Weather-Driven Data Analytics for Asset Failure Prediction

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Introduction to Digital Engineering

Innovation funding in the UK

Weather Wear Model

Current and Future Work

Results and Savings

Introduction to Digital Engineering

- Digital Engineering provides business-critical weather information services
- Based in Bristol, United Kingdom
- It has customers operating in the energy and finance sectors

nationalgrid Bloomberg

- Energy Infrastructure - Weather Information Services
  - Asset Management
  - Demand Analysis
  - Renewable Forecasting
  - Line Rating
  - Design and Build

Innovation funding in the UK

- In the UK, funding for innovative projects is provided centrally through the industry regulator (OFGEM)
- One source of funding is the National Innovation Allowance (NIA)
- Allows network owners and operators to try genuinely innovative projects
  - Share the risks and rewards
- It allows companies like ours to take innovative ideas and turn them into industry relevant solutions

Motivation for our NIA project

- Optimum Asset investment is strategically very important to National Grid (NGET)
  - E.g. physical inspections, replacing conductors
- Main sources of environmental asset damage: ***Wind***, ***Corrosion***
- Investment is driven by ***risk classifications*** based on these sources
  - Higher risk -> more investment
- Current classifications are ***basic***:
  - Wind: elevation above sea level
  - Corrosion: distance from coast/pollution sources
- This can lead to investments being made in the wrong place!
- National Grid want to know if weather simulations combined with data analytics of defect data can lead to better risk classifications

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Weather Wear Model - Outline

- Weather data from a regional NWP model over the British Isles
  - 12 years of simulated weather (2005 - 2016) at 3 km resolution
  - Further local refinements from 50 m resolution terrain and land use data

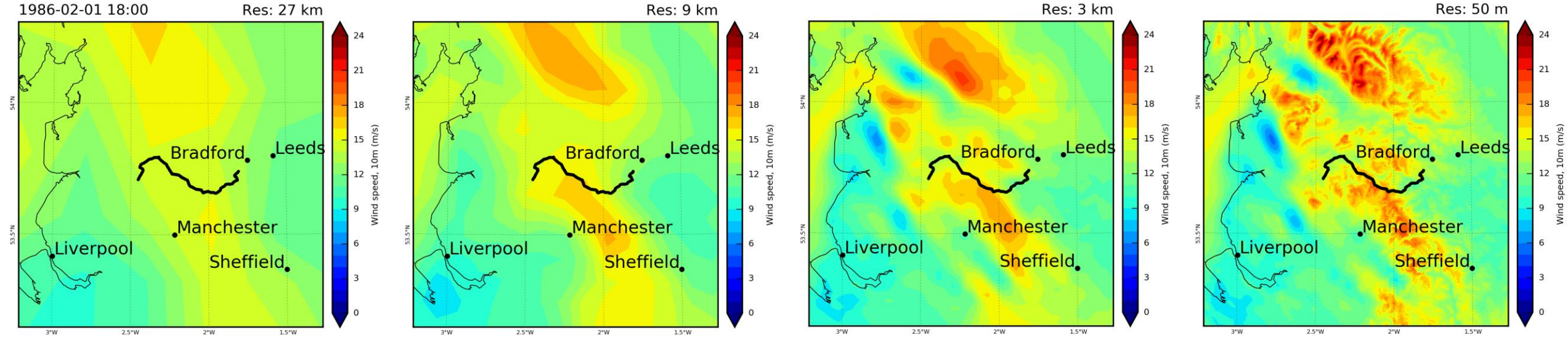
- Model outputs total **wind-induced vibration energy**, accounting for:
  - Span characteristics (cable diameter, length, mass)
  - Angle of attack of wind
  - Local turbulence
  - Resonant modes
  - Icing conditions leading to galloping

- Vibration energy is converted to **damage rate** using defect records
  - First phase: defect data from 15 test routes

Weather Wear Model – NWP

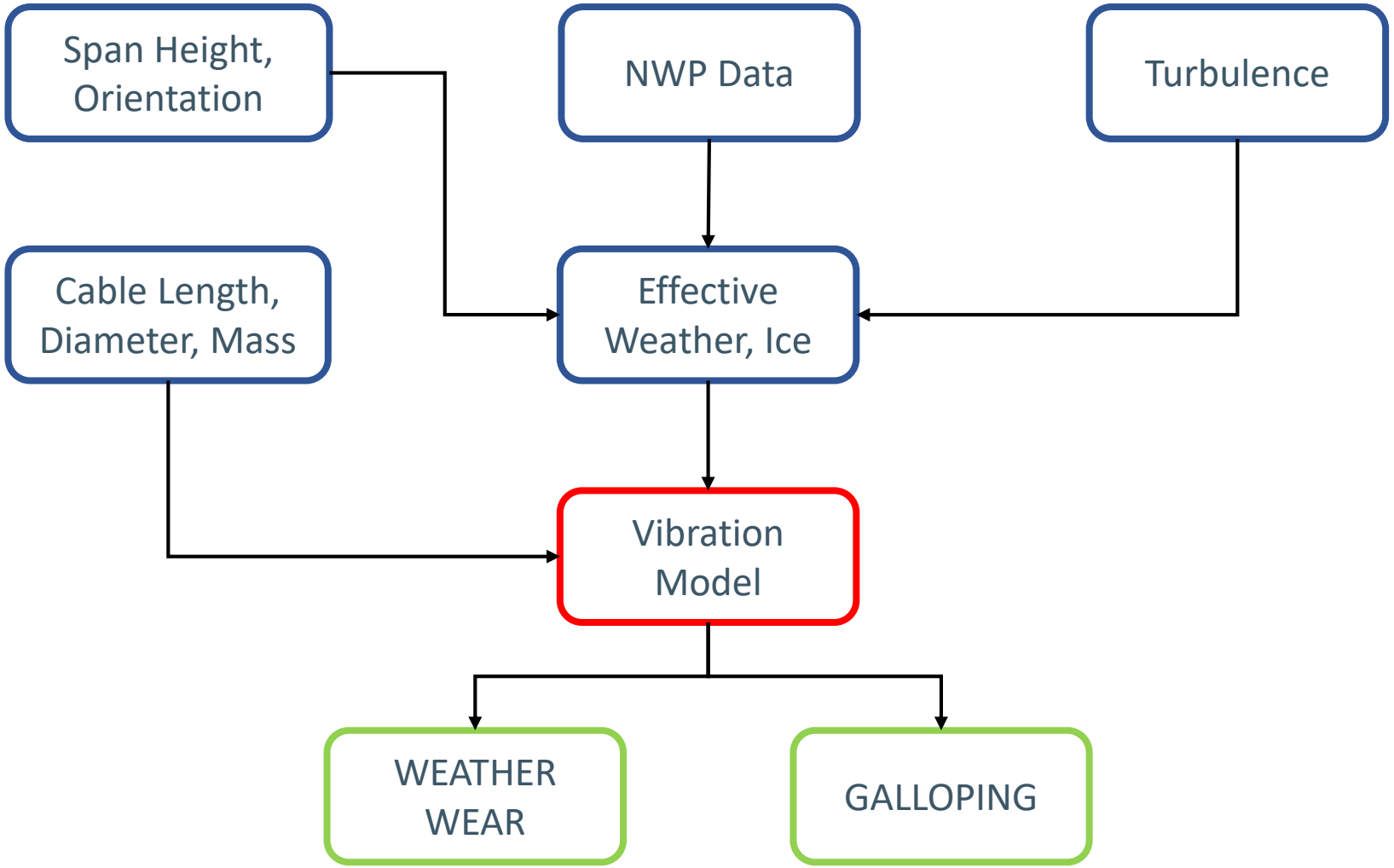
- High resolution models can resolve short-lived events at specific locations

- Example: galloping event on February 1, 1986
  - (https://www.youtube.com/watch?v=GDiflCB4gvM)

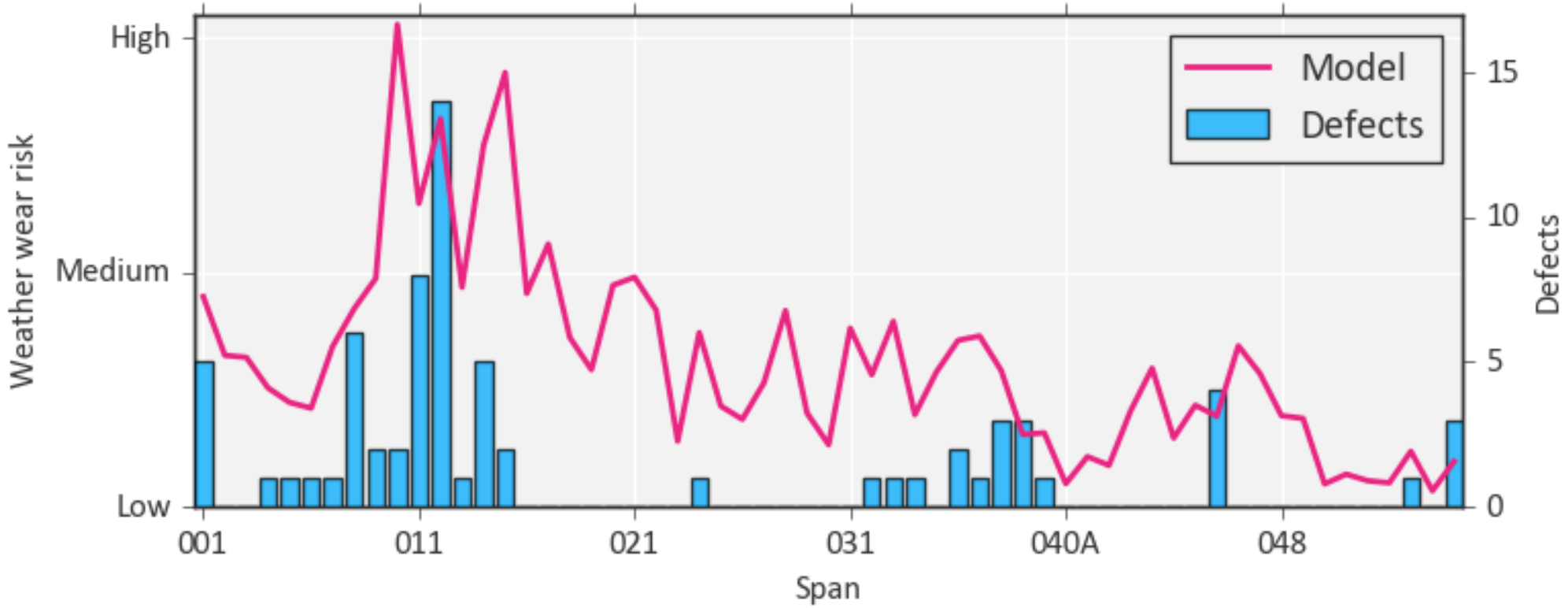


Increasing resolution

Weather Wear Model - Outline

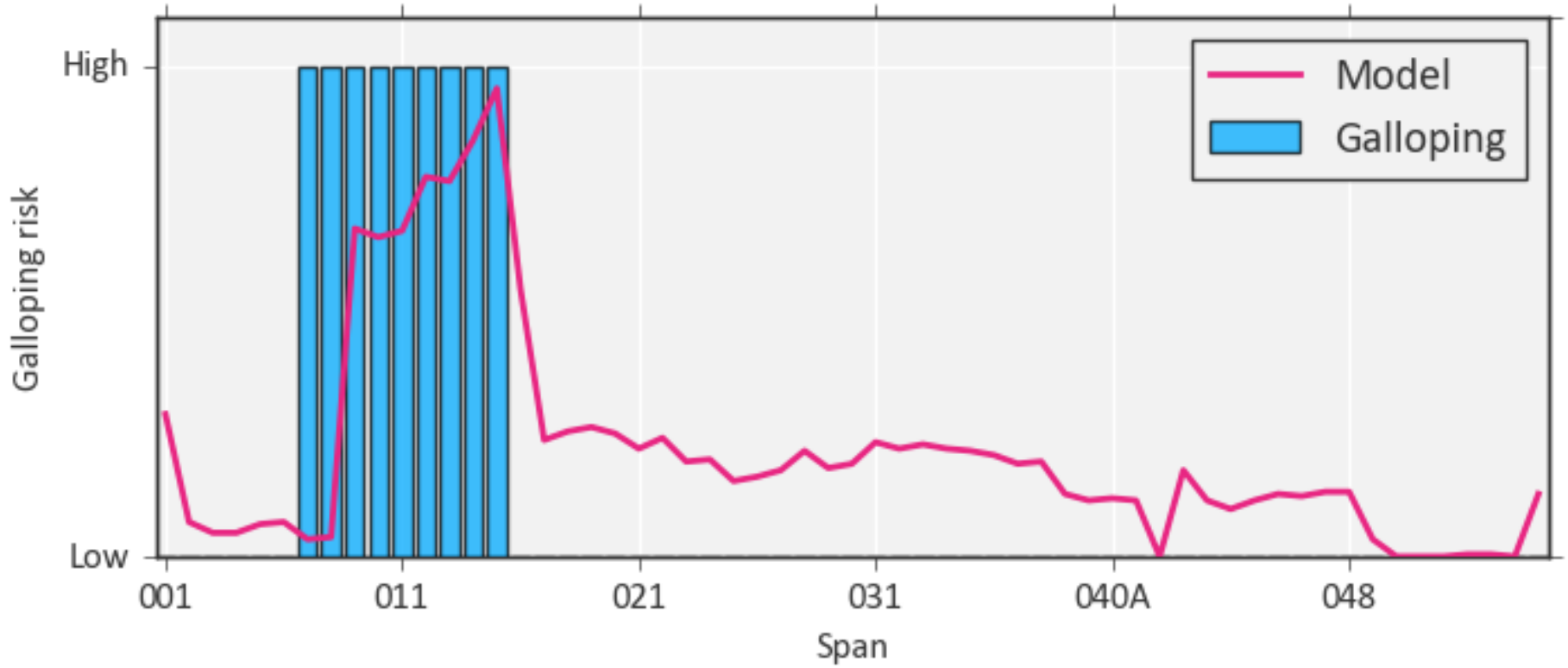


Weather Wear



- Most defects observed in the section at highest risk of weather wear
- Elevation-based criterion would set the whole route at high risk

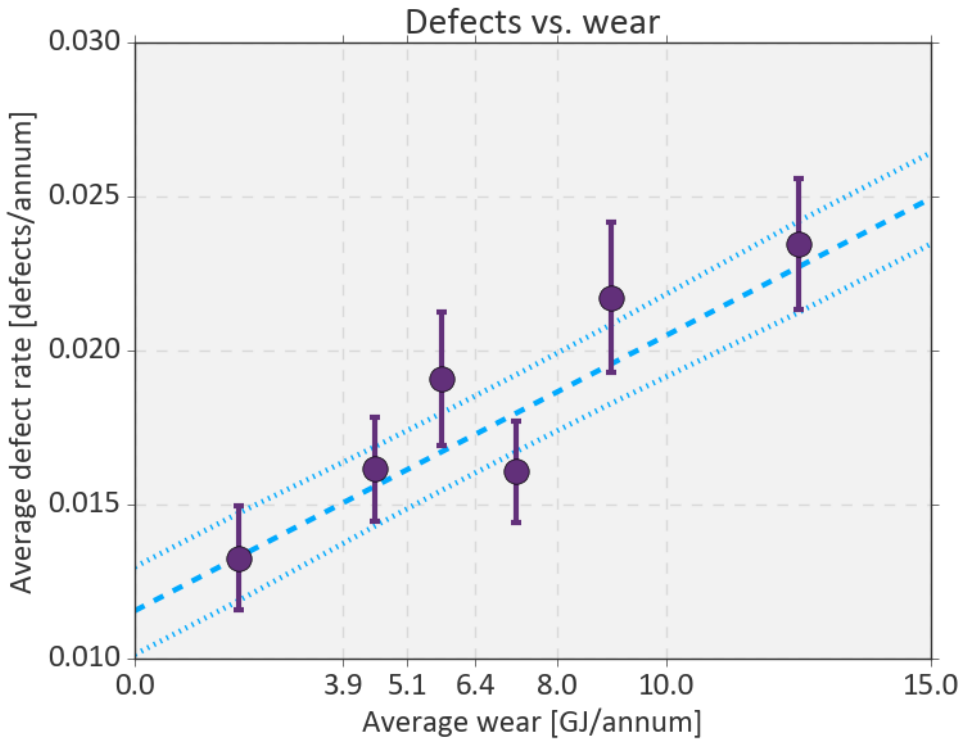
Galloping

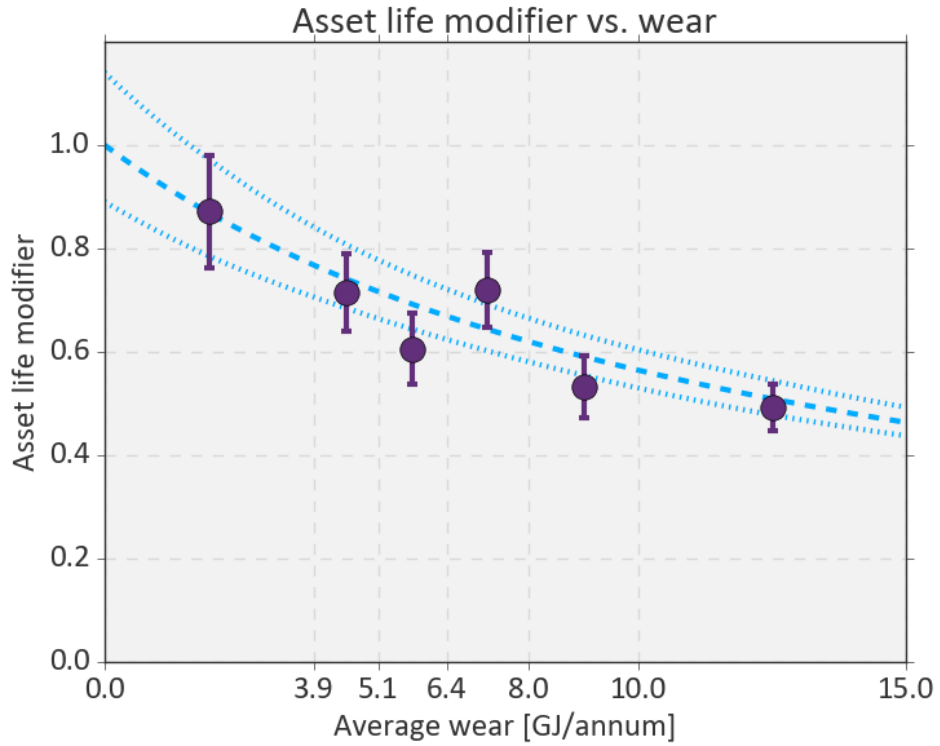


- Section where galloping was observed is correctly identified as high risk
- No such criterion currently available to NGET

Defect Risk and Asset Life Modifier

- Wear output trained against defect records yields yearly defect rate
- Inverse of rate provides ***asset life modifier*** as a function of wear





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Weather Wear Risk

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Current developments

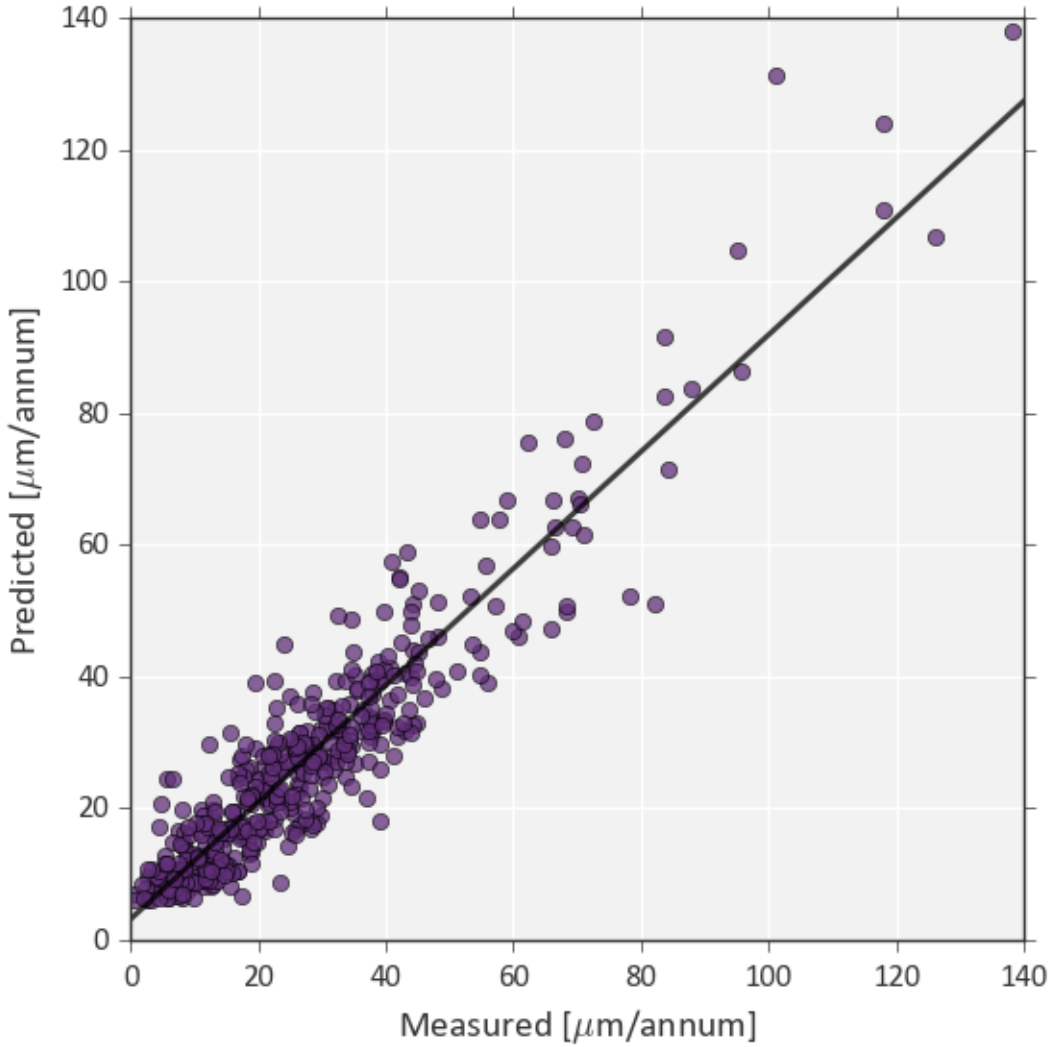
NIA Project NGET_0181 (this work)	
Name	ECALM (Phase 1)
Spans	3444
Length	1161 km
Budget	£250k
Model	Wind only

NIA Project NGET_0206 (in progress)	
Name	ECALM
Spans	10459
Length	3480 km
Budget	£900k
Model	Wind + Corrosion

- ECALM: **E**nvironmental **C**lassification and **A**sset **L**ife **M**odels
- A new project is expanding this study to the **whole set of ACRS conductors** managed by NGET
- Includes **combined** analysis of wind and corrosion for each span

Corrosion Model

- Currently being applied to NGET's network together with wear risk
- Based on Artificial Neural Networks
- Trained on data from long-term campaigns over 77 sites in EU and USA
  - Error: 7.3 µm
  - Correlation: 0.95



Combined Impact of Wear and Corrosion

- Highlights areas of increased risk from combined effects
- Weather wear is shown to be a bigger driver of damage than corrosion alone
- Further refinements under development
  - This is valid for ACRS conductors in England and Wales
  - Values in table are **relative** to the upper-left quadrant

Asset Life Modifier	Low Wear	High Wear
Low Corrosion	1.00 +/- 0.06	0.87 +/- 0.04
High Corrosion	0.98 +/- 0.06	0.75 +/- 0.04

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Results and Savings

- The new risk classifications **doubled the chances of detecting defects** which halves the cost of “wasted” physical inspections
- The new risk classifications have been used as **evidence** to **support the decision** to defer replacing conductors on various routes
- Deferring this work saves $850k / mile
- The above factors lead to savings of $25,000,000 over the next 4 year period

Savings

Reliability and operability

Transmission Owner **Title:** Classification of wind exposed overhead line spans

NIA reference: NIA_NGET0181 **Supplier:** Digital Engineering **Budget:** £250k

Overhead line showing signs of deterioration.

Innovation in numbers

3,444

Line spans analysed across 15 OHL routes

£20m

Reduction in RIIO T2 costs

Classification of wind exposed overhead line spans

Environmental conditions play a major role in the deterioration of overhead line (OHL) conductors and fittings, influencing how long they can reliably operate before they need to be replaced.

This research project used advanced weather modelling techniques and mechanical response models, to more accurately assess the risk of overhead lines deteriorating due to wind exposure.

One of our findings was a greater variation between the mode and severity of the wind exposure calculated by the new model, compared to our current classification system. Importantly, when the new model was compared against actual defect reports for OHL circuits, we found an improved correlation between the two.

Another contributing factor to OHL deterioration is pollution. So we've begun to explore the potential of a new model that combines the effect of both wind and pollution on OHLs. The result will be the trial of a new classification system that uses advanced weather and pollution models, alongside mechanical wear models and asset condition information.

All of this will mean we can manage our assets more effectively. We'll have a greater understanding of how the environment contributes to the deterioration of conductors and fittings, and will be able to target spending on those assets at the highest risk.

More detailed environmental data will help us make better decisions when it comes to capital investment priorities. The estimated benefit is a reduction of around £20m on capital expenditure over the RIIO T2 period.

Available at http://www2.nationalgrid.com/Annual-Summaries.aspx

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Thank you!

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