KNIME for asset management: Automating steel loss detection with image processing and data apps

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Speakers

Frank Maio

- Manager Asset Information @ElectraNet
- Utilities Technology background
- Using KNIME since 2022

Jerome Treboux

- Senior Consultant @Forest Grove
- Ph.D. in Computer Science (Data Science)
- Using KNIME since 2011

Outline

Introduction

- ElectraNet and Forest Grove Technology
- Business Case Presentation

Steel Loss Detection and Measurement

- Machine Learning
- Project Presentation
- Outcomes

Conclusion and Q&A

Introduction

- ElectraNet and Forest Grove Technology
- Business Case Presentation

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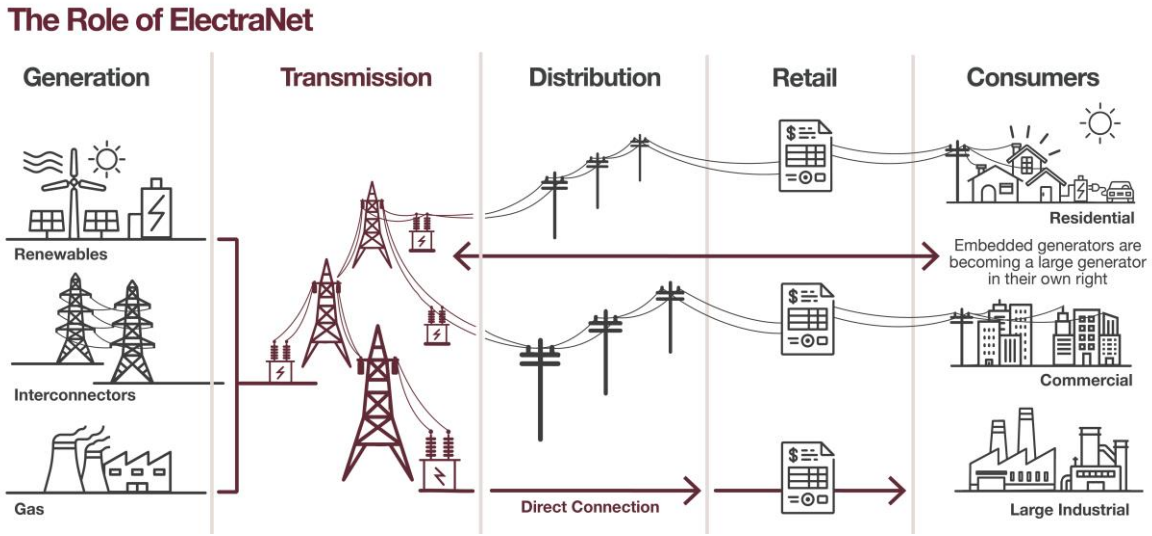
Who are ElectraNet?

Owner and operator of South Australia's electricity transmission network

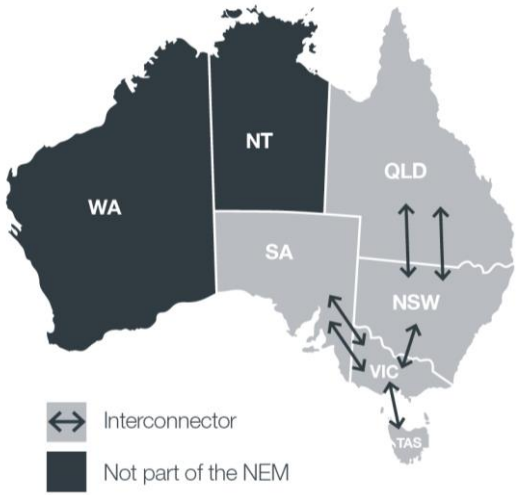
Extensive regional network covering 200 000 square km (~77 000 square mi)

Supporting the $140+ billion economy in South Australia



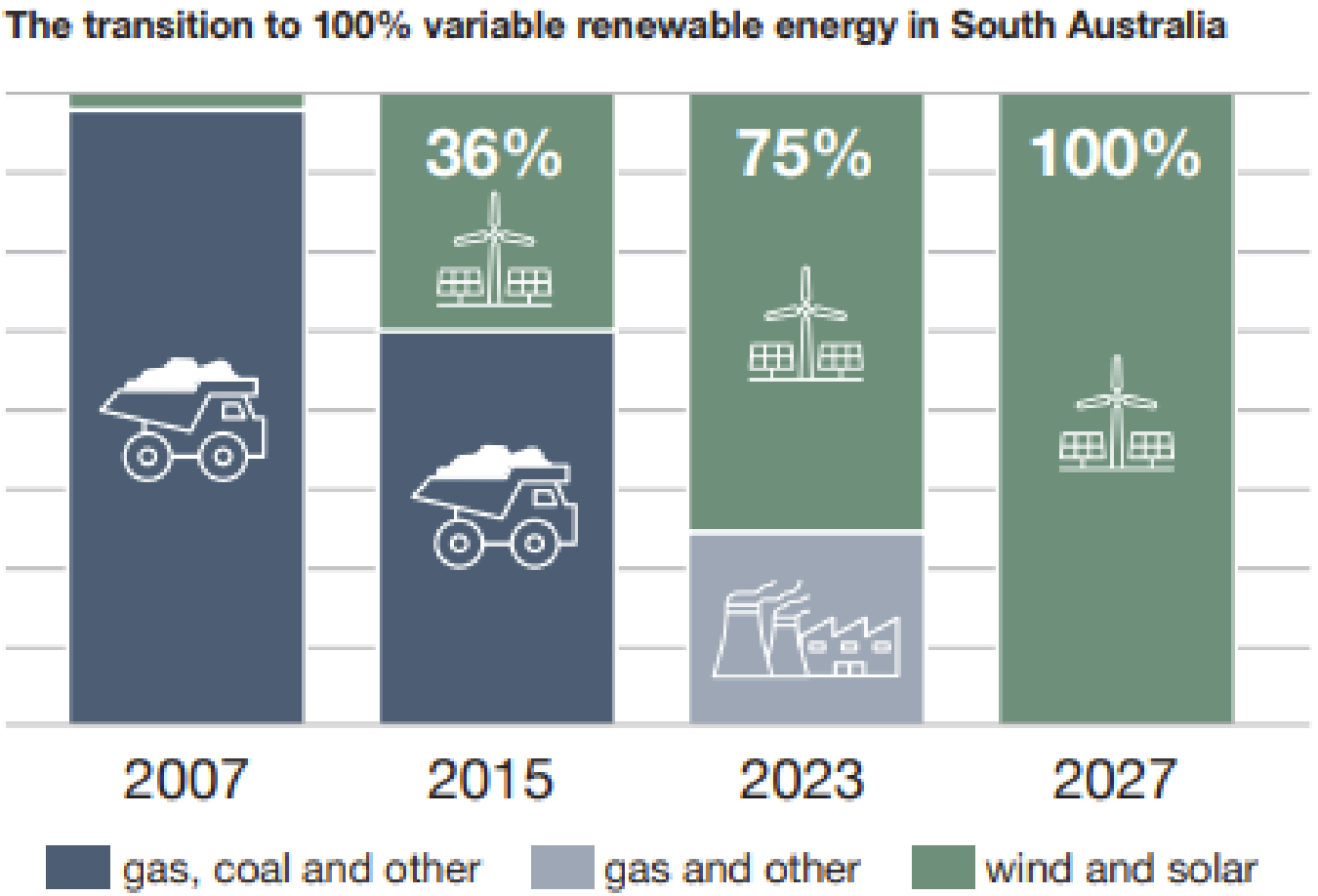
Our Key Objectives:

- Affordability and reliability to our customers
- Transmission Network security and resilience
- Safety of our personnel
- Protect the environment



Our industry needs innovative solutions

South Australia is a global leader in the adoption of Variable Renewable Energy (VRE)



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Forest Grove
Data-Driven Decision Making

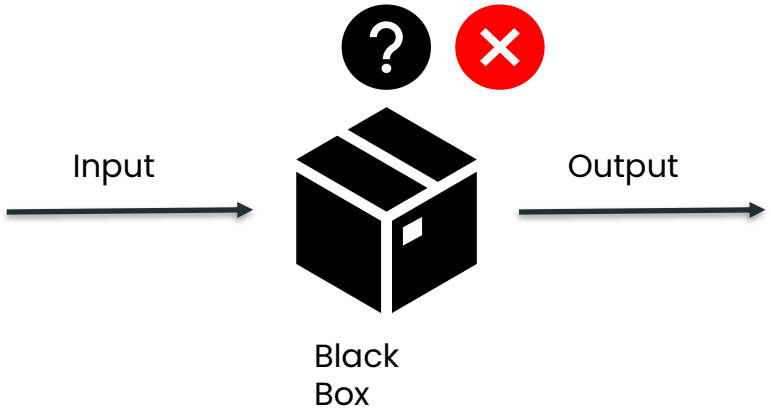
Why KNIME has been selected?

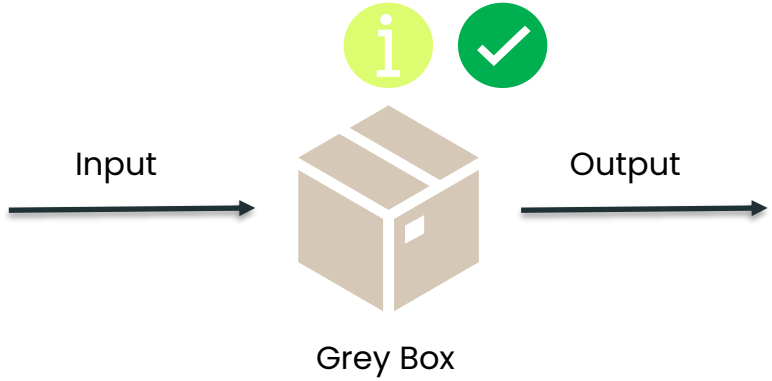
Forest Grove
Data-Driven Decision Making

Open for Innovation
KNIME

ElectraNet's Selection Criteria:

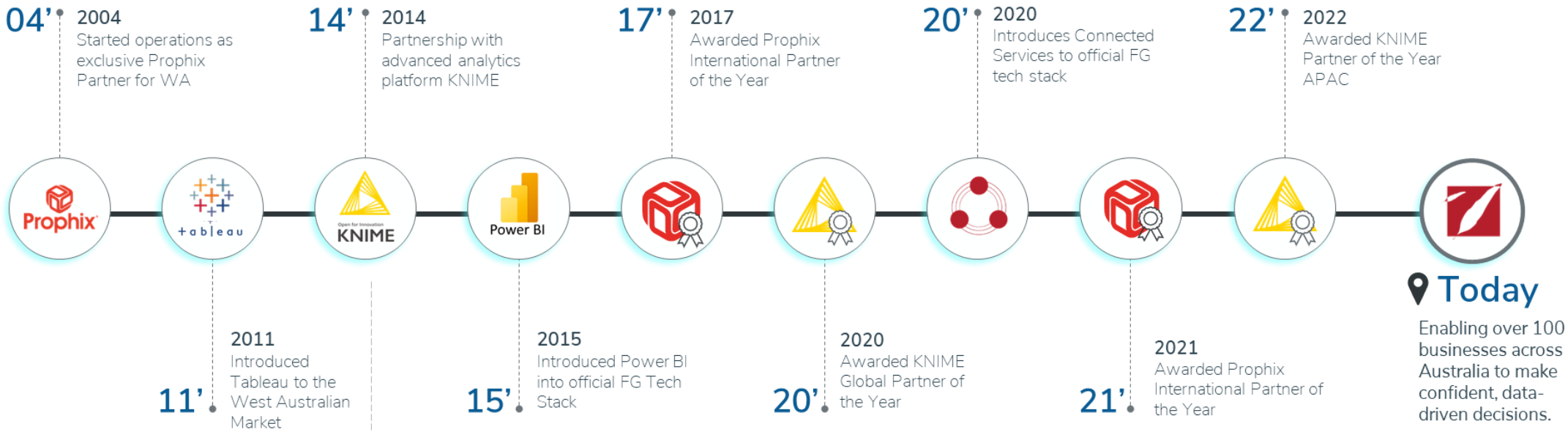
- GUI based workflow – Low Code/No Code
- Simple for analysts/engineers to utilise
- Faster and easy solution to deploy
- Flexible solution





Forest Grove Technology

Founded and operating out of Perth, WA, Forest Grove is one of Australia and NZ's leading specialist consulting firms, delivering end to end finance transformation and data analytics solutions. We have been helping business achieve success with their data for over two decades.



In 2014 we identified some key gaps in the market;

① Firstly, companies were struggling to **access their data**. They needed to **transform, clean, validate** & more. We needed an ETL tool that **both technical & non-technical** could work with to create a **single source of the truth**

② Additionally, **we knew that over 80% of analytics projects do not make it out of the data science team**. That is, deployment is a key issue. We chose **KNIME as our key data science tool** because its business model helped deal with this issue.

Forest Grove Technology - Snapshot

20 years experience in finance & analytics

→Headquartered in WA

→Consultants in VIC, WA & QLD

100+ customers across APAC

→Long-term, happy customers

→Implementation & dedicated support

Diverse, professional team of **finance & data experts**

→Specialist, varied skill sets & experience

→14+ countries

Leaders in **data literacy**

→Helping clients solve real business problems

→Growing data literacy across teams

Strategically chosen leading technologies

→Innovation, self-service & support

→Avoidance of black-box solutions

CONNECTED SERVICES · Open for Innovation KNIME · Prophix · Power BI · tableau

Proven success & credentials

→KNIME Elite Partner

→Suite of awards

What Assets do ElectraNet manage?

About 100 substation sites

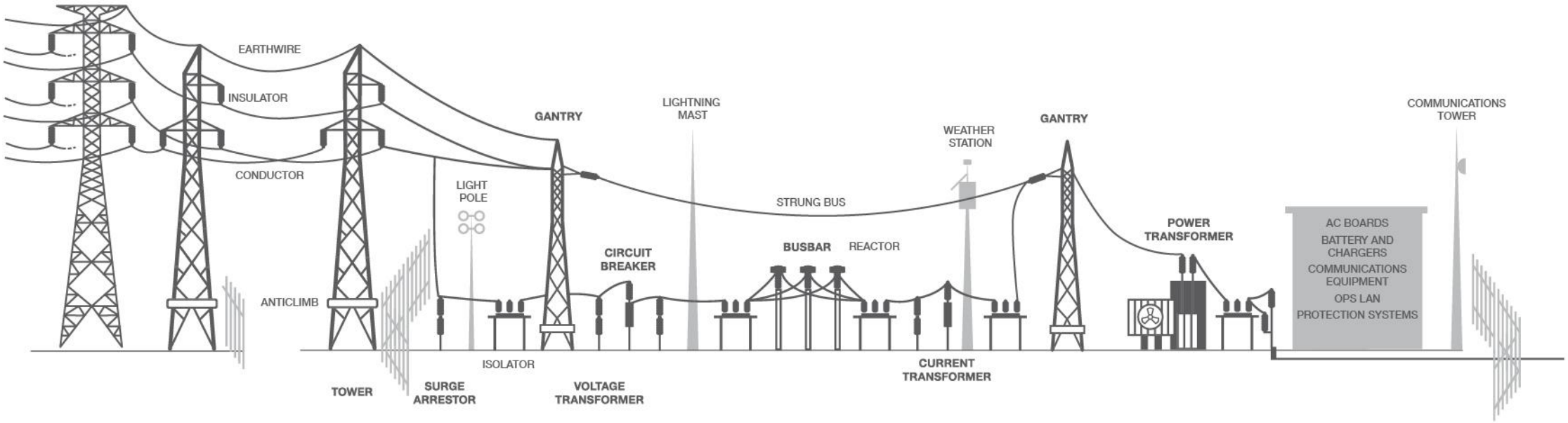
Over 6,000 circuit km of transmission lines (~3 700 mi)

166 power transformers

670 circuit breakers

3 700 voltage and current transformers

15,000 towers supporting the network



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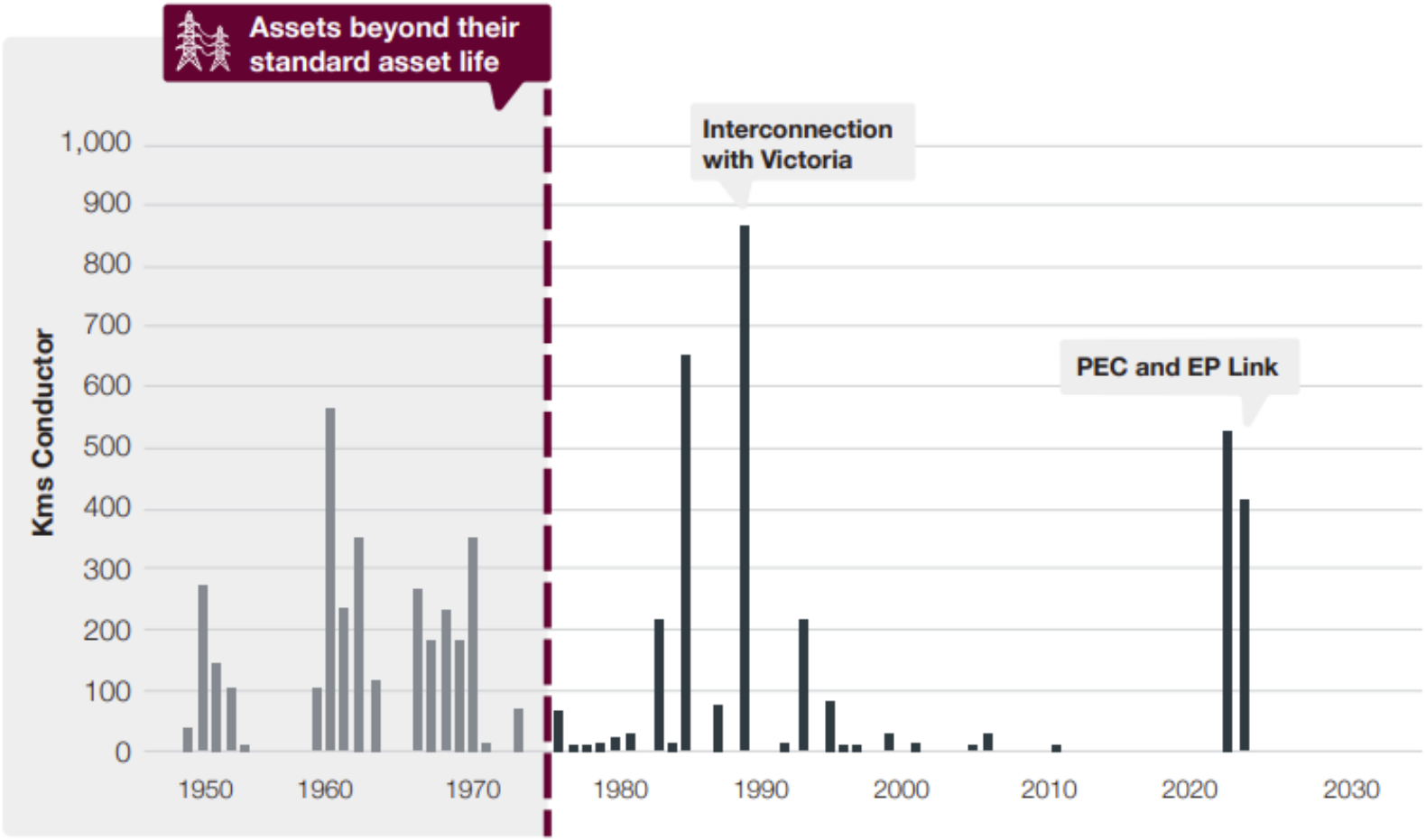
Why is data analytics so useful for ElectraNet?

Age Profile of South Australia's Electricity Transmission Lines



The standard life of transmission lines in South Australia is 55 years. By 2030 around half will have exceeded their standard life, including the major transmission line projects recently completed. It is common industry practice to operate transmission lines beyond their standard life.

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What can be the consequence of asset failure?

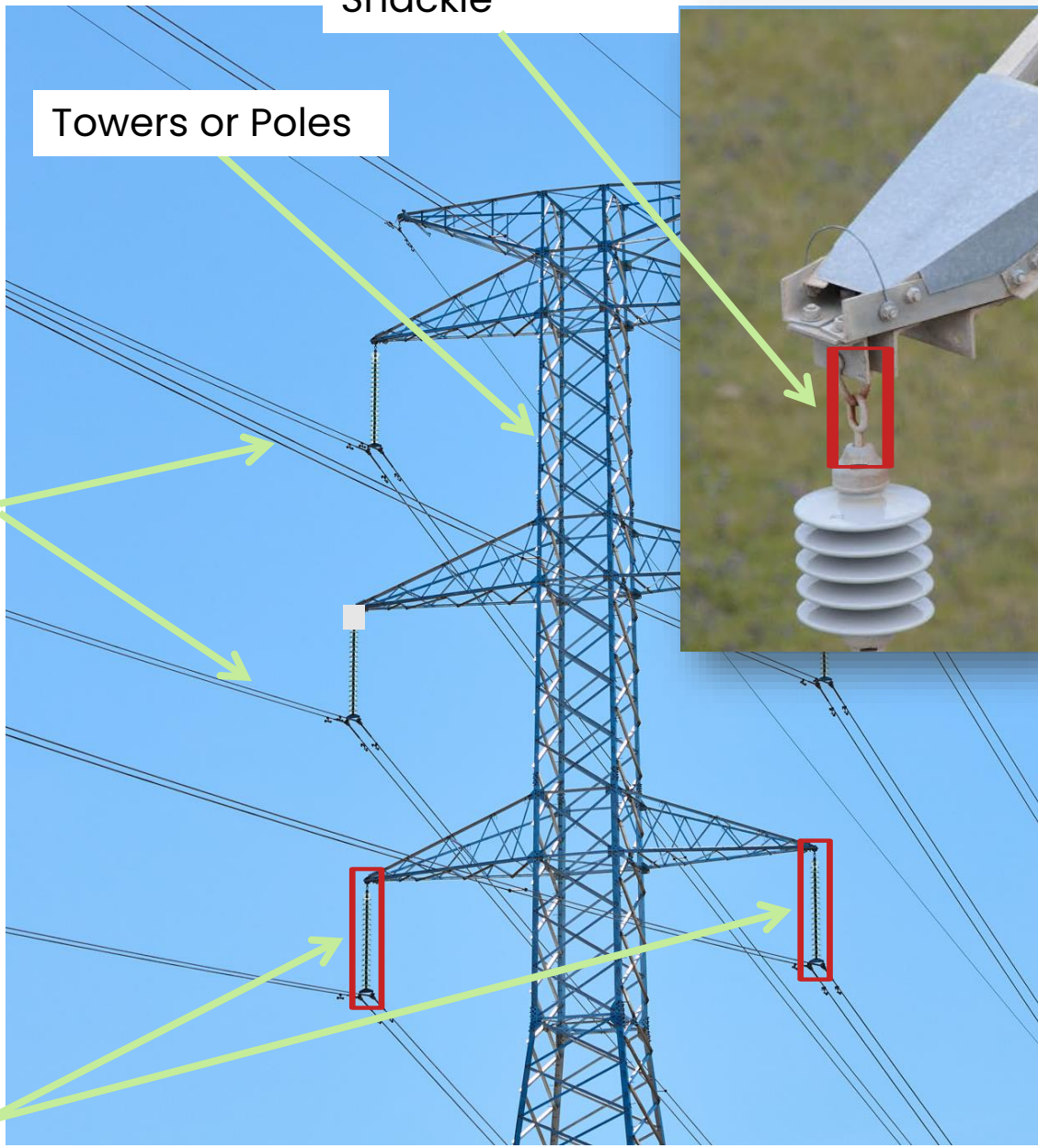
- **Bushfires**
- **Electrocution**
- **Loss of Supply**
- **Security of Supply**
- **Third Party Property Damage**

Contact with high voltage lines can cause death, injury, or start a bushfire.

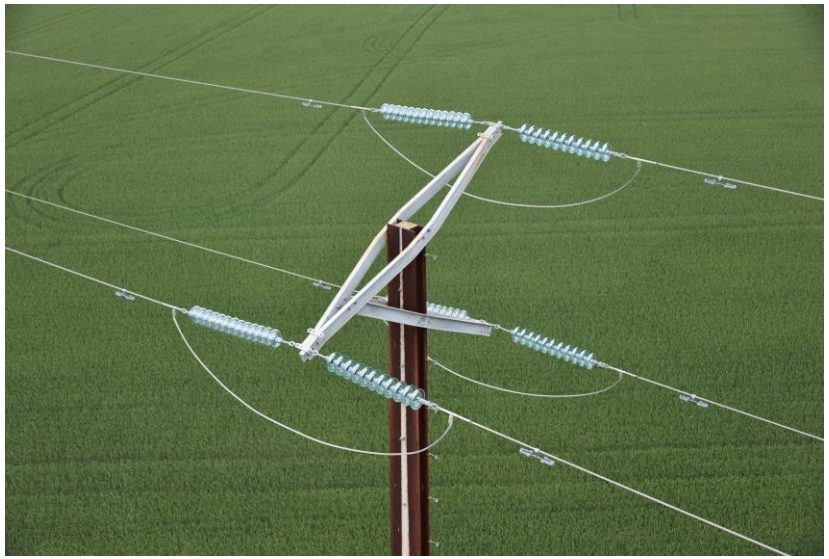
What are Transmission Lines?

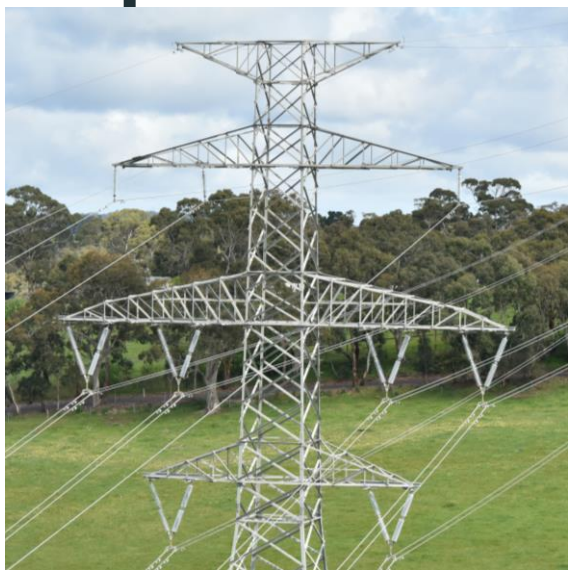
Components for a Transmissions line are:

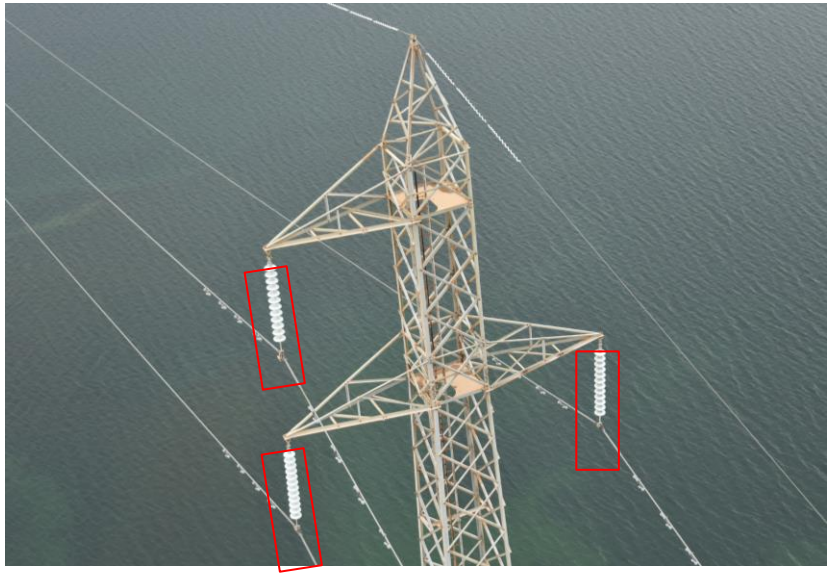
1. Conductor
2. Towers or Poles
3. Insulators
4. Shackle

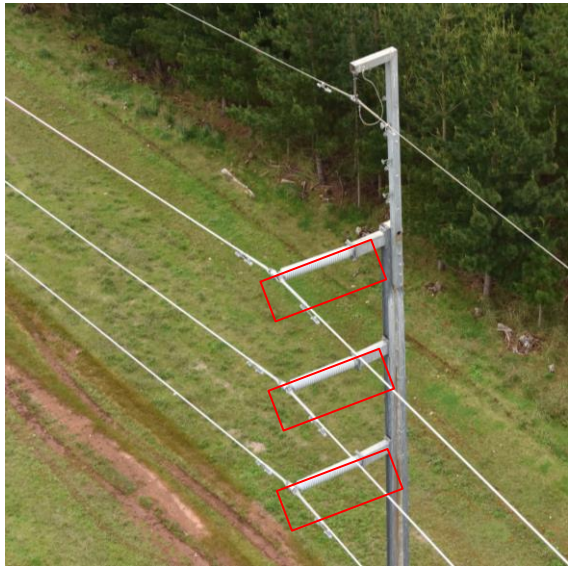


Transmission Lines examples

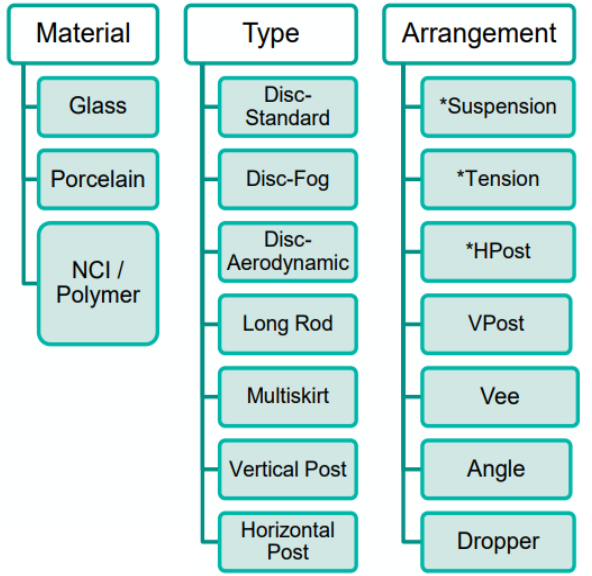








Our first image analytics project



Business Case

Validate the Data captured with our Asset Management Systems

Analytical Solution

Utilise KNIME Workflow to detect insulators

Recognise insulator attributes

Deployment KNIME Workflow for SMEs to utilise

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Our current project: Shackle detection and steel loss measurement

Business Case

Shackle defect identification

Streamline SME's manual audits to help the prioritization shackle's replacements

Analytical Solution

Leverage the previous analysis work

Deploy KNIME Workflow to detect shackles and connection points

Deploy KNIME Workflow for SMEs to utilise

Steel Loss Measurement

Machine Learning & Image Recognition
Project presentation

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What is Machine Learning ?

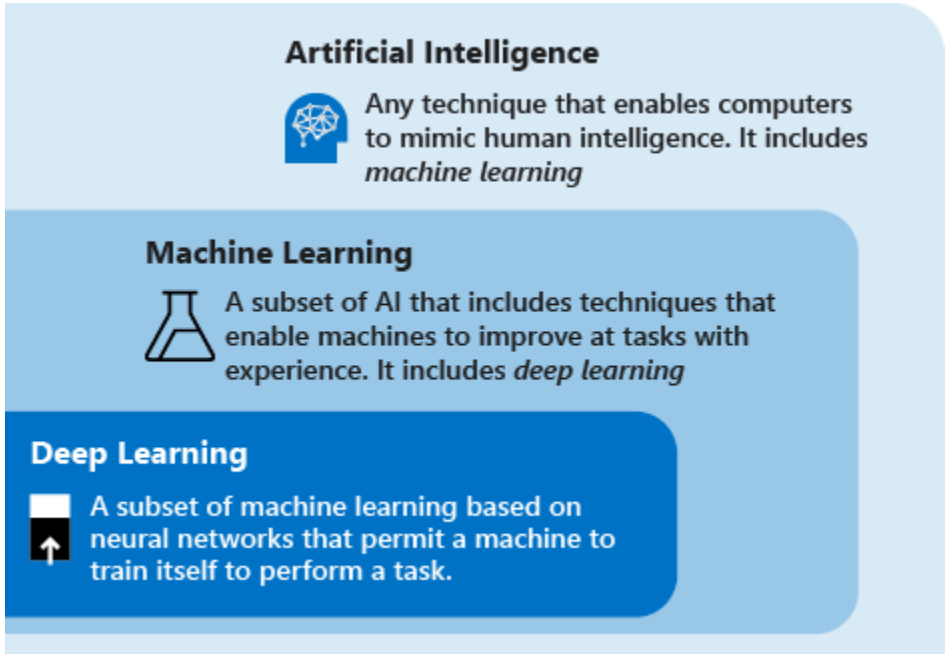
"Machine learning (ML) teaches computers to do what comes naturally to humans: learn from experience"[1]

Arthur Samuel (1959) [2]

Algorithms "learn" information from data and improve their performance

Training an algorithms result in a ML model

Daily usage: deepl, chat GPT, Siri, ...



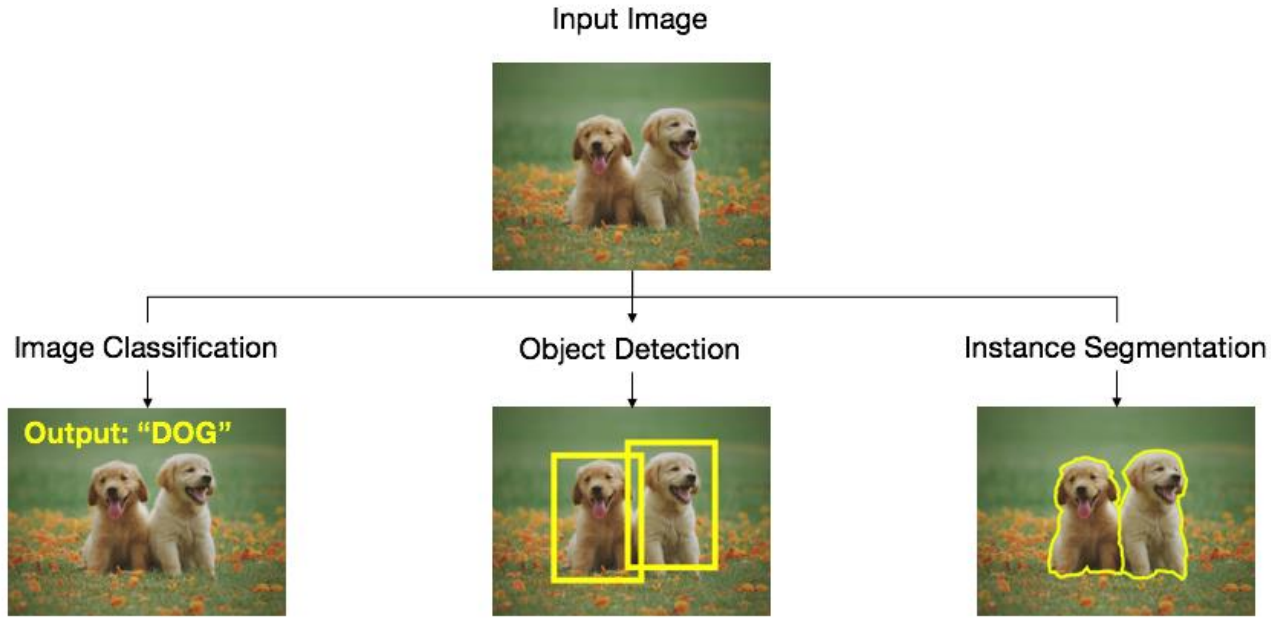
[1] Peck W.G., *Machine Learning Techniques Using MATLAB*, North Charleston, SC: CreateSpace Independent Publishing Platform, 2017.
[2] SamuelA.L.,"Somestudiesinmachinelearningusingthegameof Checkers",*IBMJournal of Research and Development*, 1959, 3(3): pp. 210–229, https://doi.org/10.1147/rd.33. 0210.
Image source: https://ai.stackexchange.com/questions/15859/is-machine-learning-required-for-deep-learning

And what is image recognition?

Image classification is a task in computer vision that aims to understand and categorize an image as a whole under a specific label.

Object detection involves classification and location of multiple objects within an image.

Instance segmentation is a computer vision task that involves identifying and separating individual objects within an image, including detecting the boundaries of each object.



Original Solution – Manual work

Steel Loss Estimate Scaled Measurement || NOTI

Insulator Drawing:

V-Shackle Type
Length = 89mm (center of bolt to inside edge of V)

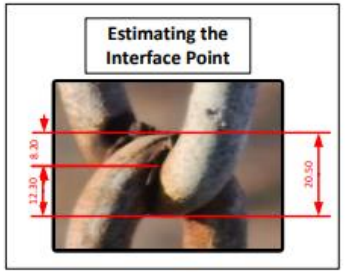
Ball-Eye Type: DC3122
Length of eye opening = 51mm

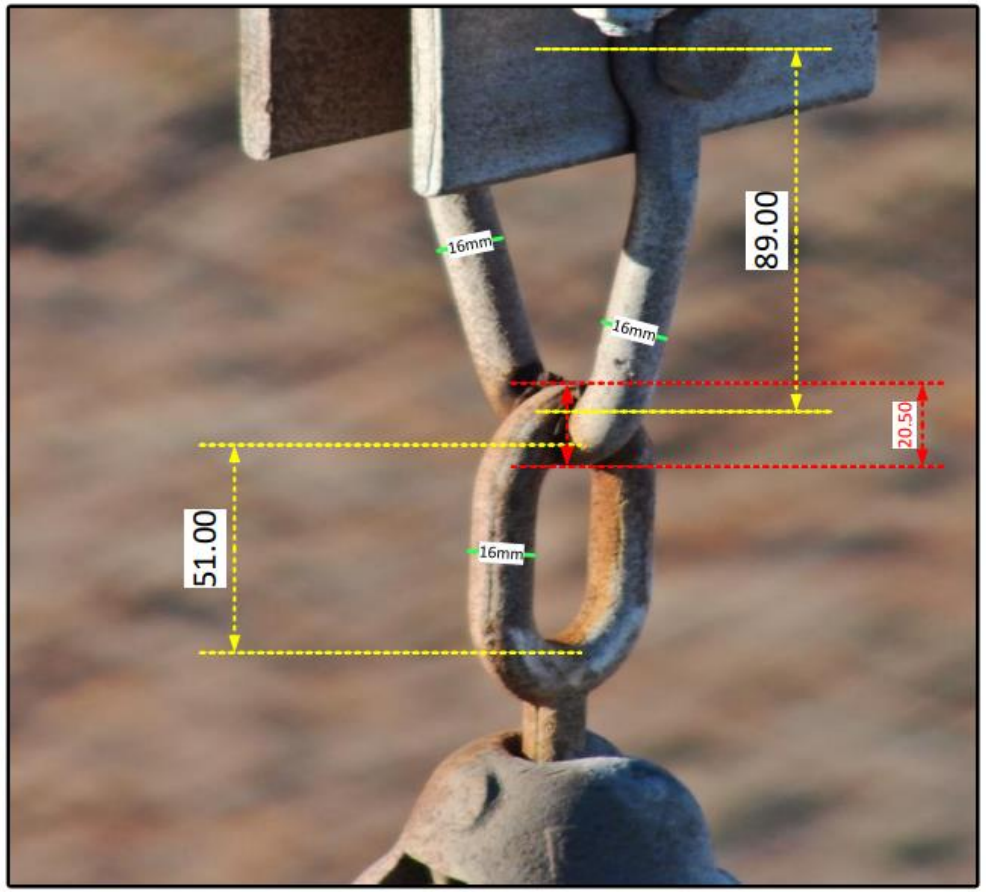
Total Steel Thickness of 100% Condition V-Shackle/Ball-Eye Interface = 32mm (16mm + 16mm)

Steel Thickness based on scaled measurement = 20.5mm
Loss = 11.5mm (36% loss)

Lab Report from Bureau Veritas:
Metal Loss on Ball-Eye = 9.5mm
Metal Loss on Shackle = 2.1mm
Total Metal Loss = 11.6mm

Note: I undertook the scaled measurement before cross checking with the Bureau Veritas report; suggest in this case that scaled measurement was an appropriate method of estimation.





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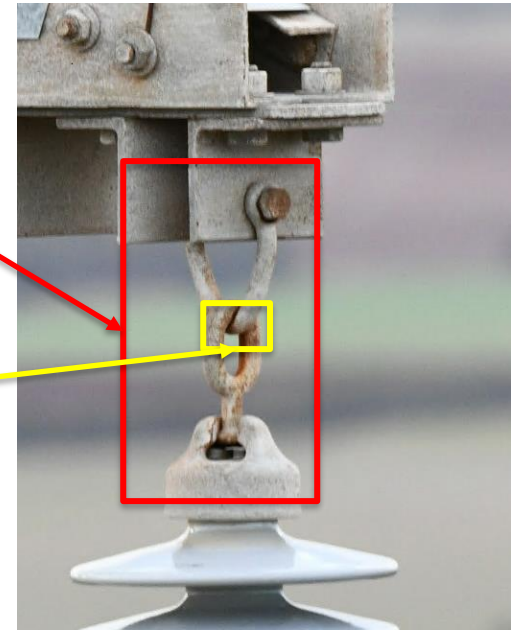
Shackle and connection point detection

We have 2 tasks:

1. Detect shackles in aerial images
2. Detect connection points within the shackles

The dataset is split into three subset:

1. Train – Used to train (or retrain) a ML model. The model learns from the available data. The data needs to be representative from the reality.
2. Validation – Used to validate the ML model after each epoch or training iteration. It assesses the quality of the ML model and allows to identify overfitting.
3. Test – Used as test dataset once the ML mode is ready to be deployed.



What model did we use ?

2 Trained model – 1 for each task

YOLO (v8) - You Only Look Once

Popular object detection and image segmentation model

Fast and accurate – close to real-time

Continuous support of the community

Existing Python frameworks

Retrain of a pre-trained model

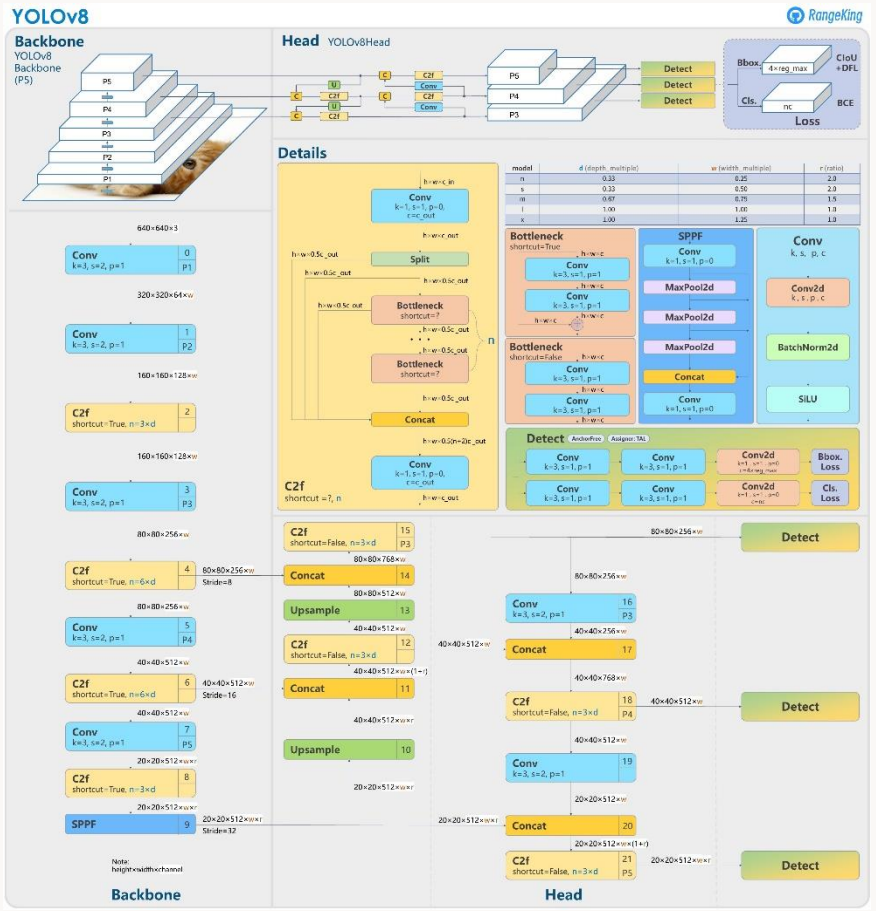
300 epochs (training iteration)

Batch size of 2

Initial Learning rate of 0.01

Images of various dimensions

Cross Entropy Loss



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KNIME Data Apps

5 workflows deployed on KNIME Server:

1. Upload images to a Blob Storage
2. Detect the shackles and connection points in the images
3. Provide the reference points for the images
4. Analyze and export the results
5. All the tasks within a single workflow

Overview of the KNIME process

Cloud

KNIME Server

Upload images

Detect Shackle

Reference points

Analyse results

All tasks within a workflow

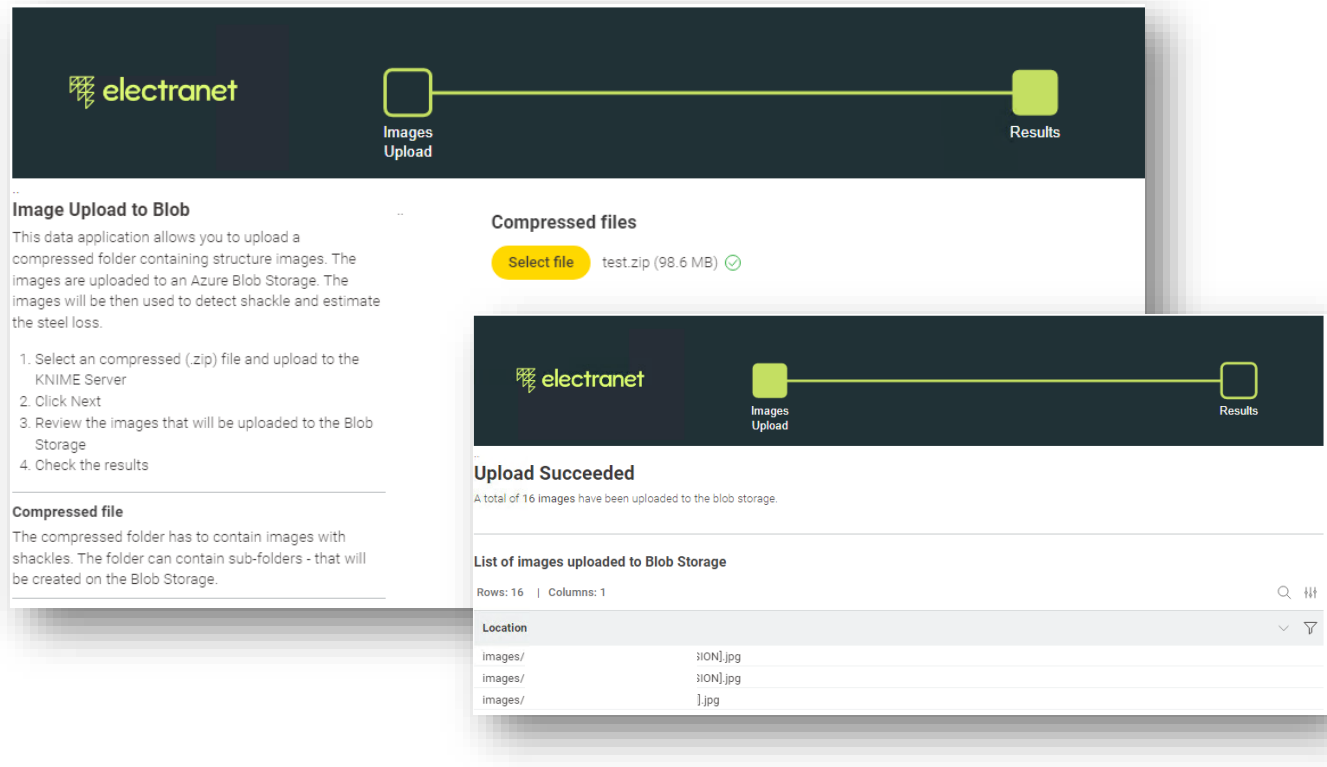
Upload images to a Blob Storage

The user compress the images

The compressed folder is uploaded to KNIME

KNIME is uploading the images on an Azure Blob Storage. The structure of the folder is maintained.

Uploaded images are logged in a governance DB for further analysis



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Data-Driven Decision Making

Detect the shackles and connection points in the images

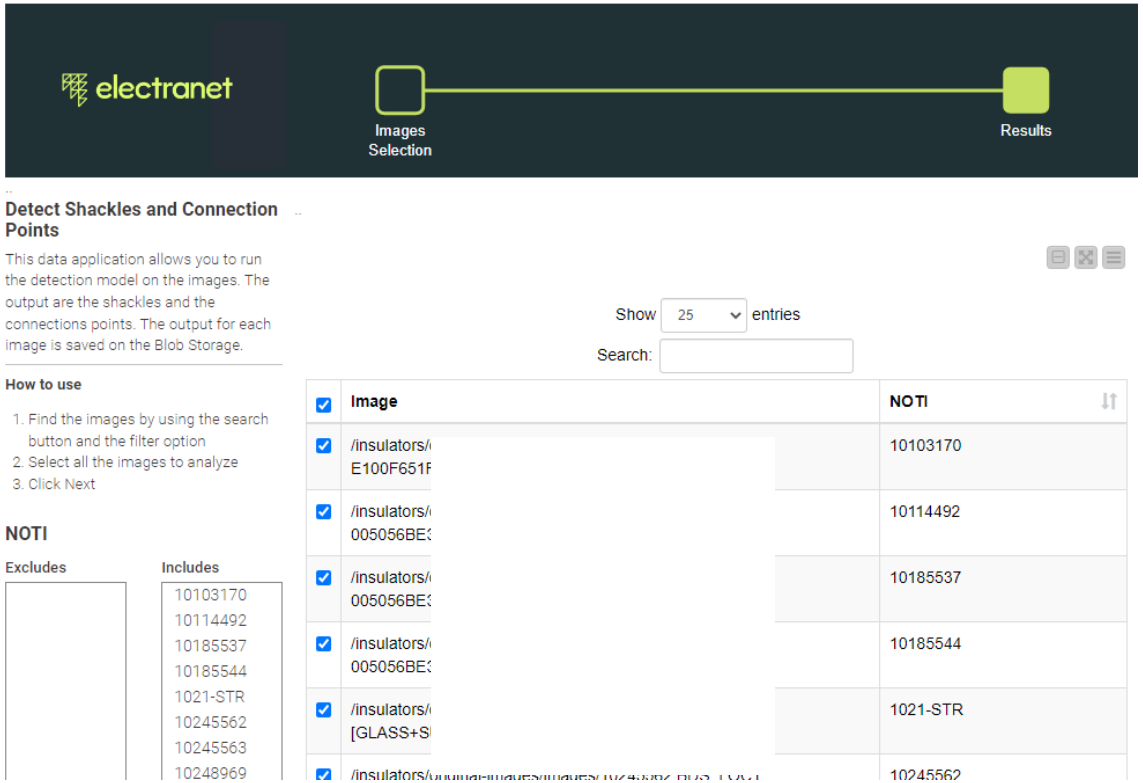
The user selects available images. A filter option is available.

Images are downloaded and processed:

1. Shackle are detected
2. Connection points are detected

Each detection are uploaded to the Azure Blob storage.

An output is provided to the user to analyse the detection outcomes.



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Provide the reference points for the images

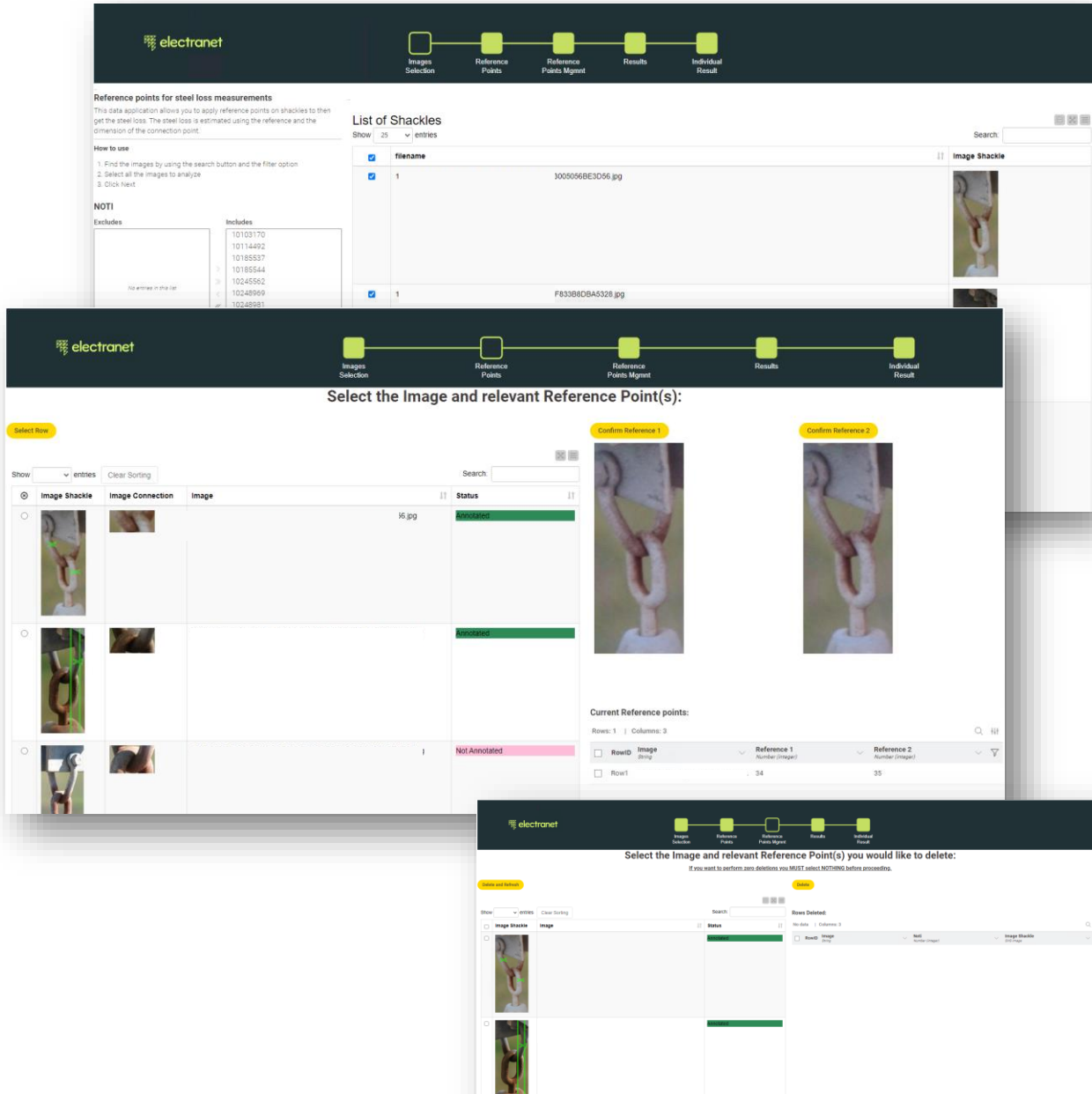
The user selects available images. A filter option is available.

Images are stored on the Blob storage and streamed within KNIME, saving space and time.

An annotation interface is displayed to the SME.

The SME provided the reference points on the images. Each reference point is saved within the DB – allowing a to save the work in real-time.

The SME will see the result of the steel loss measurement and download the reports



Analyze and export the results

The user selects available images. A filter option is available.

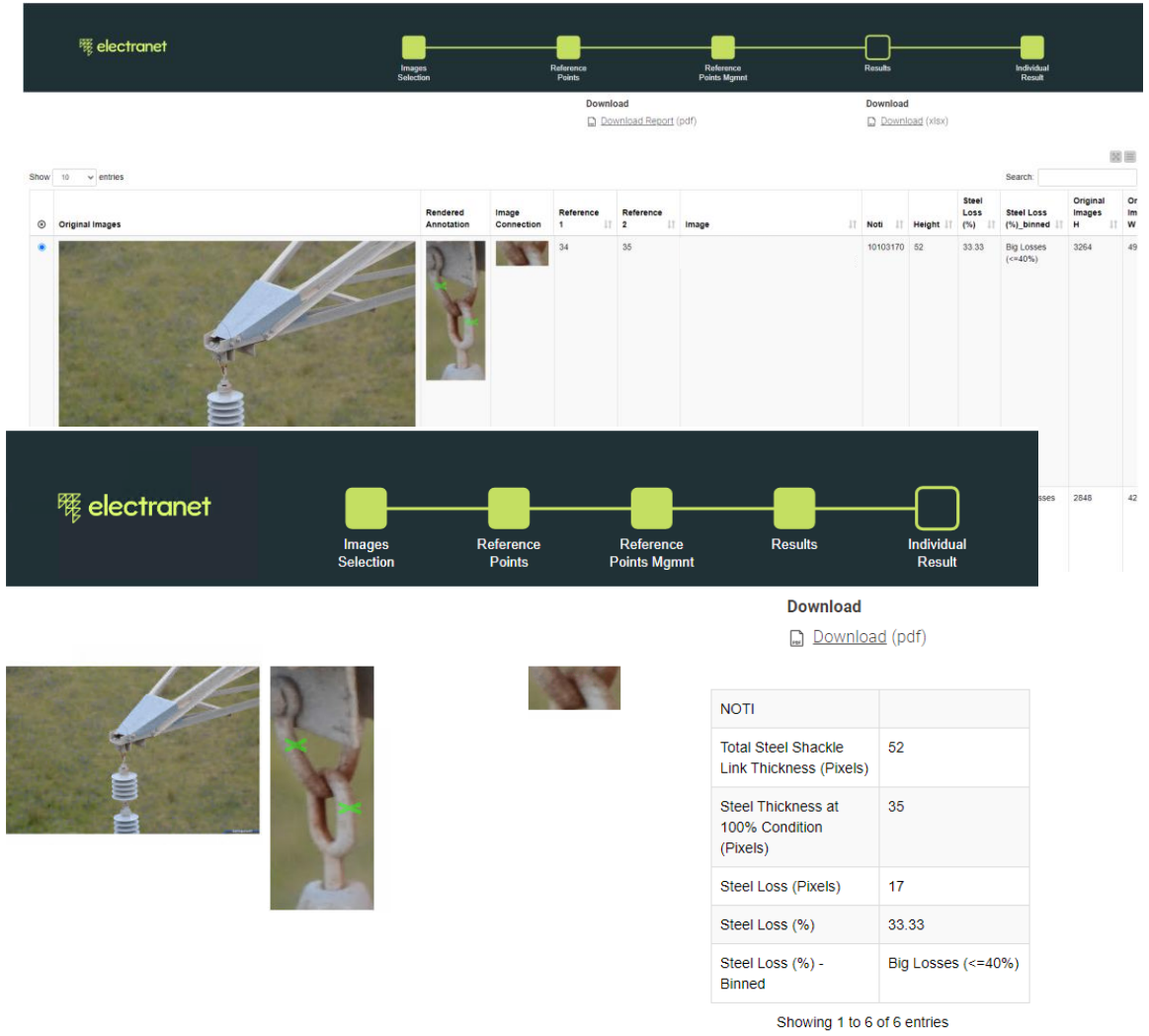
A Steel Loss is estimated using the reference provided and the connection point detected. The results are saved in a DB.

Measurement is computed using the reference point provided and the size of the cropped connection point.

The output can be downloaded for further analysis

Each Shackle has a report with information about Steel Loss and related images

The report can be downloaded as PDF for archive or further analysis



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Outcomes

The process has been validated by the SMEs

The outcomes allows the SMEs to prioritize the maintenance on the network

It saves a lot of manual work

The improvement made to this process are:

Using a remote storage to store the images and the outcomes (e.g., PDF, Excel)

Additional workflows have been added to

- Upload images to the Blob storage manually
- Automatically apply the image recognition on new images on the Blob Storage on a schedule basis
- Provide the references only
- Explore the results only, without the need to run the process again

- Future improvements
  - Adding the possibility to suggest the reference points

Steel loss measurement (estimated time)

Per image:
Manual: ~15 minutes
Automated: ~0.5 minute

Dataset (~41 000 images):
Manual: ~400 days
Automated: ~14 days

Gain: >95% of the time

What’s Next ?

Improvements and maintenance

Other PoC:

1. LLMs for maintenance comments summarization
2. Image recognition to detect electrical components in PDF plans

Thank You

For more information please contact:

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