




IT systems for network management and the quality control of air pollution measurements

Challenges of operating an air quality network – tips for system design

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Regional Air Quality Monitoring in SE England ~170 sites

Also DEFRA particles network (with NPL)

- Gravimetric samplers
- Particle counters
- Particle sizing
- Automated nitrate and carbon
- 2 GCs
- traffic counter




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Contents (challenges)

- Data collection
- Near real-time dissemination
- Interfacing with the human
- Handling the 'other' information
- Ratification
- Tips for system design

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Data Collection

KCL networks are bottom – up

- No consistent site design or logging systems


Networks set up for different purposes

- Measurement of 'classical' pollutants
- VOC measurement by GC
- Particle characterisation

Over 50 different site information storage / retrieval systems

- Analogue or digital input loggers
- On board loggers
- PC systems (ip connectivity)

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Data Collection

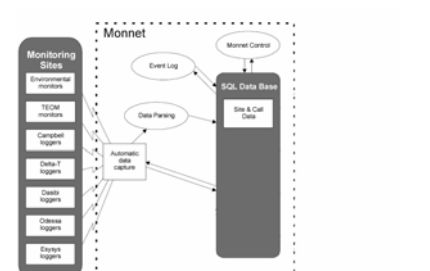
Possible solutions

- Buy different manufacturer's software for each site type
An operational nightmare!
- Retrofit consistent logging systems
Looses on-board systems information
High cost per site
- Develop a flexible data collection system
High central cost
Low incremental cost

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Our solution - MONNET



The diagram shows a central 'MONNET' box containing 'Monitoring Sites' (with sub-items: Environmental monitors, TEOM monitors, Canister loggers, Data-IT loggers, Dust loggers, Ozone loggers, Emission loggers) and 'Event Log'. This connects to 'Automatic data capture', which feeds into an 'SQL Data Base' containing 'Site & Call Data'. A 'Monnet Control' box is also connected to the database.


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Near real-time dissemination



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Near real-time dissemination

Web pages, AURN DDU, Email feeds, Data downloads


24 hour, 7 day per week

Between 5 and 30 mins to check

6000 measurements per hour or 1 million per week

Requires automated checks

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Near real-time dissemination Automatic Checks

Analysers diagnostics

- equipment automatically flags faults
- Ideally direct analyser links ie no logger

Automatic interpretation of analyser diagnostics


- retention time drift for GC systems
- particle counters

Realistic output from site equipment?

Realistic ambient concentration?

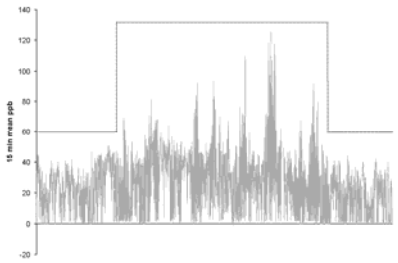
- Absolute peaks
- Relative concentrations
- Really not simple.....

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Automatic Checks – O₃ at Sevenoaks

Scaled measurements 2003

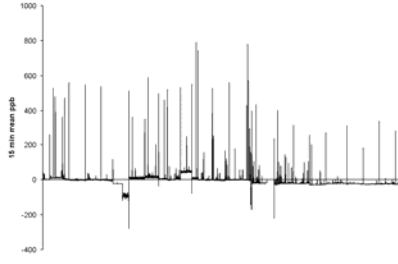


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Automatic Checks – SO₂ at Bedford

Raw measurements 2005

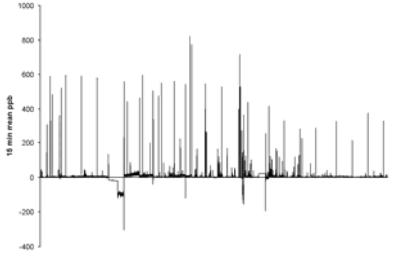


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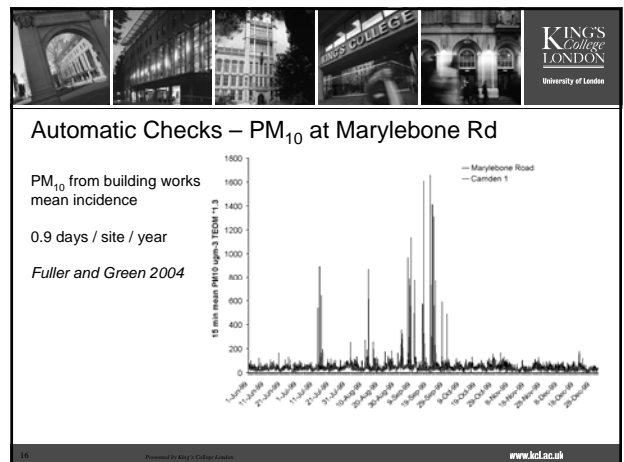
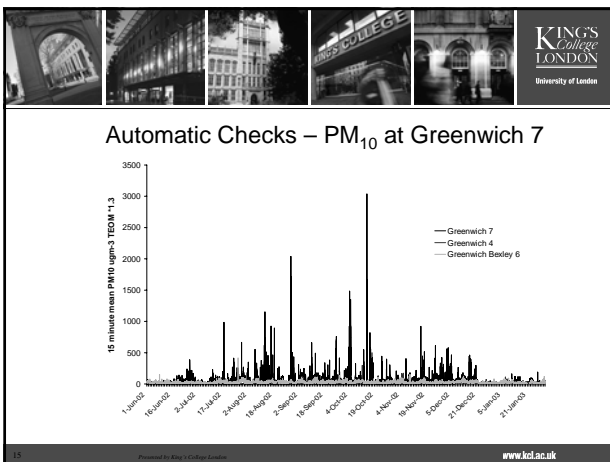
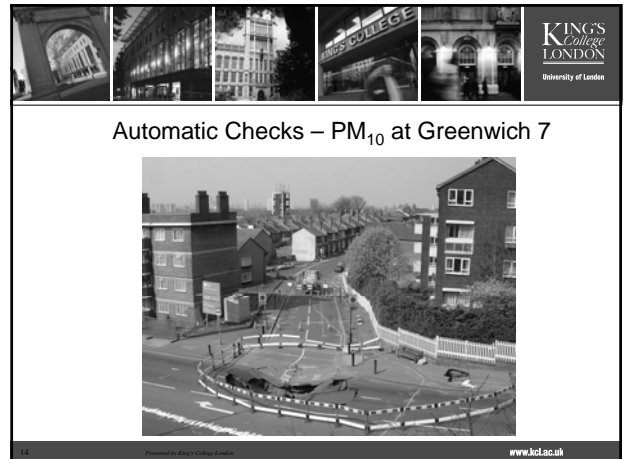
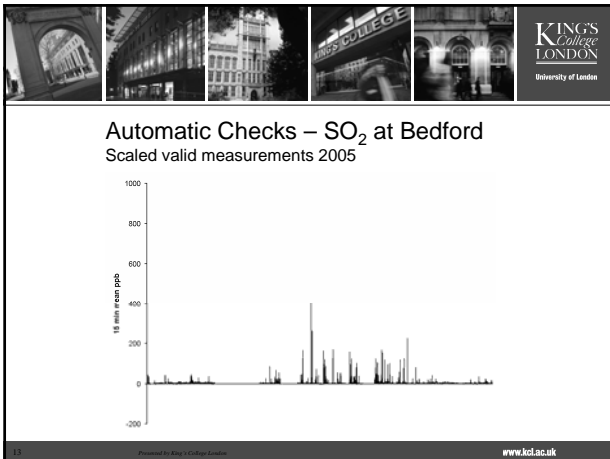


Automatic Checks – SO₂ at Bedford

Scaled measurements 2005



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Interfacing with the human

Clear information

Graphical displays

Pre – selected information for human decision

- Comparisons between pollutants and sites
- Confirmation of automated decisions
- Overnight calibrations

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Handling the 'other' information

What is it?

- Call outs
- Calibrations
- Audits
- Service and repair reports

- total of around 7000 per year
- (AEAT have an automated calibration reader)



Handling the 'other' information

SiteFiling

- a tool for moving and storing site information

- configurable on a site / instrument basis
 - Particles data to NPL
 - QA/QC data for AURN to AEAT



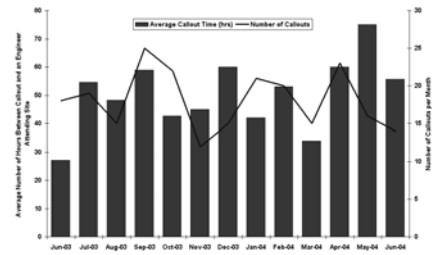
Handling the 'other' information

SiteFiling - Instrument call outs

- 8 different service organisations
- Service organisation is invisible to our operator
- Automatic copies to NPL (particles) site owners
- Automatic reminders for unattended call-outs
- Enables tracking service organisation response



Handling the 'other' information



Ratification

What is it?


- Retrospective recalculation of all measurements in light of
 - Calibration histories
 - Instrument performance history
 - Audits
 - Key to producing the final dataset
 - Presentation of information is crucial



Ratification

When did a fault occur?

- Eg fault found at 6 monthly audit but should we delete 6 months measurements?
- Can it be determined from calibration performance?
 - Traced to service / repair?



Ratification


Cumulative Sum (CUSUM)

Page (1954) for industrial process control

Other applications include:

- Epidemiology
- Efficacy of treatments
- Change points in air quality measurements
 - Barratt et al 2006
 - Carslaw et al 2006

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Ratification - CUSUM

$$z_j = \frac{y_j - \bar{x}}{\hat{\sigma}_y}$$

y_j is the observed value at time j
 \bar{x} is the desired process mean
 $\hat{\sigma}_y$ is an estimate of the standard deviation of the observed values.

These are accumulated over time to compute the CUSUM, S_j , at each time point j


$$S_j = S_{j-1} + z_j \quad \text{where } S_0 = 0$$

Separate application to positive and negative deviations, with a 'slackness' factor k

$$S_{j+} = \max[0, (z_j - k) + S_{j+}]$$

$$S_{j-} = \min[0, (z_j + k) + S_{j-}]$$

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Ratification

- a knotty problem at Watford

During 2005 PM_{10} improved the roadside in Watford

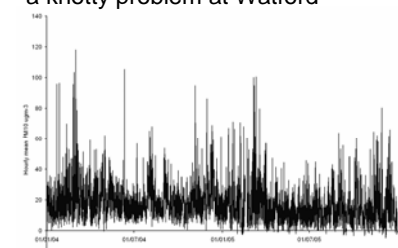
- It got so good that the annual mean fell below nearby background sites!
- No maintenance and service problems
- Sustained perfect audit results

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Ratification

- a knotty problem at Watford

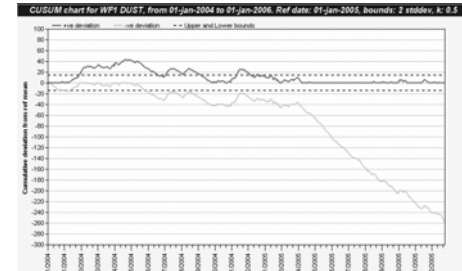


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Ratification

CUSUM chart for WPI DUST, from 01-Jan-2004 to 01-Jan-2006. Ref date: 01-Jan-2005, bounds: 2 stdev, k: 0.5



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Ratification

- a knotty problem at Watford

CUSUM identified a change at service

Through investigation by ESU revealed an accidental entry of 6.196 instead of 3 as the TEOM offset.

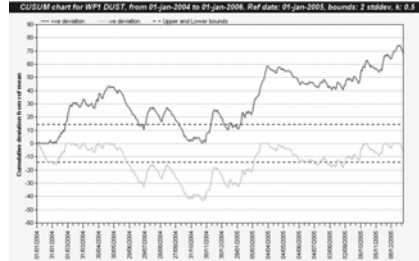
- TEOM software was corrected
- Measurements were recalculated to remove the offset error

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Ratification

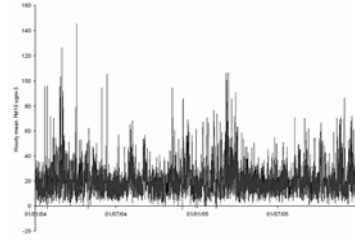
– a knotty problem at Watford – fixed!



Ratification

– a knotty problem at Watford – fixed!

Watford (blue) of Stevenage (red)



Tips for Systems Design

- Collect measurements direct from equipment without loggers
- Scope for automated post-measure QC is limited without excluding pollution incidents
- Collect all possible diagnostic information from site
- Automated systems for the 'other' information
- Use a database and you can create your own analysis tools
- Use humans judiciously