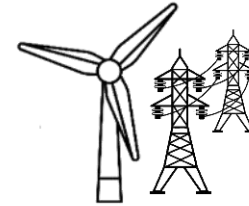## 3DX™ Blade Expert Network



3DX™ Cloud          Blade Experts
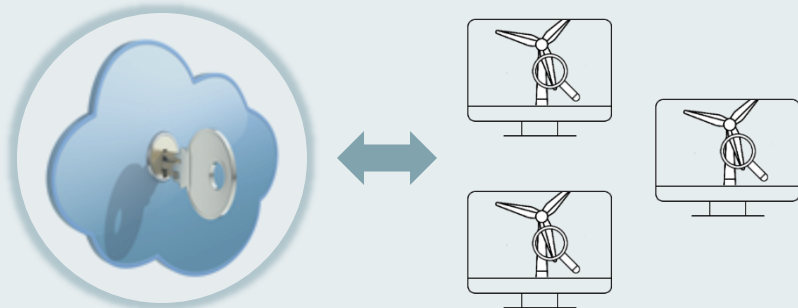
- ➤ Blade experts can annotate and review damages from anywhere in the world

- ➤ Customers can use their own blade experts or outsource to independent blade experts (Sulzer & Schmid Blade Expert Partner Network)

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# Customer Universe
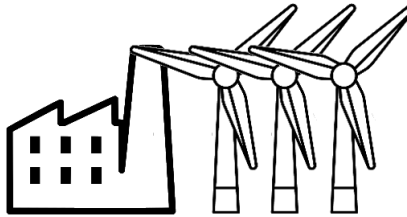
**OEM's**
- ➢ High volume campaigns
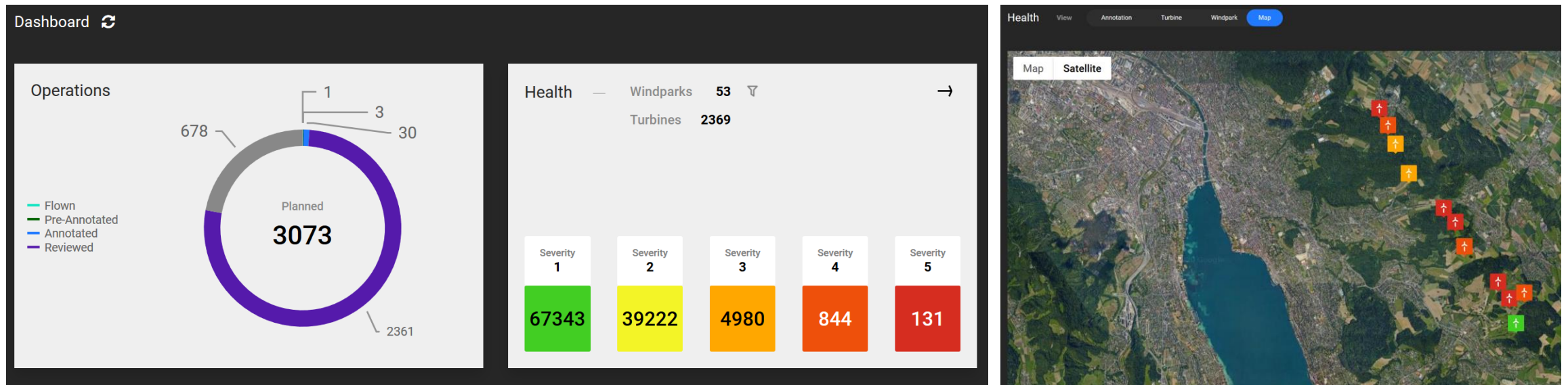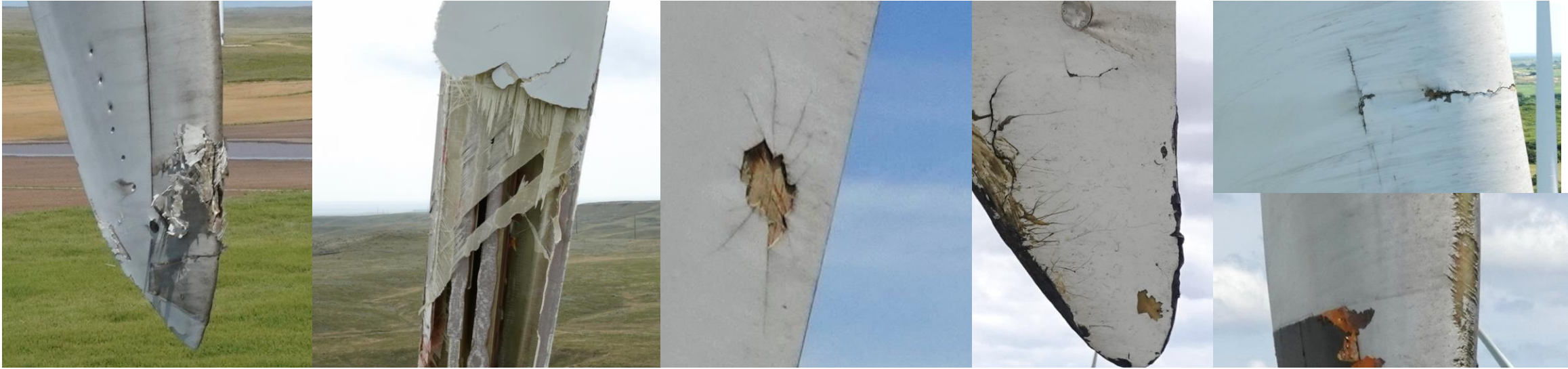- ➢ Annual inspections
- ➢ Very high efficiency

**Operators**
- ➢ Multi-national operations
- ➢ Different types of inspections
- ➢ High efficiency

➢ Sulzer & Schmid is serving OEM's and operators

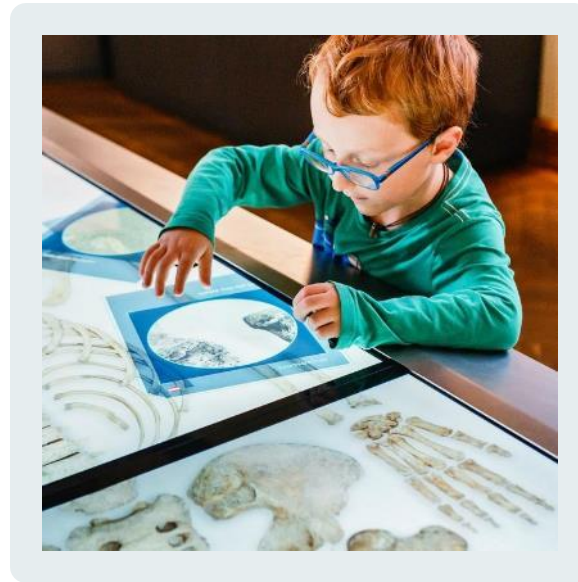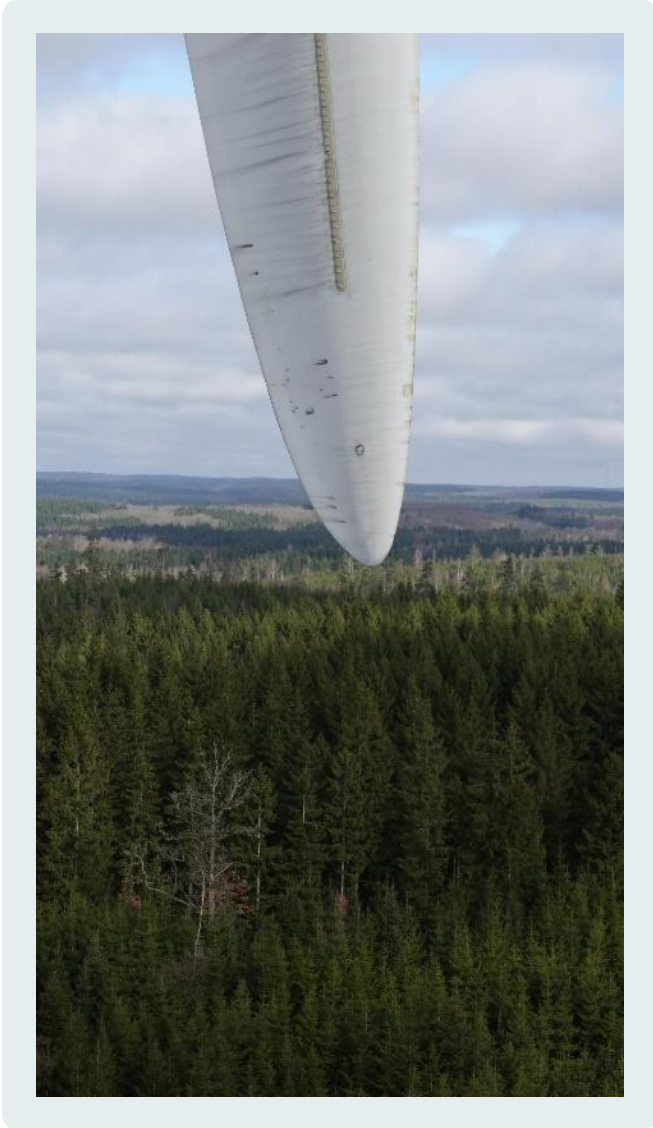➢ Our customers have a global footprint with very large fleets

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# Thank You!

# Annex

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# Appendix

## Automated Intelligent Blade Inspection
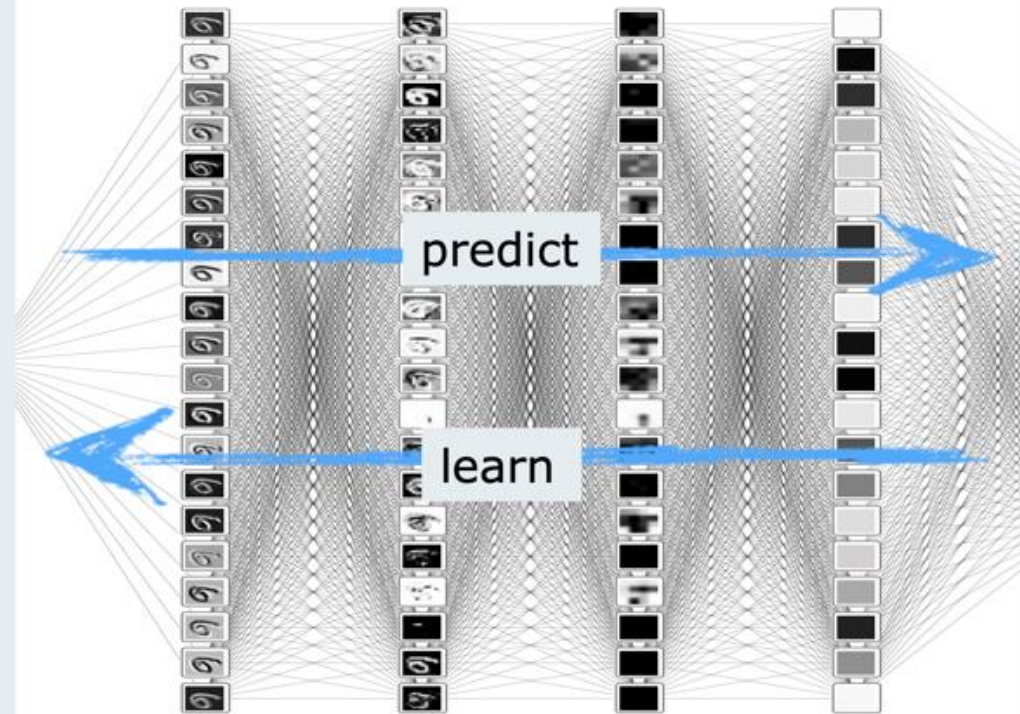
by

# Supervised Damage Detection

How do we find the underlying function used by human annotators?

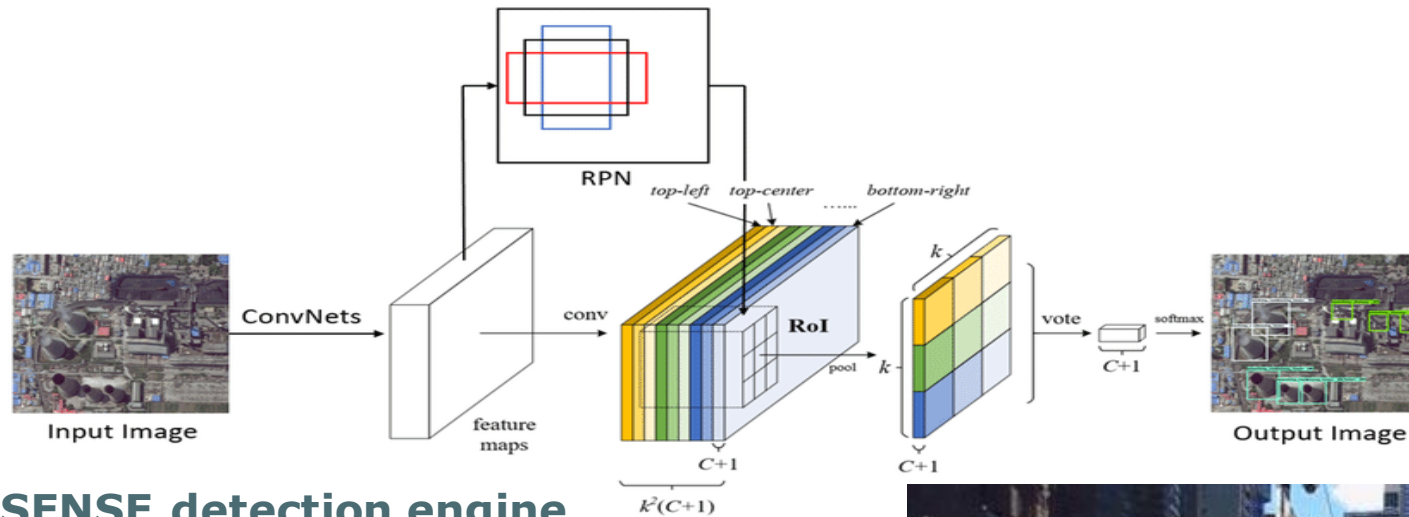SULZER SCHMID

# Supervised Damage Detection



Use existing human annotations to train deep network

predict

learn

**From data to knowledge**

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# AI-Approach of Nnaisense

➤ Customize **NNAISENSE detection engine** with:

- loss function to cope with noisy and missing labels
- identify correct scaling of detection layers

➤ **Recursive merging strategy**: to minimize false positives and provide more useful detections to the blade expert

➤ New **data augmentation** technique to simulate different environment conditions specific to the wind turbine domain for enhanced generalization

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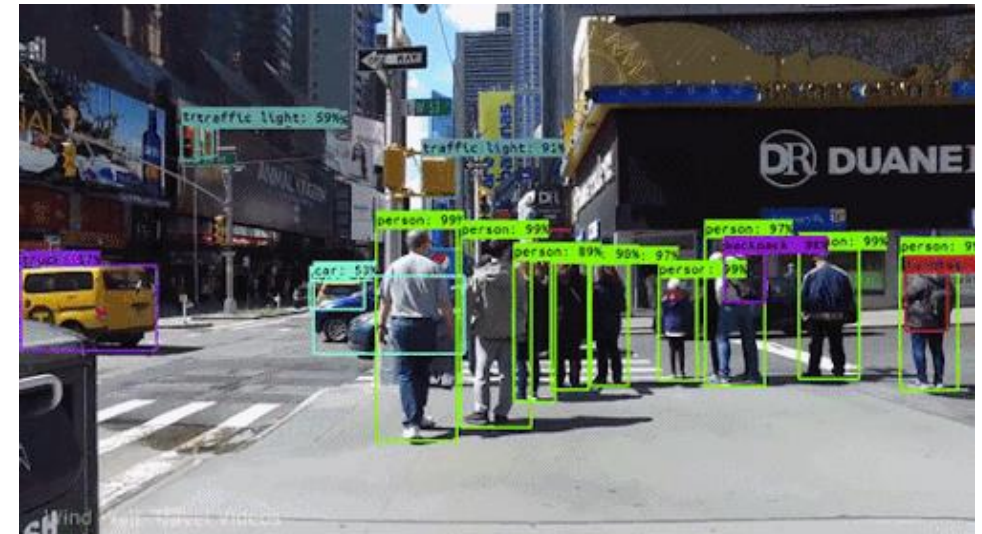
# Further Development of the AI-engine
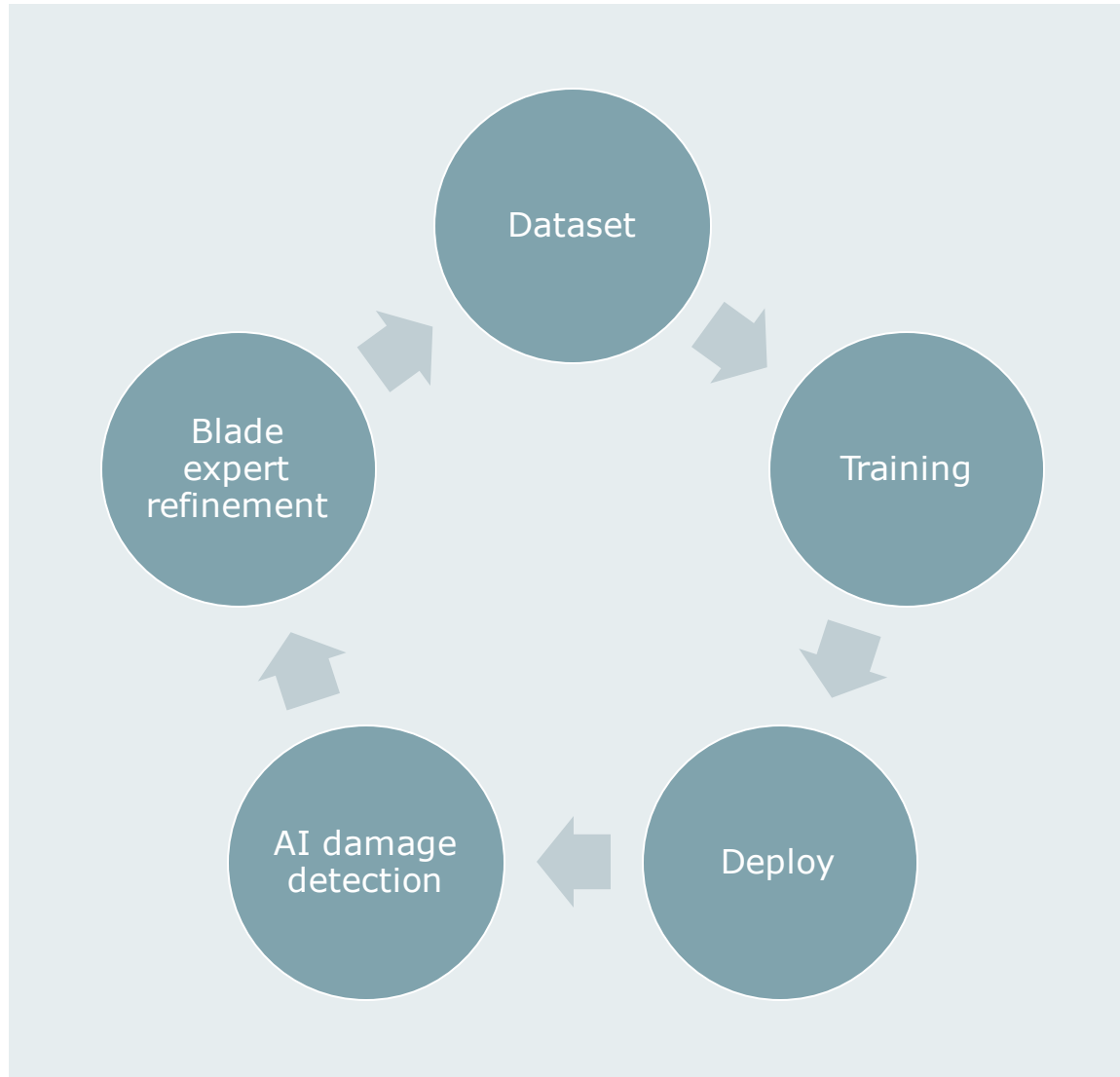


- ➢ Positive feedback loop that continually improves training data at scale, delivering better performance

- ➢ Improved AI detection frees expert to focus on edge cases

- ➢ …in turn, model trains on more "hard" examples to improve further

- ➢ …in turn, blade expert workload further reduced by better annotations, and so on…

- ➢ Leads to unprecedented data quality in the sector with minimal production overhead

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