Prediction of Combined Sewer Overflow Chamber Water Levels using Rainfall Forecasts

Presented by

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Overview

- About United Utilities
- Drivers for Change
- Innovation and R&D
- Why Predict CSO levels?
- Why do a Proof-of-Concept (POC)?
- CSO Level Forecasting Methodology
- POC Architecture
- Prototype & Results
- Summary

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About United Utilities

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Challenges at United Utilities

- Regulatory and customer commitments
- Key Performance Metrics
  - Outcomes, Blockages, Spills
- Be more efficient
  - Reduce Totex – Capex and Opex
- Technology Disruptors
- Apply Innovation

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Innovation Projects at United Utilities

Innovate UK

- Water Network Event Recognition
- Wastewater Network Event Recognition
- Water Process Event Recognition
- Water Network Event Localisation
- Event Management for Intelligent Water Networks

STREAM
Shaping careers, delivering innovation
The Industrial Doctorate Centre for the Water Sector

Cranfield UNIVERSITY

The University Of Sheffield.

UNIVERSITY OF EXETER

EPSRC

Imperial College London

Newcastle University

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Wastewater Network Drivers and Opportunities

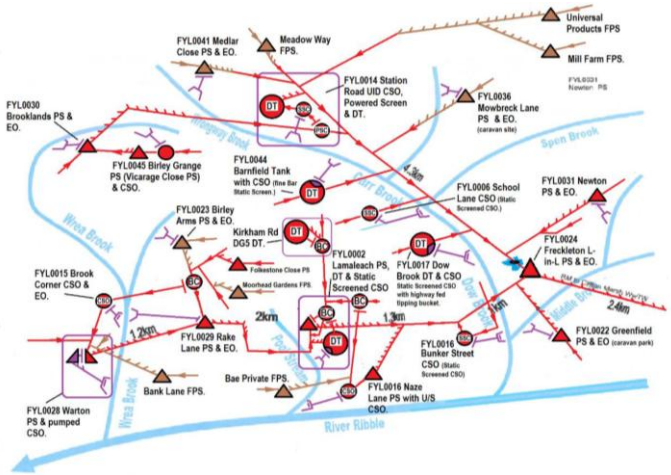
Benyon letter calls for more CSO monitoring by 2020

17/10/2014 Share: 13

Defra has published a letter urging the UK water and sewerage companies' (WaSCs) to introduce monitoring for the "vast majority" of combined sewer overflows (CSOs) by 2020. The letter, to WaSC chief executives, was written on July 18, 2013 by then water minister Richard Benyon and has been published now under the Environmental Information Regulations 2004 (EIRs).

Environment Agency

Event Duration Monitoring Programme



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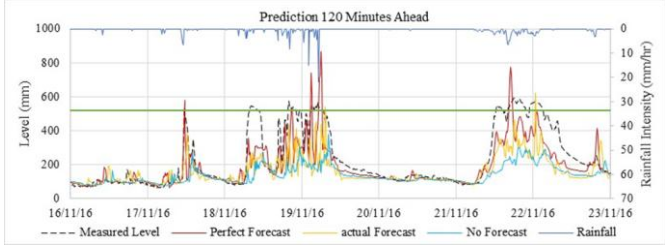
Why do CSO Level Prediction? Drivers



- Get ahead of incidents e.g. flooding, pollution
- More efficient and effective operational response
- Go when need to go and not when don't
- Reduce false alarms & call-outs e.g., wet weather alarms
- Inform Active System Control, load balancing
- Targeted risk based maintenance instead of periodic

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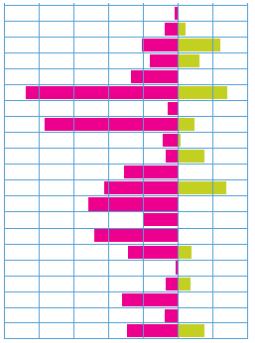
Why do CSO Level Prediction? - Benefits



- Environmental protection
- Improved Regulatory Compliance
  - Ofwat – ODI, SIM incentives
  - Environment Agency – consent compliance, avoid fines
- More efficient operation
  - e.g. energy cost saving, reduced cost of failure
- More efficient maintenance
  - risk based prescriptive not periodic
- Totex approach – potential avoidance of capex
- Analytics savings – data driven vs hydraulic modelling

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Why do a Proof-of Concept? - Aims

Demonstrate an online CSO spill forecasting system

- Link time series data and analytics platforms
- Understand how advanced analytics can be developed in an agile way
- Understand potential for productionisation
- Demonstrate accuracy and robustness of system

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CSO Level Prediction Methodology

- Evolutionary Artificial Neural Networks (EANNs) to predict water level in a CSO chamber up to 6 hours ahead
- 24 EANNs with different forecasting horizon (i.e., 15 minutes to 6 hours ahead) that run in parallel
- Inputs:
  - Past CSO levels
  - Observed radar rainfall
  - Radar rainfall forecast

Not as computational demanding as hydraulic models and do not require the calibration of a large number of parameters

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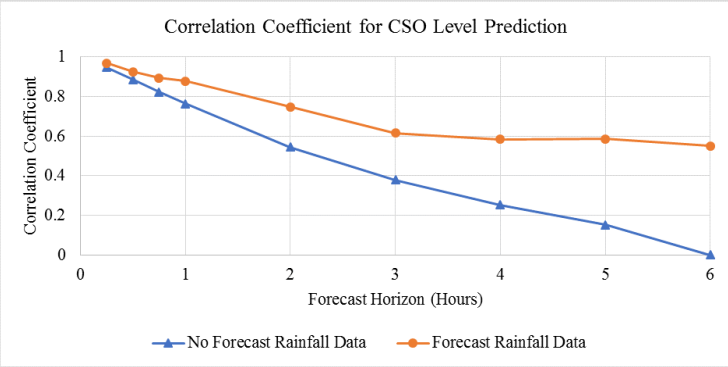
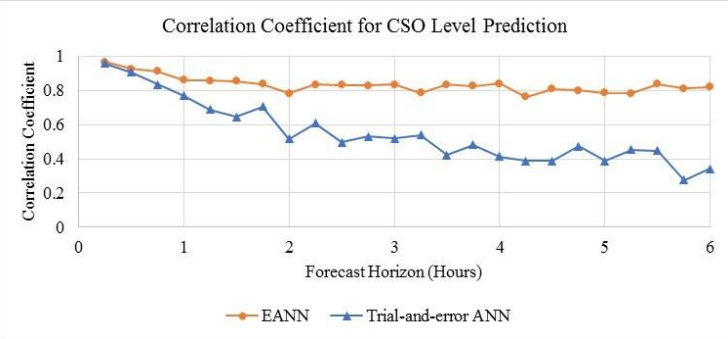
Scientific Advances

- Using forecast rainfall data when forecasting CSO level measurably improves the ANNs prediction accuracy and prediction range
- The Evolutionary optimisation strategy enables to automatically select the optimal ANN input structure and parameter set:
  - dramatic reduction of the efforts required from a human expert to design an ANN model whilst enabling outperforming the quality of the results achievable through human expert intervention
  - each EANN model is tailored to the particular CSO and forecasting horizon



Rosin, T., Romano, M., Woodward, K., Keedwell, E. and Kapelan, Z. (2017). "Prediction of CSO chamber water levels using rainfall forecasts." Proc. of the 15th Computing and Control for the Water Industry conference, Sheffield, UK.



Rosin, T., Romano, M., Woodward, K., Keedwell, E. and Kapelan, Z. (Submitted). "Prediction of CSO chamber water levels using Evolutionary Artificial Neural Networks." Proc. of the 13th International Hydroinformatics conference, Palermo, Italy.

Accurate predictions & practicality of the methodology operationalisation

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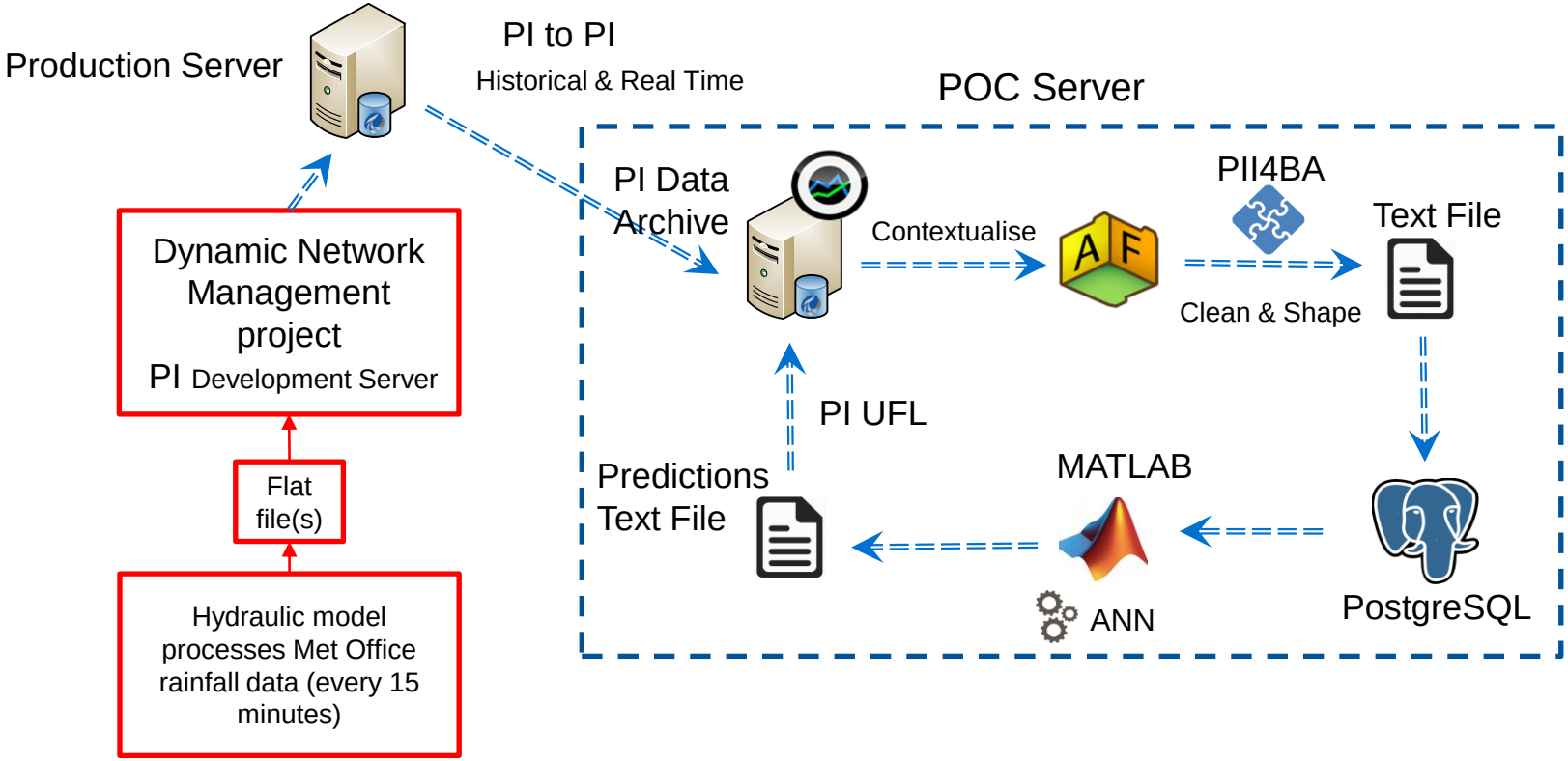
POC Architecture



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POC Prototype – Smart Alerts

- Intervene when needed - e.g., spilling during dry weather
- Reduce call-outs - e.g., wet weather spills
- Get ahead of incidents - e.g., flooding, pollution

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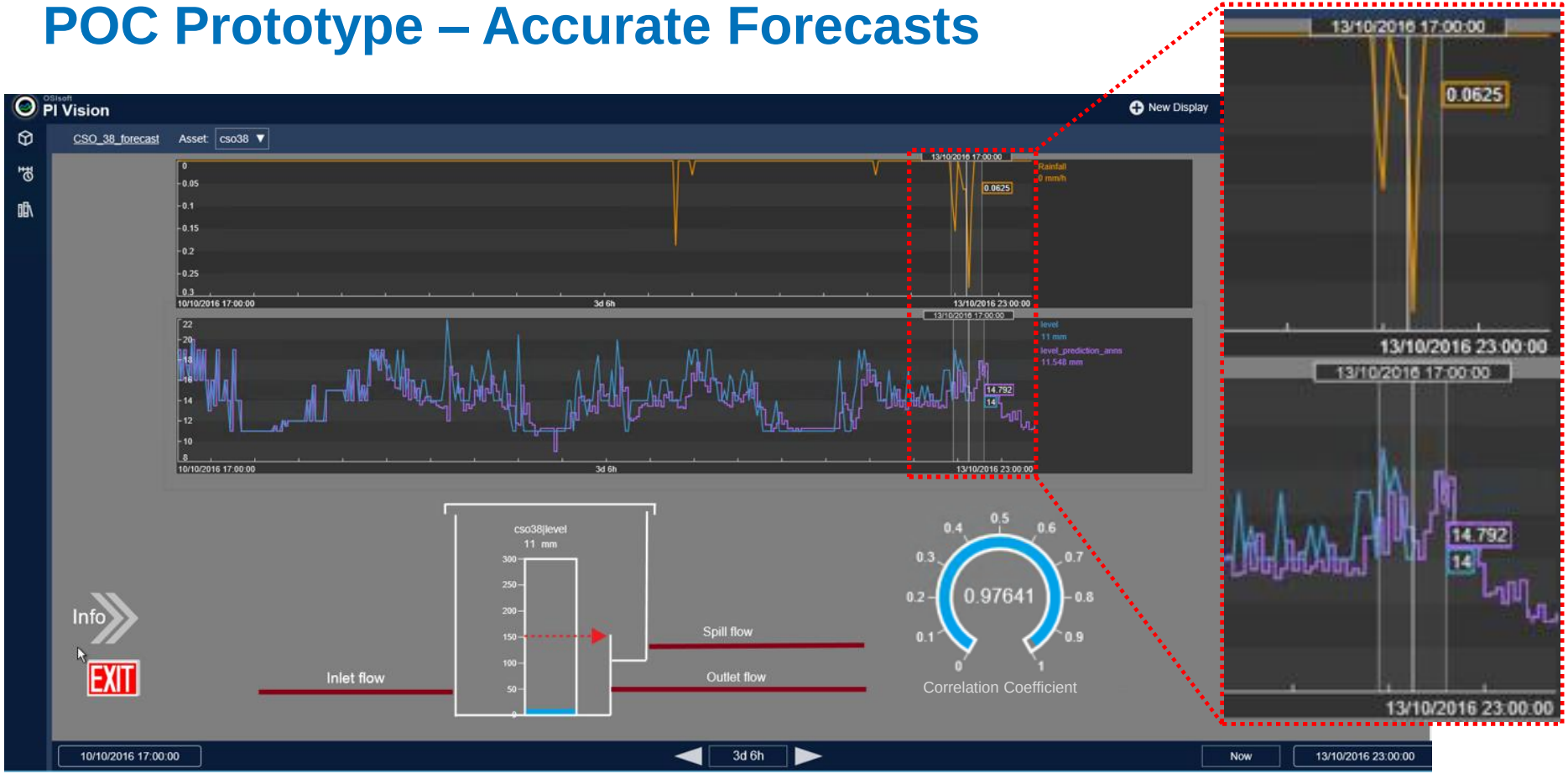
POC Prototype – Accurate Forecasts



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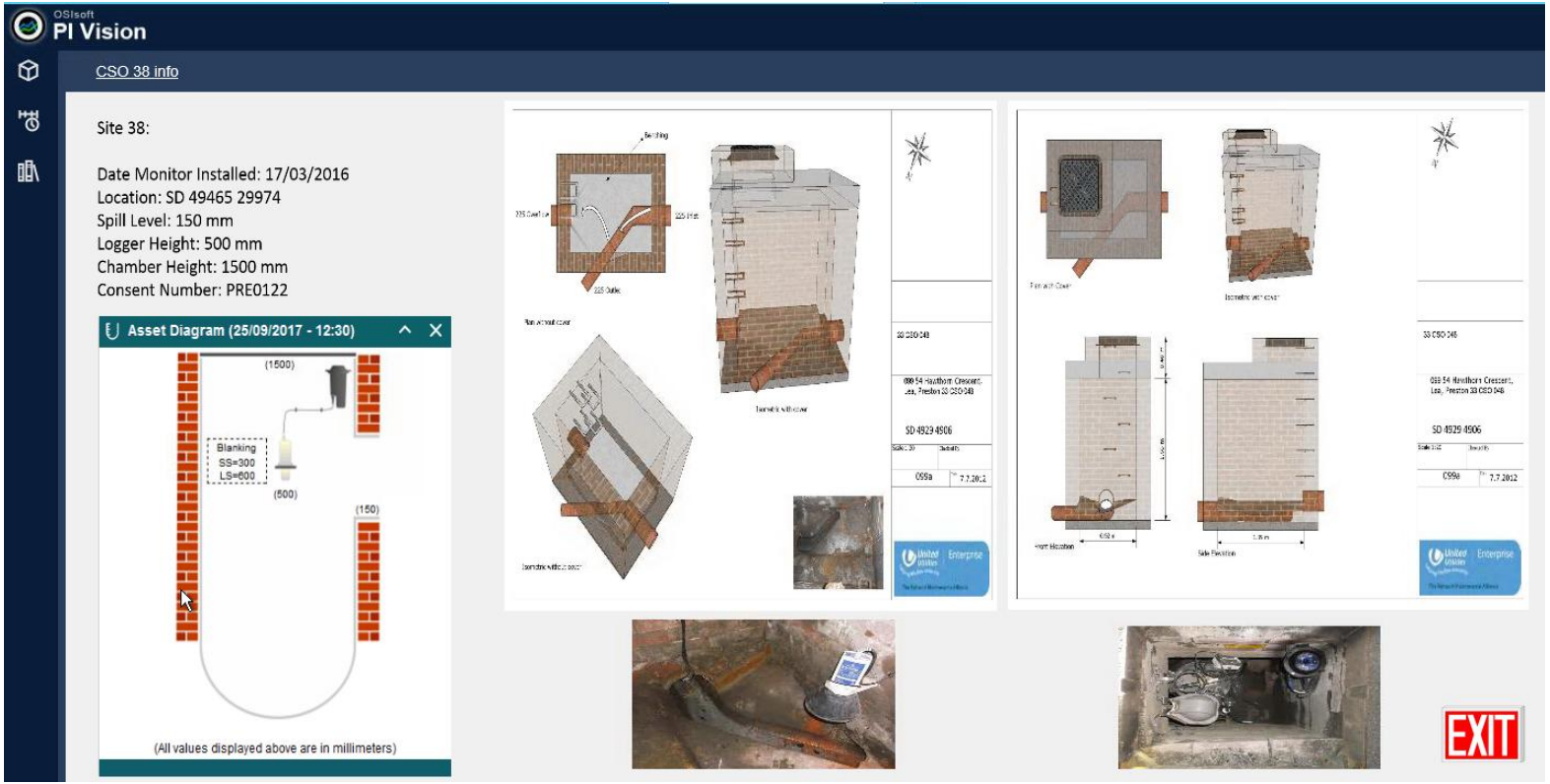
POC Prototype – Readily Available CSO Information



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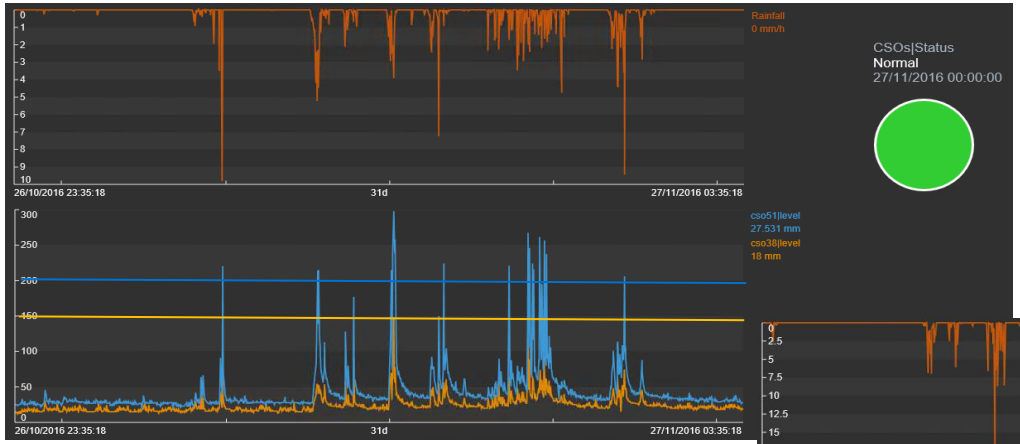
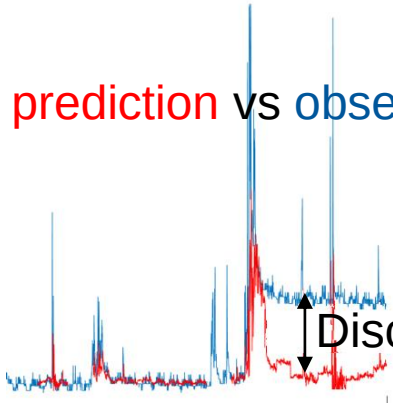
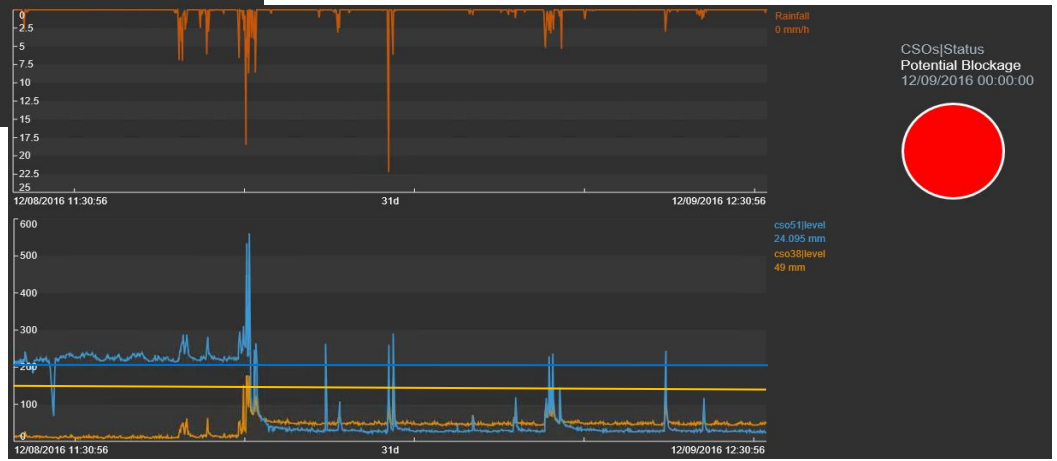
POC Prototype – Targeted Risk Based Maintenance and Prompt interventions



Model prediction vs observed level





Further development of methodologies for:

- near real-time detection and diagnosis of unconsented spills, blockages and collapses
- active network control and optimisation

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Summary – A Successful Proof of Concept that Will Enable Further Development

COMPANY and GOAL

United Utilities vision is to be the best UK water and wastewater company, providing great service to our customers. The company seeks innovative solutions to support this vision.

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CHALLENGE

Agile development and adoption of advanced analytics is difficult

- Access to online time series data
- Integration of online time-series data to analytics platforms
- Development and assessment of algorithm performance
- Automation and productionisation of algorithms

SOLUTION

Link time series data to MATLAB via PII4BA to create an online CSO level forecasting system

- Small scale POC (2 CSOs)
- Work with academic partners and OsiSoft
- Algorithms development and testing with real-life online data
- Automation of algorithms

RESULTS

Agile development of an online system producing accurate CSO level forecasts

- Successful integration of time series data to analytics platform
- Novel machine-learning algorithm that produces highly accurate short term CSO level forecasts
- Reliable, fully automated system
- Technology customisable to UU needs
- On-going investment and R&D – e.g. potential scaling up, other POCs

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Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

Please remember to…

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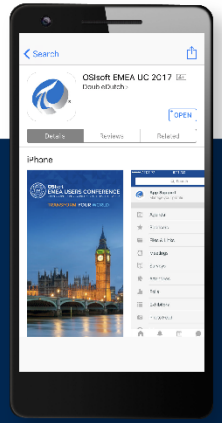

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Danke

谢谢

Merci

Gracias

Thank You

ありがとう

Спасибо

Obrigado

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