Sensor systems. Evolution of QA/QC – a personal (and brief!) perspective

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AGENDA

ASIC

30 April to 3 May 2024

- Get some thoughts brewing for discussions later
- Early use of sensor systems in UK
- QA/QC evolution for sensors
- Current situation
- Future?

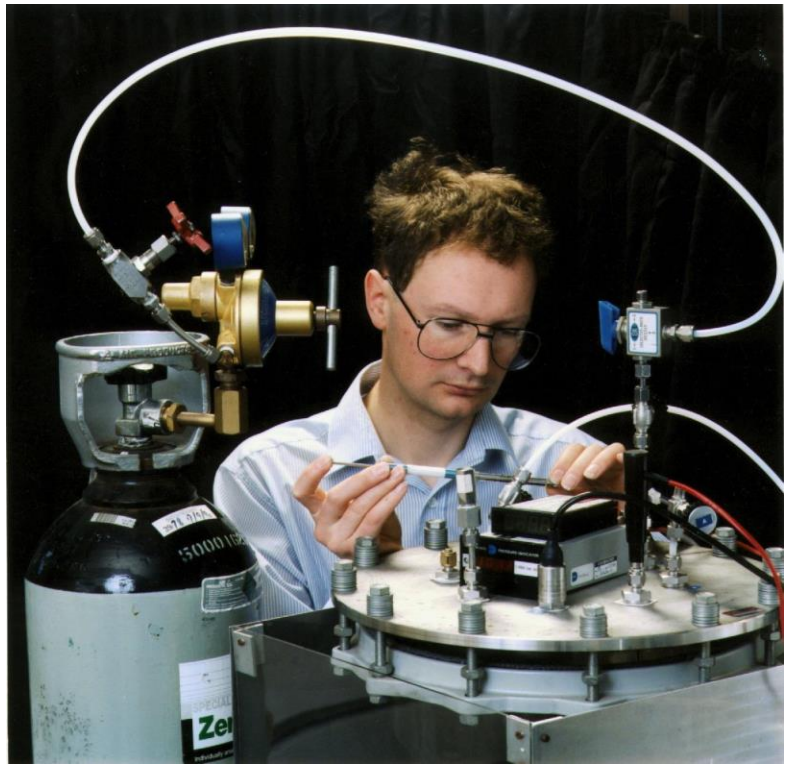
WHO WE ARE

A global strategic, environmental, and engineering consulting business

- Transport
- Air Quality and Environment
- Sustainability
- Policy, strategy and economics
- Energy Decarbonisation
- Water
- Digital Modelling

Sensor System Calibration and QA/QC – First principles

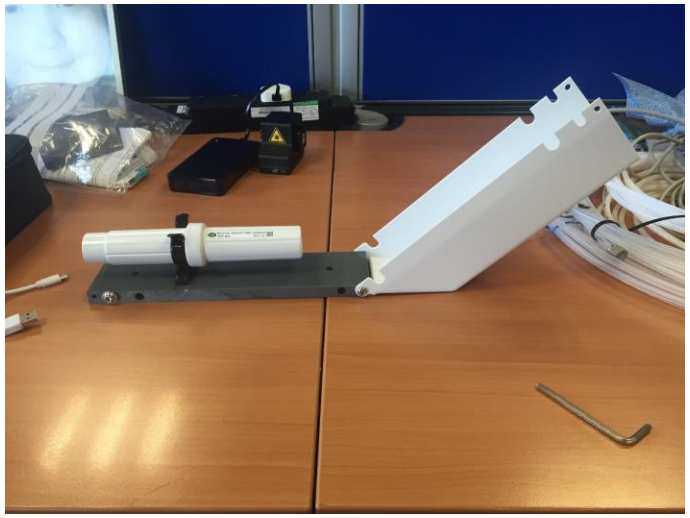
- Ricardo have provided QA/QC for UK network data since the 1960's.
- Application of fundamental metrological principles (two-point calibration with traceable gases, derive slope and intercept values, correct raw data).
- Initially followed these principles for early sensors, but clear that ambient- level concentrations would create challenges.



Sensor systems – in the early days

- UK investigations from the late 80's onwards
- NO_2, CO and PM_{10}
- Primary focus on short term studies (fixed locations), mobile surveys (walking and in-vehicle) and occupational exposure
- Calibration used modified procedures for reference grade equipment (gas cylinders, scrubbed pumped zero air) – no accounting for interferences

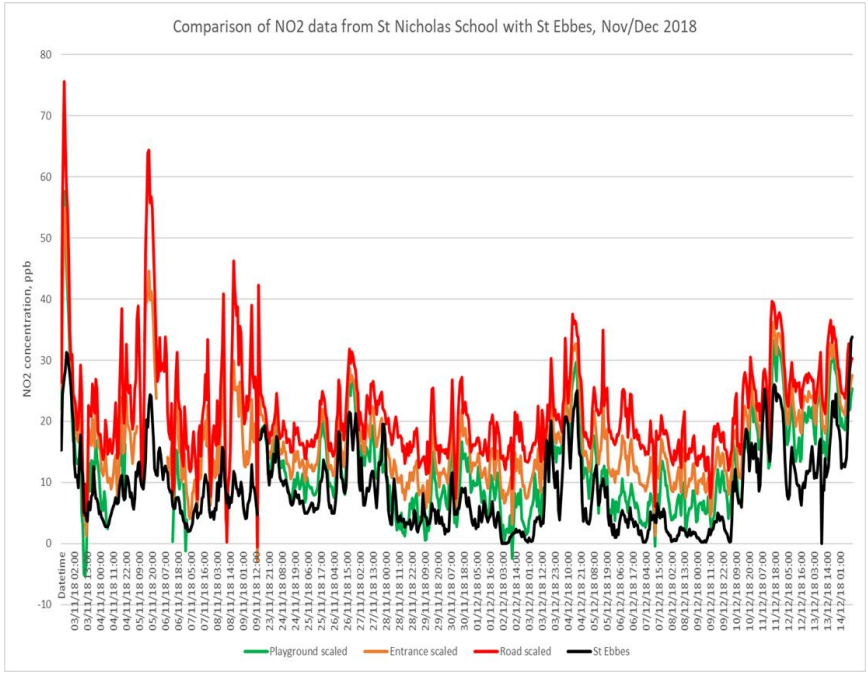
Developments -10's



- Sensor system providers started to market their devices for ambient measurements, both fixed and mobile
- So many questions!
  - Calibration?
  - Repeatability?
  - Drift?
  - Effect of movement?
  - Comparison with Ref?
  - Interferences?
  - Data processing?
  - QA/QC?
  - etc…

QA/QC, first stab for sensors?

- Co-location
- As long as possible
- Review datasets, reject obvious failing sensors
- Scale individual sensors based on initial results
- Deploy in chosen campaigns
- Co-location after campaign (if possible)



Into the 20's – many system providers – how do you decide?

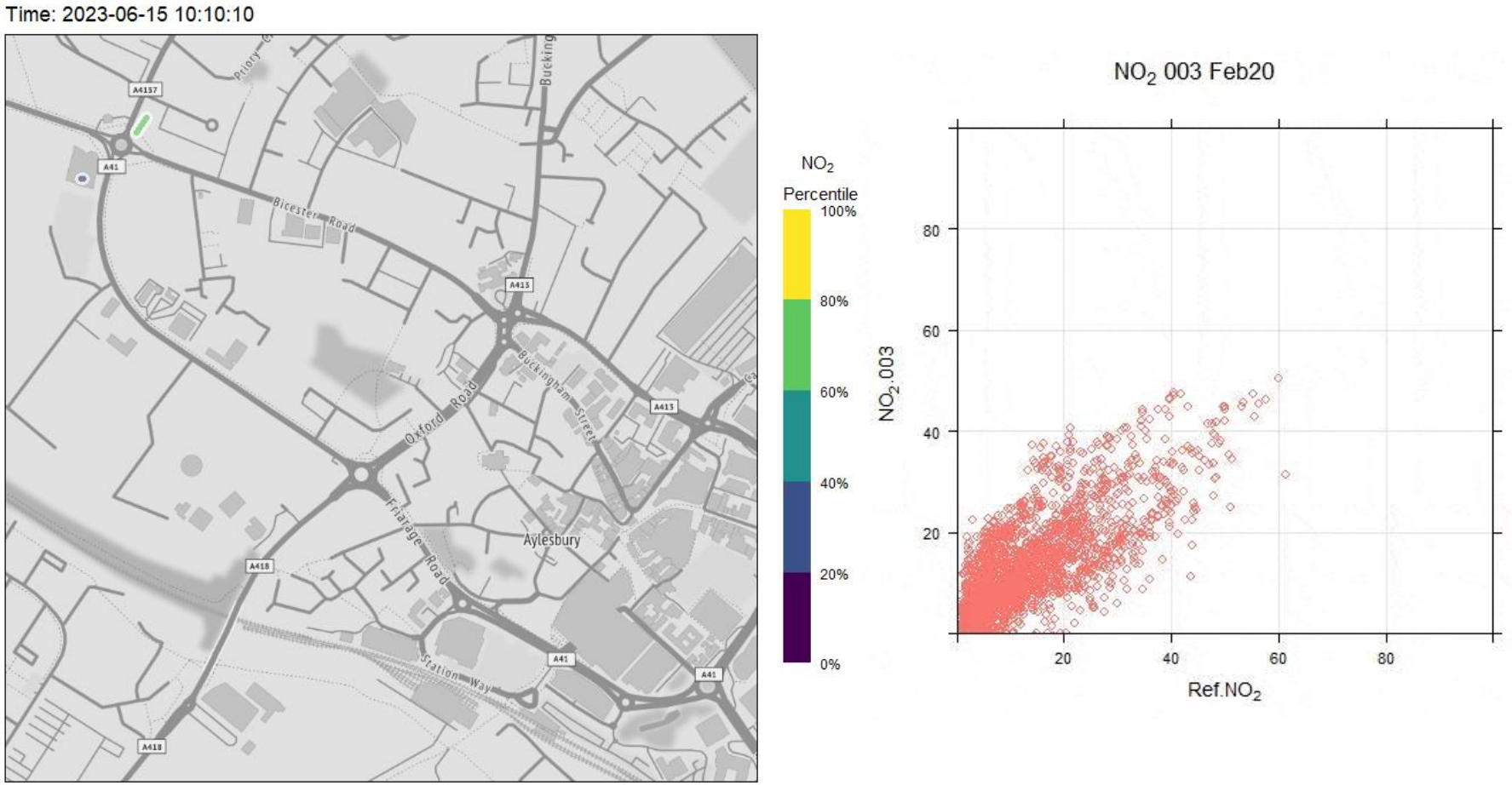
- We run continuous co-location studies at three locations in the UK (since 2018!)
- Suppliers always welcome to deploy their systems to access reference-quality data (NOx and PM)
- We evaluate performance, they get data to improve their systems
- Win for us, Win for them, Win for end user.

System	Price	PM10 raw	PM10 + QC	PM25 raw	PM25 + QC	NO2 raw	NO2 + QC
System A	££££						
System B	£££						
System C	£££						
System D	£££££						
System E	£££						
System F	££						
System G	££						
System H	££						
System I	££						
System J	£						
System K	£						
System L	££££						

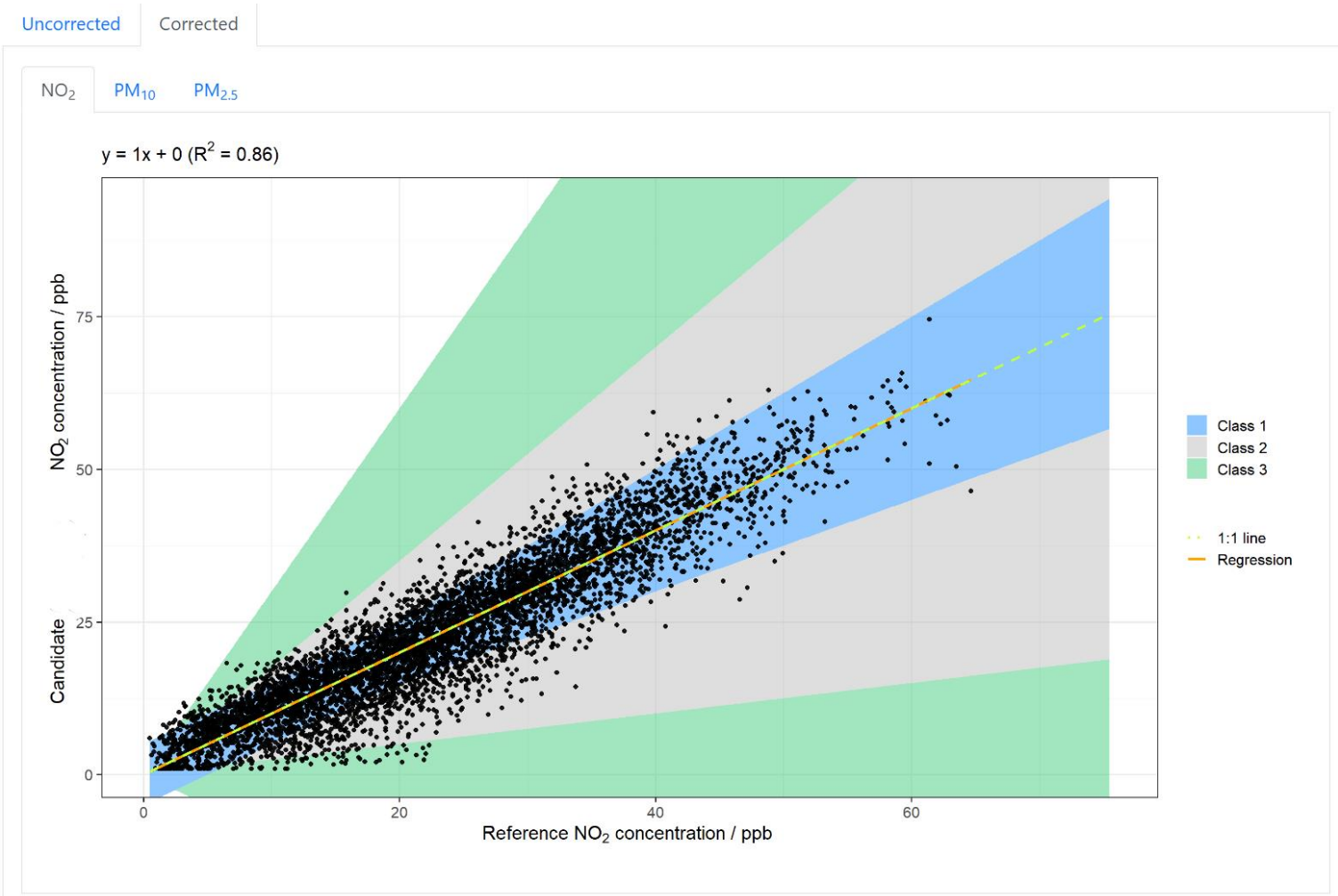
Table shows that nearly all systems can be improved with QA/QC. High price not always a quality guarantee!

Considerations! What have we learned so far?

- Co-location
- Dataset training
- Interference “correction”
- Roadside / UB / Rural / Industrial
- Sensor ageing / Seasonal response
- Confidence that measurement uncertainty is maintained (**and fit for purpose**)
- Rapid identification of performance anomalies
- Understanding sensor limitations (T, rH, “guessing” PM_{10}, fixed vs mobile, etc.)
- Variability between “identical” systems

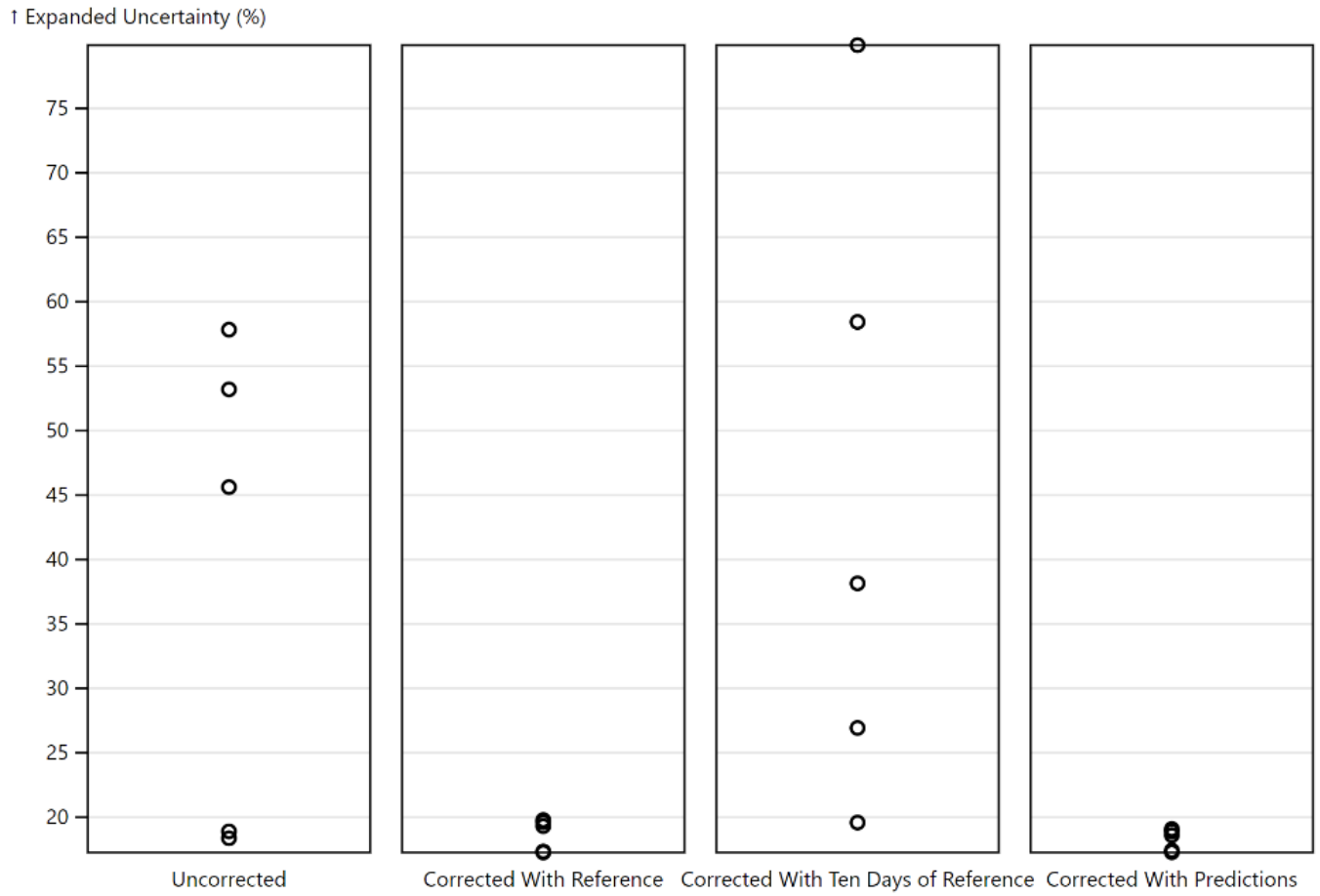


Future gazing



- It won't be possible to process sensor system data in the same way we do for reference grade equipment (just sheer numbers of sensors and data!)
- European Technical Specifications TS17660 -1 and -2 will help to quantify performance and time period for this certification
- But ongoing QC critical for seasonality and regionality variations in data verification
- Some kind of assistance needed

A possible solution?



- Similar to work done by others (e.g. Cambridge)
  - Establish baseline periods from regional reference analysers and identify periods of commonality
  - Use this information to cross reference sensor systems and calculate slope/offset factors
  - Explore validity of correlation for a range of location types and distances
- Investigate for different pollutants ($PM_{2.5}$ easiest…)
- Verify and sell as a service!
- BUT! When does this stop being a measurement? (and does that matter?)

Take home message:

QA/QC / post-collection verification is essential!

Thanks for listening!

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