# Improved Feed Pump Performance through Predictive Analytics
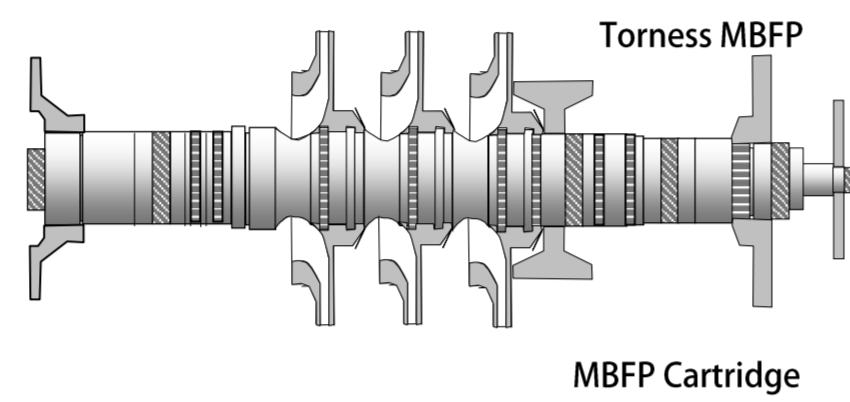
Bruce Stephen, Blair Brown, Andrew Young, Stephen McArthur,
Graeme West, Craig Michie, Andrew Duncan*, Henrique Helfer-Hoeltgebaum*

Department of Electrical and Electronic Engineering, University of Strathclyde, Glasgow
Email : Bruce.Stephen@strath.ac.uk, Blair.Brown@strath.ac.uk, Andrew.Young.101@strath.ac.uk
*The Alan Turing Institute, Email: aduncan@turing.ac.uk

University of **Strathclyde** Engineering
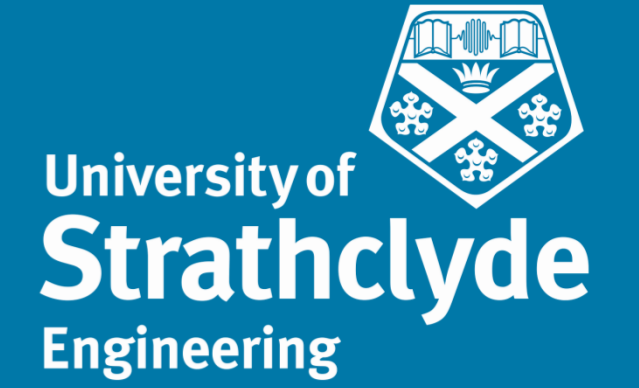
Problem Statement

❖ EDF Energy desire to decrease the time associated with fault diagnostics of MBFPs and extend the maintenance cycle period.
❖ Weir Engineering Services (equipment manufacturer) wish to gain insight into the health status of the MBFP, supporting maintenance cycle extensions and aiding with logistic planning.
❖ Collaboration brings together relevant academic and industrial partners to conduct fundamental research and translate technology into industry.
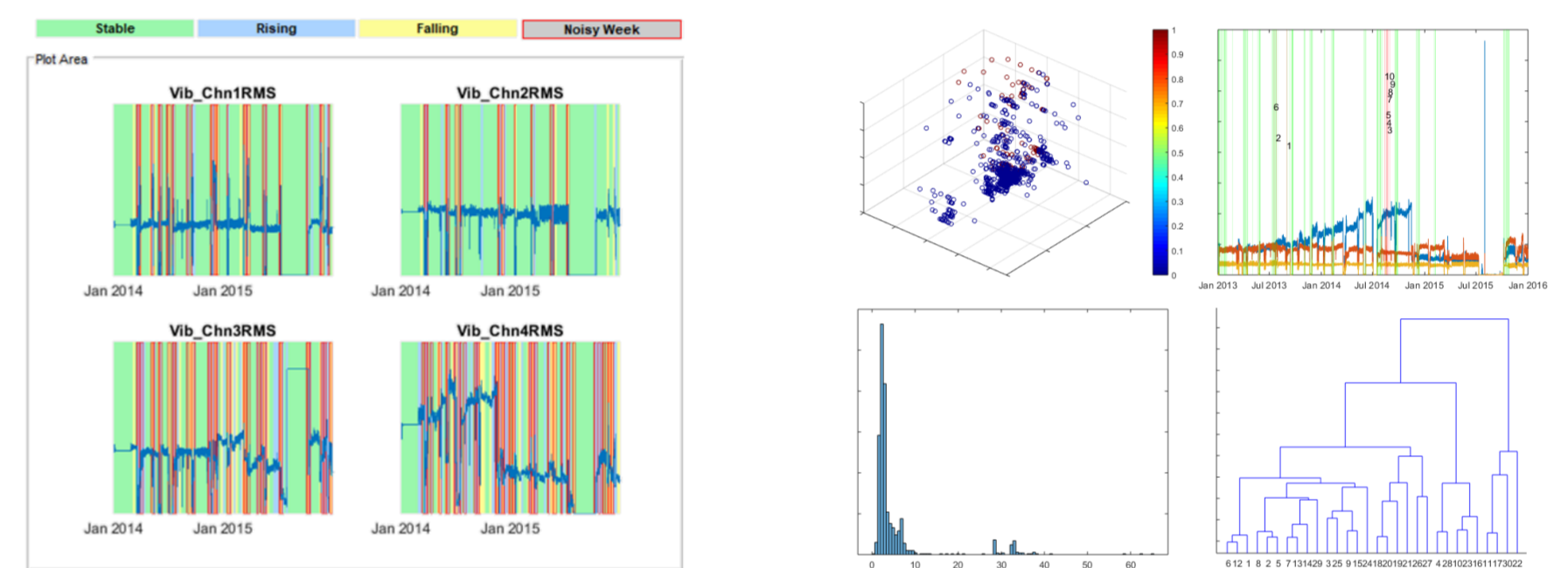

Torness MBFP

MBFP Cartridge

Fundamental Research

❖ **Probabilistic Pump Curve**
❖ Pump operation will inevitably stray from operational guidelines. Is it possible to quantify how far and then use this in a predictive model?
❖ Pump curve operating region 'visits' are captured and their impact quantified against known indicators of performance.

14 Operational Pump Curve Regions identified with a Gaussian Mixture Model

Cumulative region visits compared against cumulative thrust bearing movements — can this be used as a predictor?

❖ **Multivariate Change Point Detection**

Multivariate Online Principal Component Analysis

Detecting related changes in data in high dimensions is impossible for human operators; this work uses the dimensionality reduction techniques (PCA) [2] to identify the drivers of change clearly. The resulting low dimensional signal can be interpreted to identify where changes have occurred.

Compositional Statistics
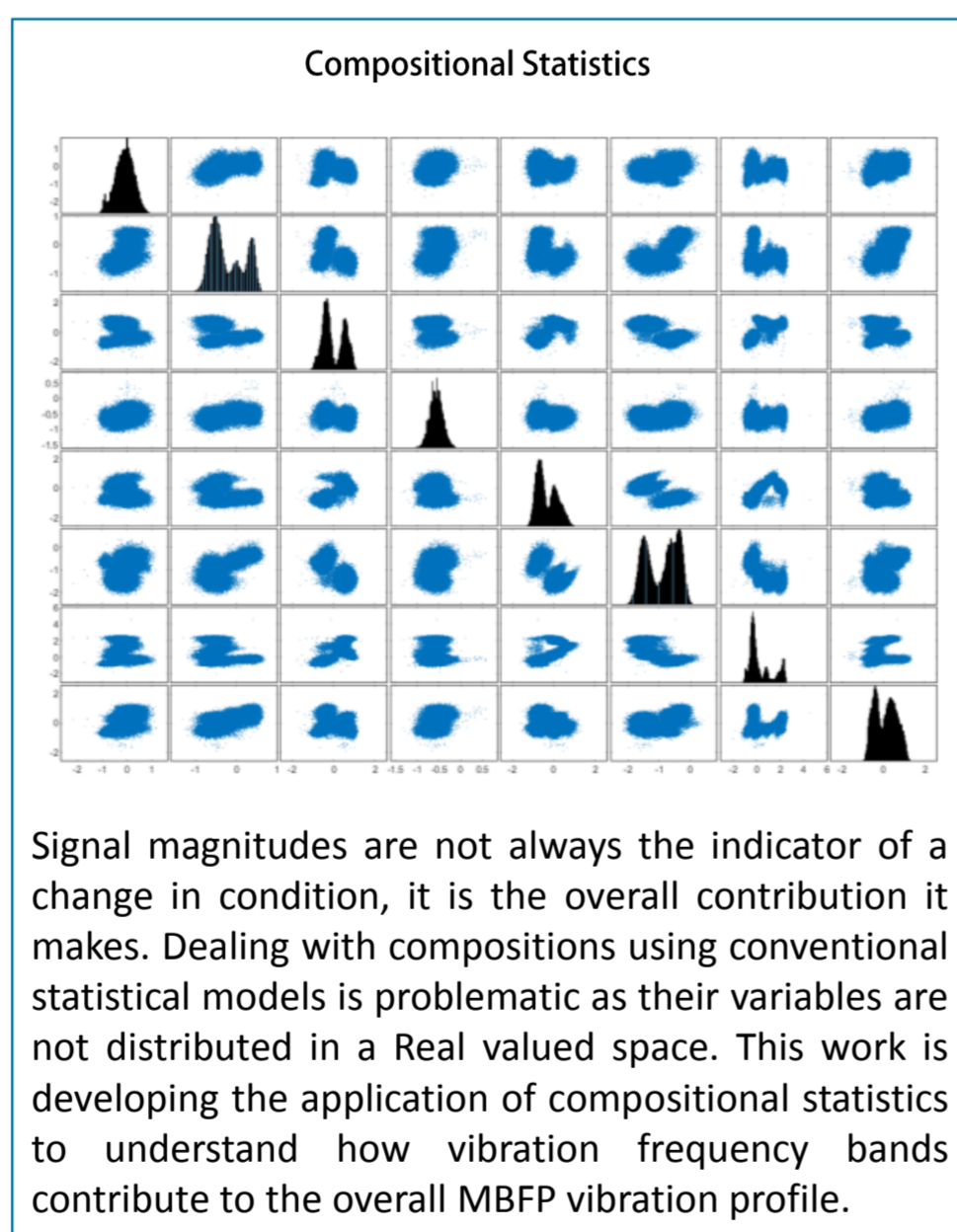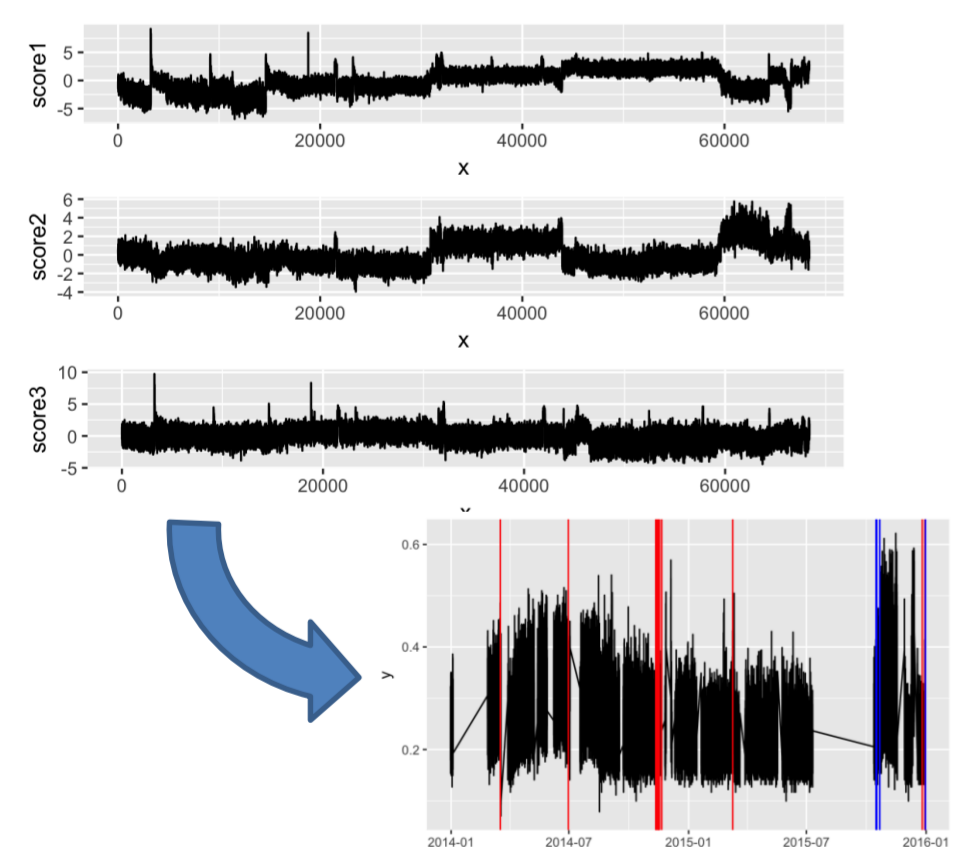
Signal magnitudes are not always the indicator of a change in condition, it is the overall contribution it makes. Dealing with compositions using conventional statistical models is problematic as their variables are not distributed in a Real valued space. This work is developing the application of compositional statistics to understand how vibration frequency bands contribute to the overall MBFP vibration profile.

❖ **Signal Decomposition**
❖ Vibration signal deconstruction and constituent analysis to provide analysis and estimation of health.
❖ Divergence of signal component parts assessed for underlying trends.

Decomposition Methods

Bregman Divergence

Automated Pump Diagnostics

❖ Accelerating the impact of previous research conducted to aid EDF Energy with fault diagnosis;
❖ Output will relieve the burden on analysts by automating elements of the real diagnosis process;
❖ The pace of fault diagnosis is accelerated by embedding expert asset knowledge provided by Weir Engineering Services.

Weir Service Solutions Pump Diagnostic Rules

❖ Tool will supplement EDF Energy's existing process in order to conduct asset diagnostics faster;
❖ EDF Energy indicate that by refinement of the deployed techniques the tool could be used in parallel with the existing process.
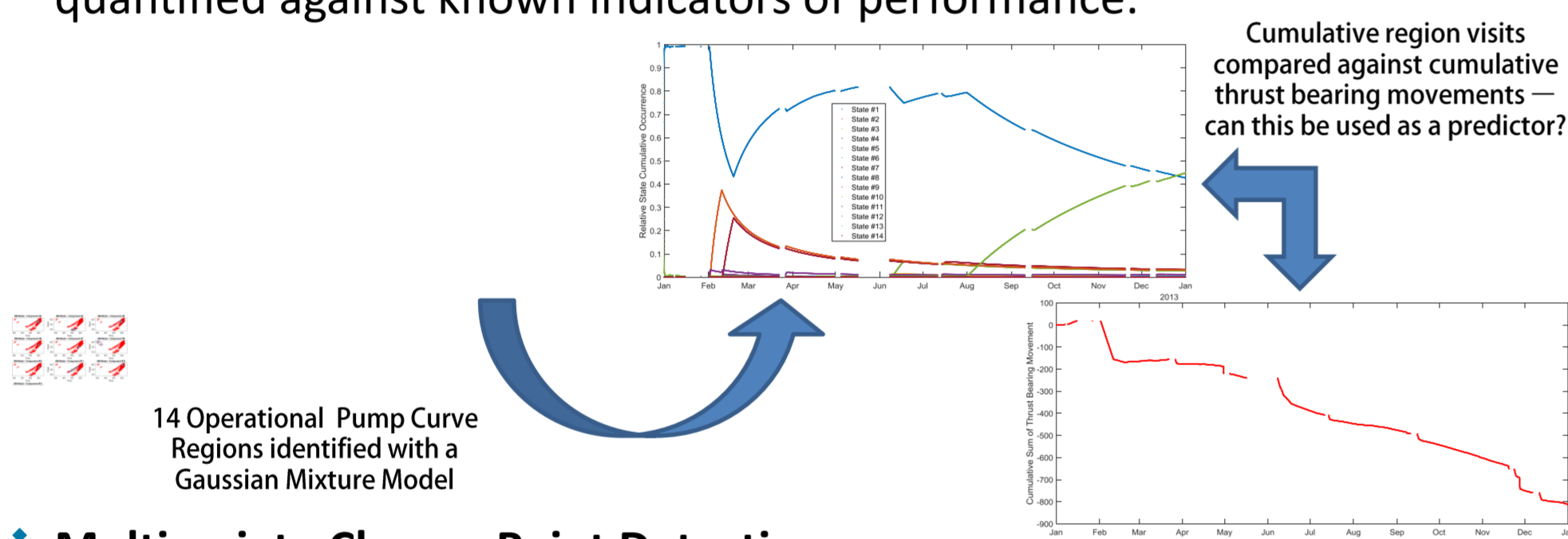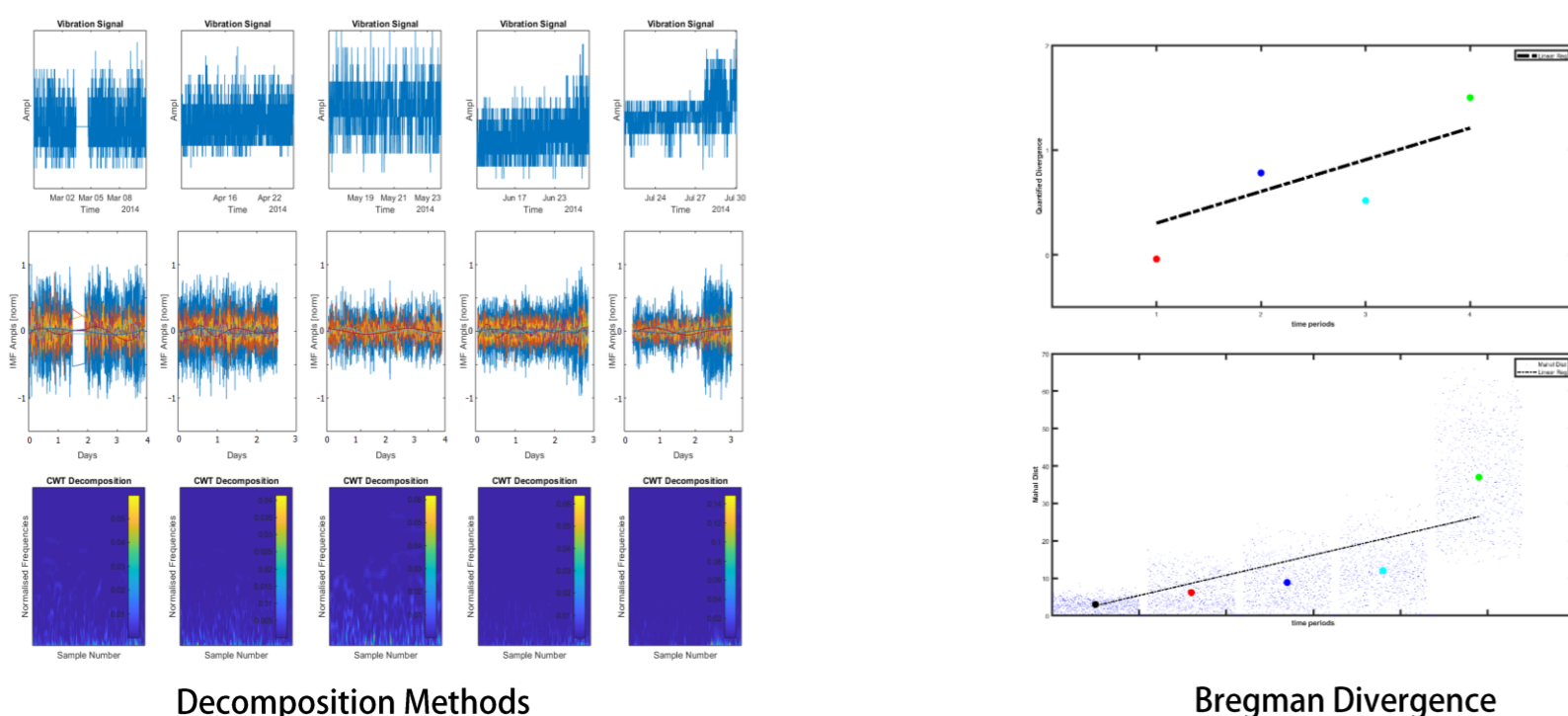

Example user interface for signal to symbol transformation

Historical data trend classification

Data Visualisation Techniques

❖ Novel means of visualising the energy contributions from composition of vibration signature;
❖ Help operator and OEM identify asset state changes;
❖ Quantifying how 3-simplex distribution shape evolves over time can be used as a metric for evolving asset health state;
❖ The underlying analysis techniques associated with the novel visualisations support parallel work in diagnosis and prognosis.
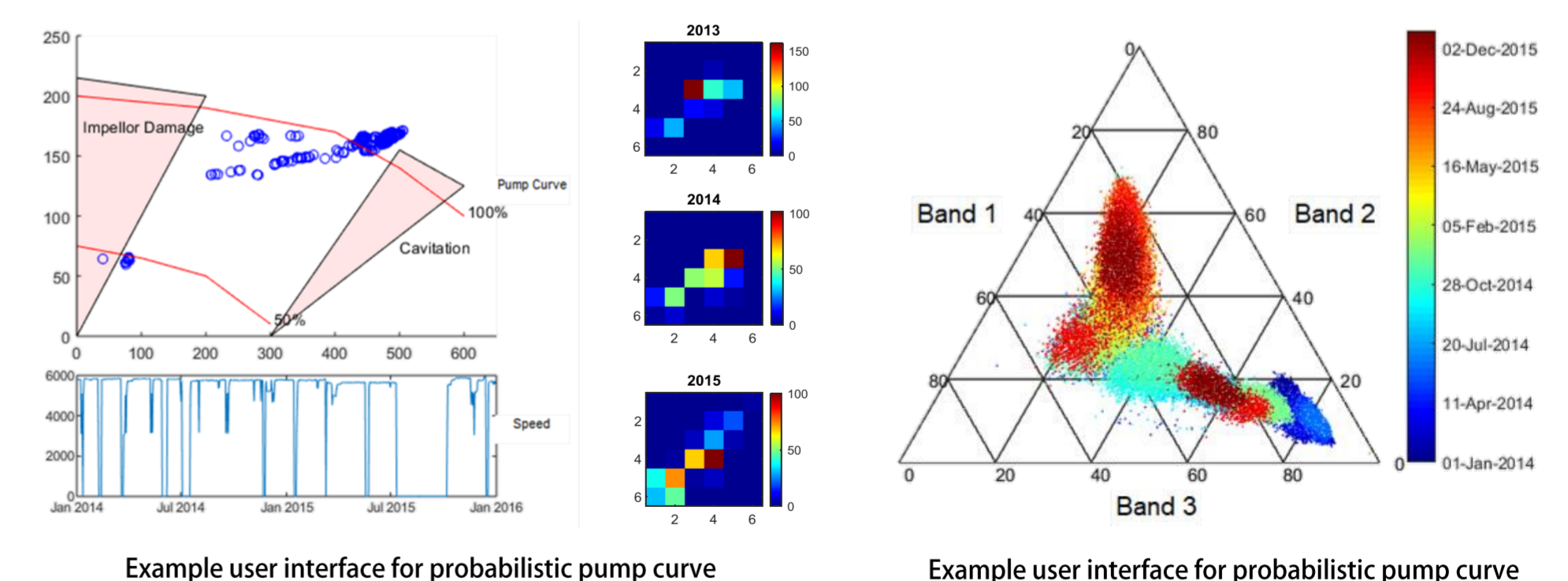
Example user interface for probabilistic pump curve

Example user interface for probabilistic pump curve

Future Work

❖ Pull through fundamental research into algorithms and techniques that can be translated and deployed. for all programme partners.
❖ Demonstrate an intelligent system that reduces the data analysis burden currently experienced by asset analysts.
❖ Additional case studies based on a broader asset base and driven by partner priorities.
❖ Formalise software development plan.

EDF ENERGY | WEIR | The Alan Turing Institute | EPSRC Engineering and Physical Sciences Research Council | UNIVERSITY of STRATHCLYDE ADVANCED NUCLEAR RESEARCH CENTRE