Next Generation Urban Air Quality Monitoring Technologies

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Quality - Service - Innovation

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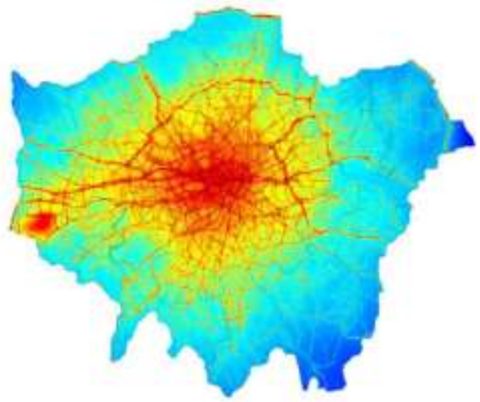
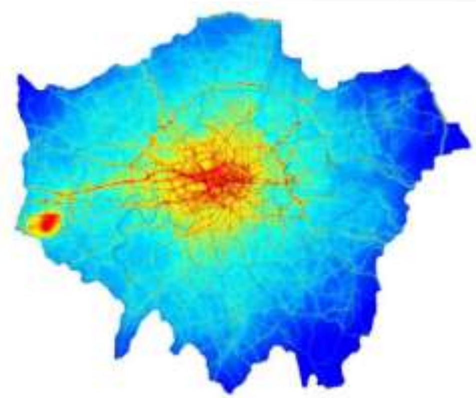
ENVIRONMENTAL MONITORING & DATA MANAGEMENT TECHNOLOGY

London Air Pollution in Context

2004





2010

Compliance based on 2008/50/EC CAFE Directives

UK and 18 other countries failing to meet 2010 targets

UK potentially now faces **£300m EU** fine

Impact of air pollution estimated at **50,000** deaths/year

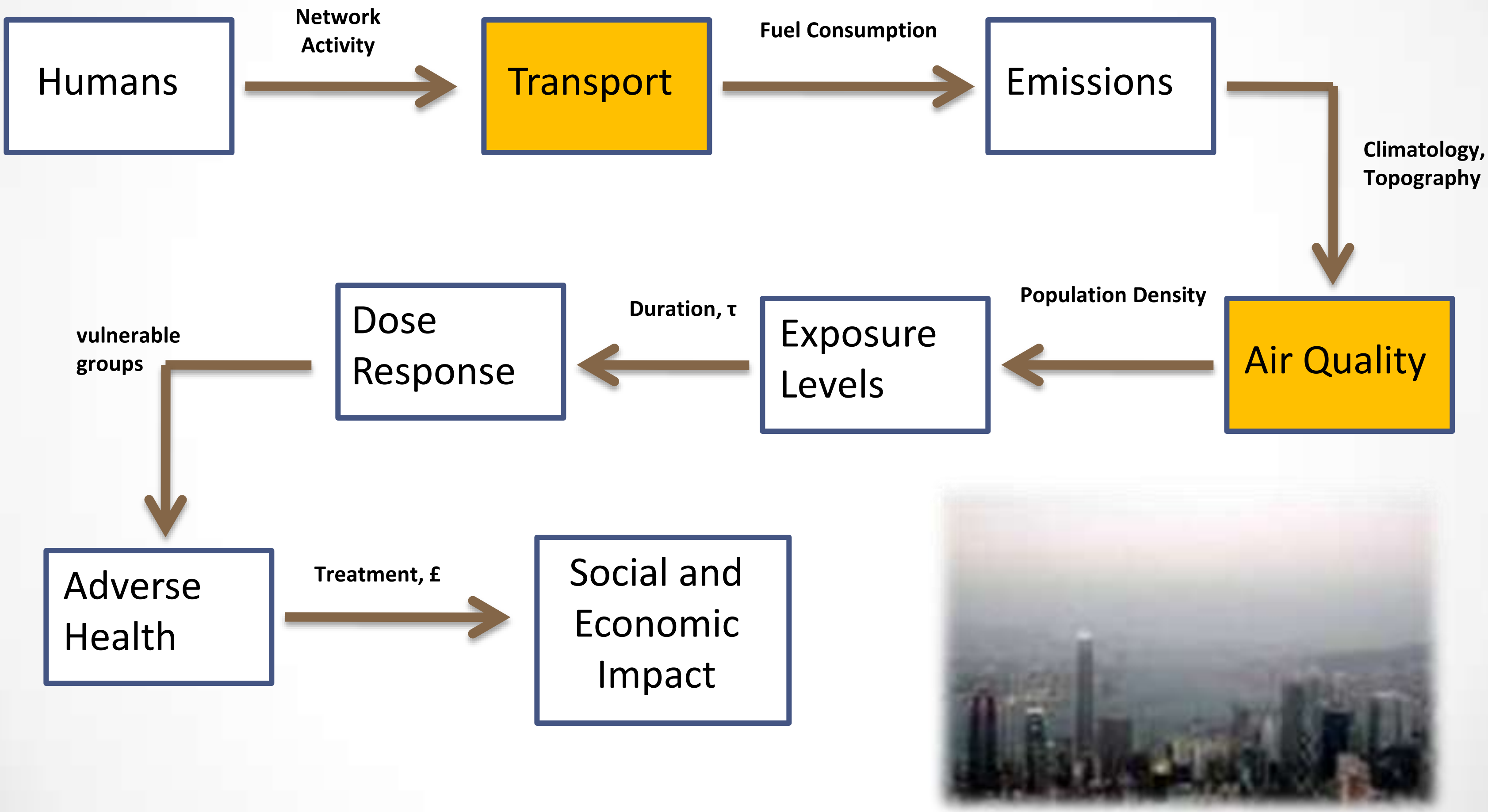
Air pollution estimated to cost **UK £20bn/pa**

2015 final deadline, but understanding and strategies required to be demonstrated by member states

Greater need for higher time/space resolution indicated, short and long term strategies


A few weeks in, London exceeds EU's pollution limit for the year

There is a strong link between transport activity, air quality, and its eventual impact on society



Current Monitoring Technology

- Existing monitoring technology is out-dated, expensive to buy and maintain and cumbersome
- Local and Regional authorities do not want to maintain many monitoring stations neither is there space or money for additional monitoring stations
- Sparsely distributed fixed monitoring sites do not provide representative data
- Quality of information limited by low time/space resolution
- Value of existing data analysis limited by heavy assumptions and inaccurate modelling in urban areas

What do we need?

- Compact, credible and affordable monitoring technologies for real-time ppb analysis of multi species pollutants

- Robust deployable fixed and mobile sensor networks

- On-demand modelling and analysis tools

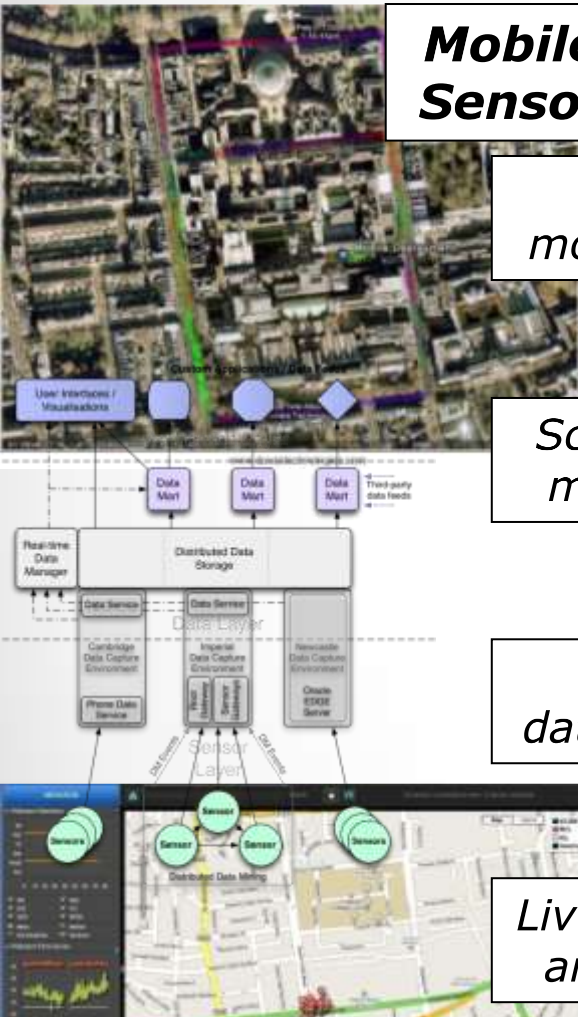
- Supportive datasets *(traffic, meteorology, health, epidemiology etc)* to demonstrate the value of sensor networks, and influence policy change

MESSAGE Research Programme

- Mobile Environmental Sensing System Across Grid Environments
- 3 year project initiated October 2006
- Funded jointly by EPSRC and DfT (~€5m), under EPSRC's e-Science demonstration programme
- 5 Universities, 20 industrial partners
- Pioneering combination and extension of leading edge grid, sensor, communications and positioning technologies
- Create radically new sensing infrastructure based on combination of mobile and fixed sensors

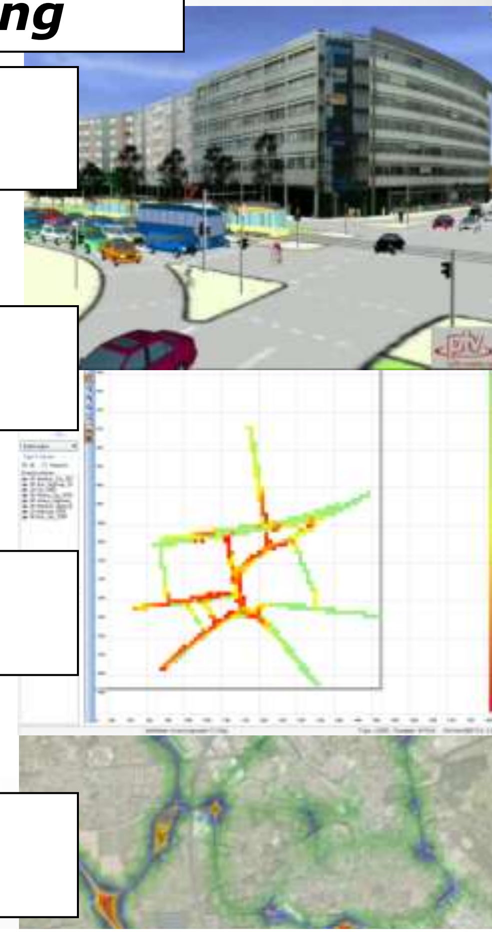
The MESSAGE "System"

Measurement and Modelling



Mobile Wireless Sensor Network ⟷ **On-Demand Modelling**

Mobile Wireless Sensor Network	On-Demand Modelling
Fixed and mobile sensors	*Scenario models*
↓	↓
Scalable data-management	*Pollutant Emissions*
↓	↓
Federated database query	*Pollutant Dispersion*
↓	↓
Live display and analysis tools	*Impact Analysis*



Fixed & Portable

- Fixed Sensor Network (low cost)
    - Enhanced Electrochemical Sensors
    - Optical PM Monitor
    - Cellular and Mesh Communications
    - Extremely low power
    - Small, Robust Sensor Pods
    - Open Data Format
    - Pushed via Cloud Servers
    - Verifiable by std gas
- Portable Spectrometer
    - DUVAS
    - Multi Gas Monitor
    - Fast Response < 1sec
    - Portable on foot or on vehicle
    - Battery Operated
    - Open Data Format
    - Pushed via Cloud Servers
    - Verifiable by std gas

Low Cost Network Sensor Technologies

- Metal Oxide
  - Sensitive but insufficiently selective
  - Require mains power
  - Require stable humidity
- NDIR
  - Mainly for CO and CO2
- PID
  - Good for VOC's
- Electrochemical
  - Selective but until recently not sufficiently sensitive
  - Many gases available
  - Until recently not sensitive enough

Electrochemical Sensors

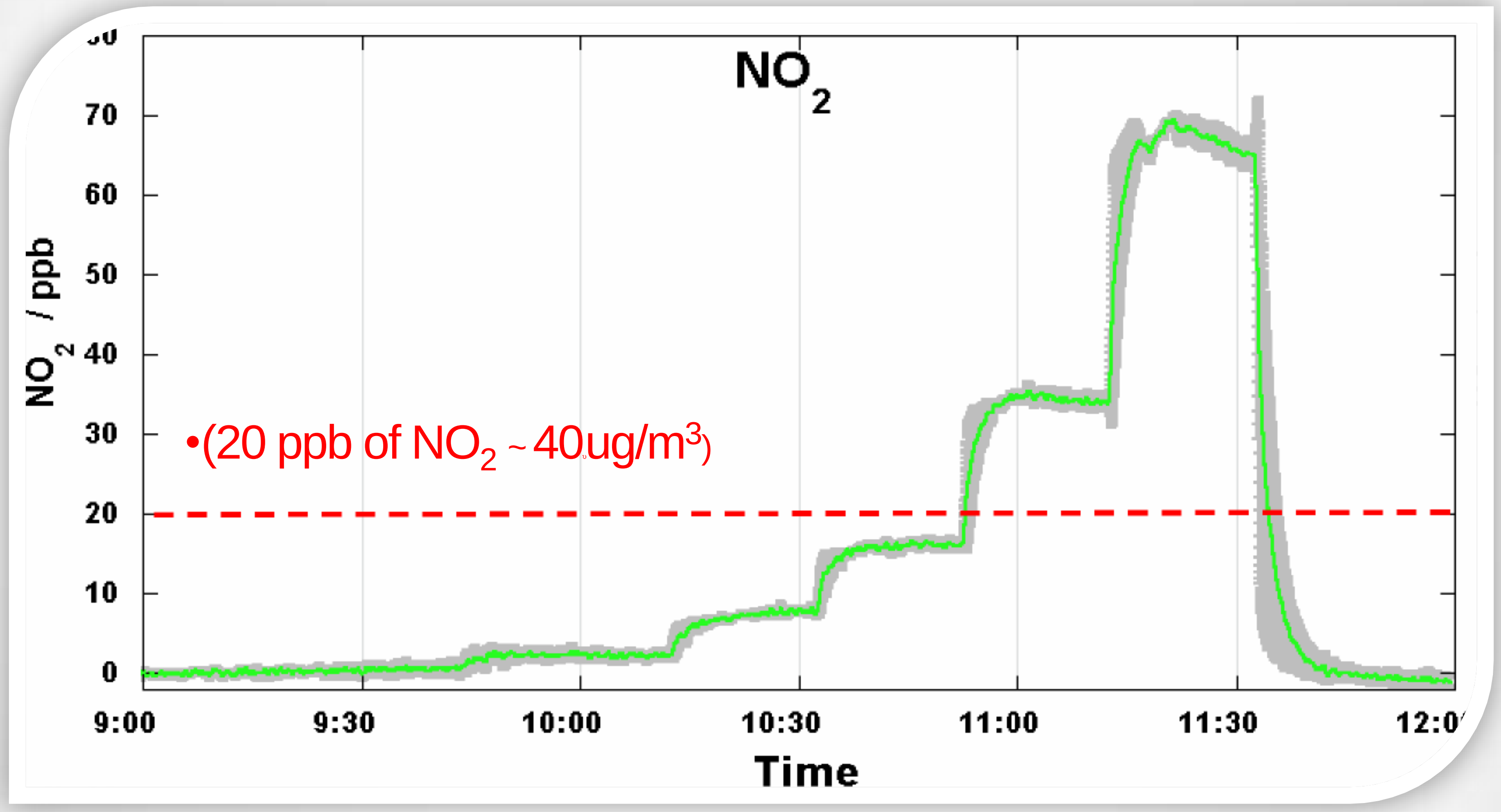
- Can they be made sensitive enough ?
- Can they be made robust enough ?

- Are they specific enough ?
- Are there any interferences ?

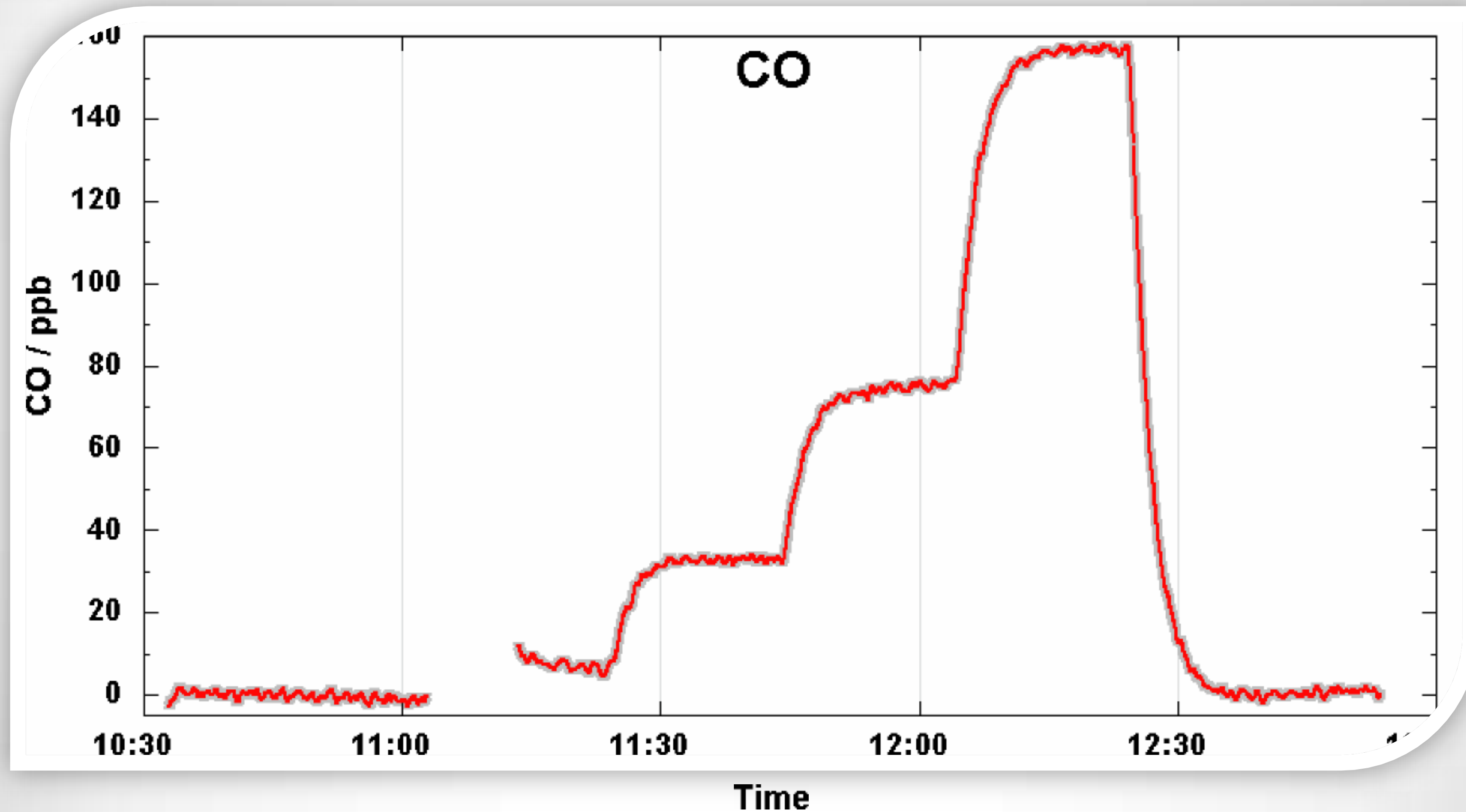
Enhancements

- Hardware
  - - Improved sensitivity and stability
  - - Improved selectivity
  - - Quantification of ambient temperature & humidity effects
- Control electronics
  - - Improved stability/noise characteristics
- Software
  - - Algorithms for baseline correction
  - - Performance monitoring
  - - Calibration methodologies

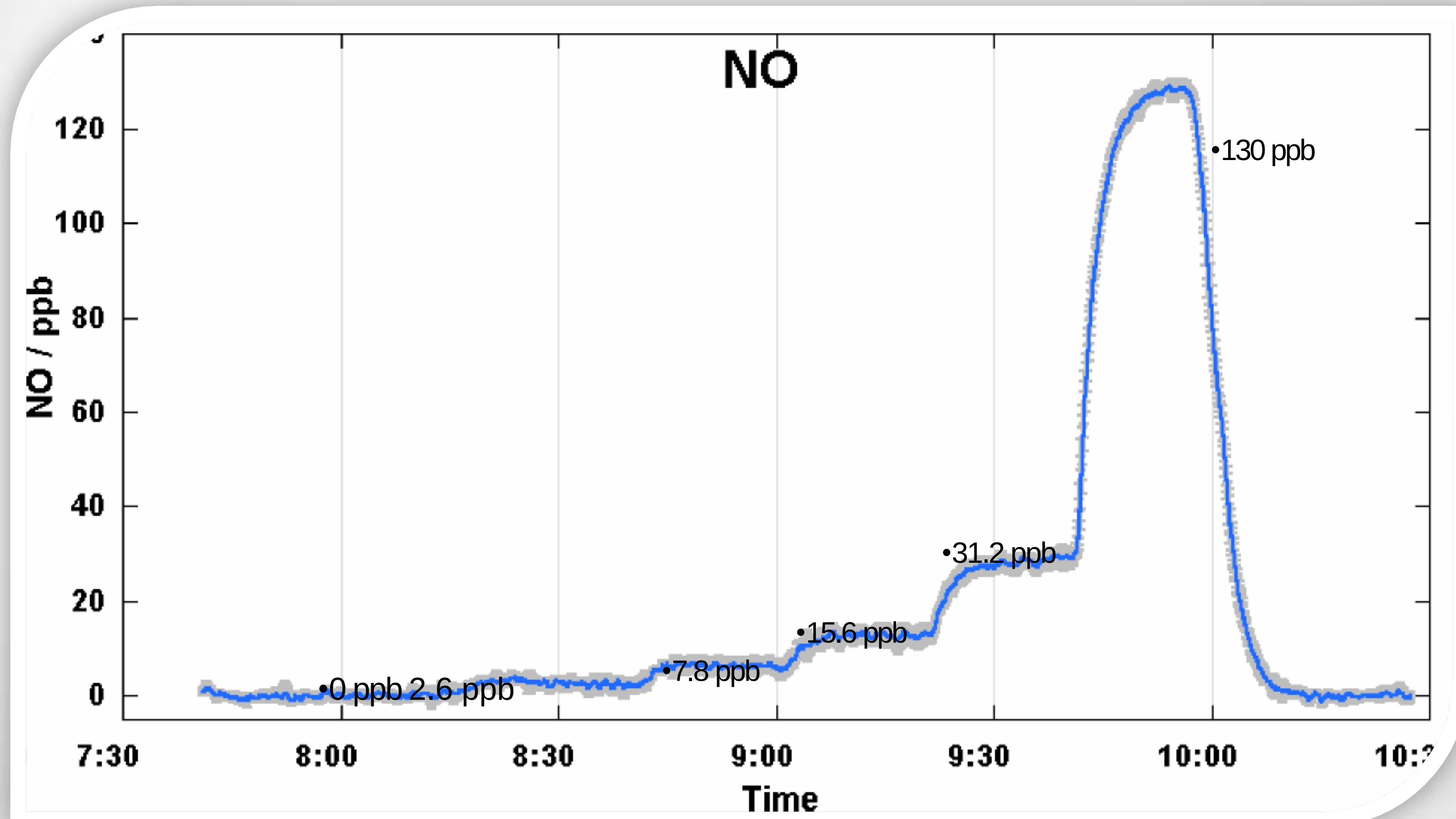
Performance of (enhanced) electrochemical sensors NO2 sensitivity (laboratory)



Performance of (enhanced) electrochemical sensors CO sensitivity (laboratory)

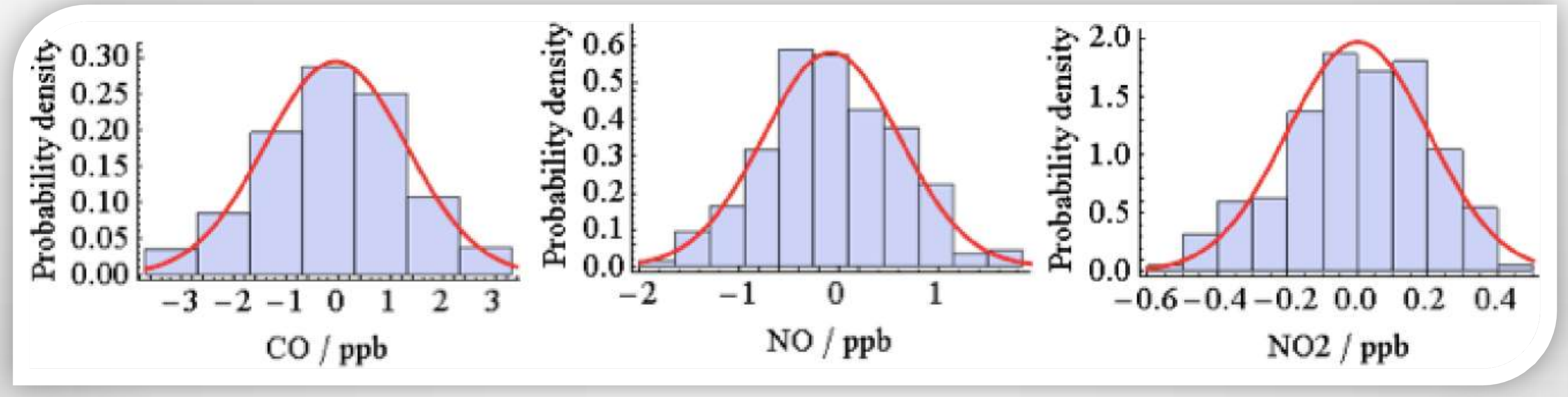


Performance of (enhanced) electrochemical sensors NO sensitivity (laboratory)



Sensor Performance (laboratory)

- Typical LDL's …
  - < 5ppb (< 7 ug/m^3) for CO,
  - 1-2 ppb (~2-4 ug/m^3) for SO2, O3 , NO & NO_2.
- Typical sensor T_{90} ~ 10-20s (determined by diffusion)
- Very low power consumption



Performance - In the Field

Is laboratory performance replicated in the field ?

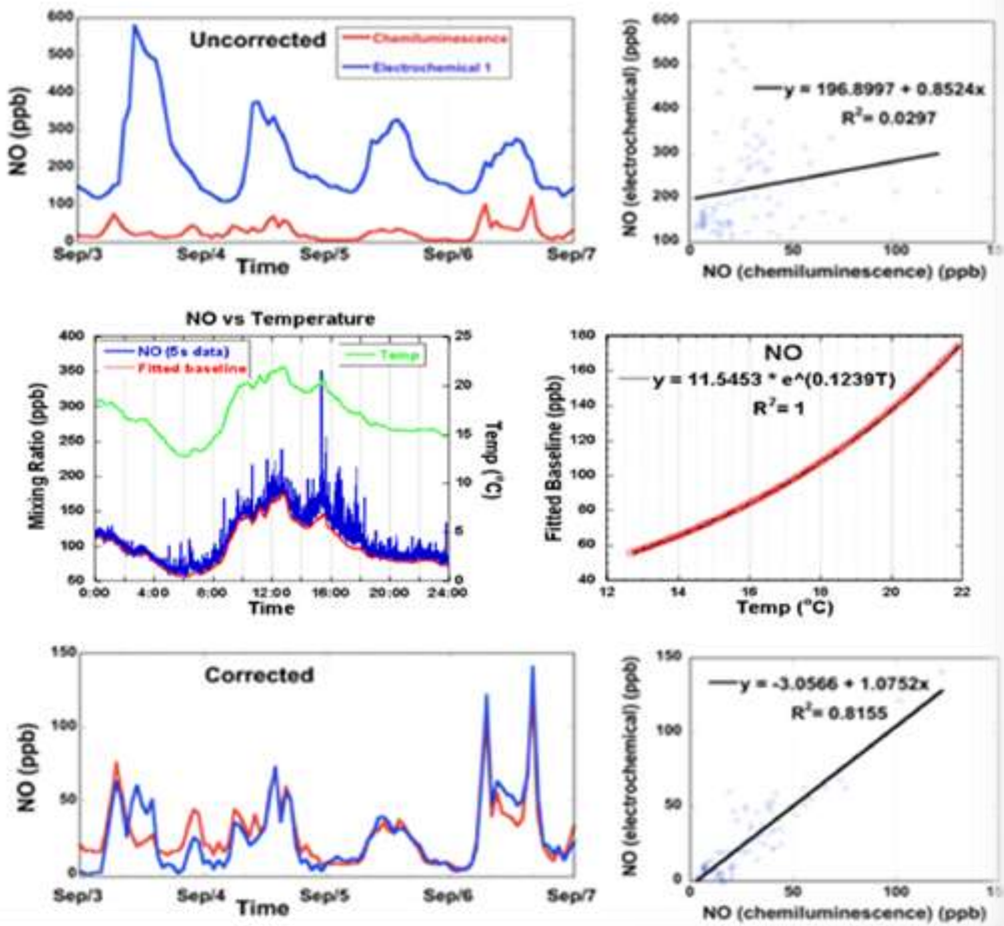
Electrochemical sensor baseline & temperature correction

Electrochemical vs Chemilumineneence

Sensor temperature and baseline correction

Baseline temperature corrected

(compared to ratified data)



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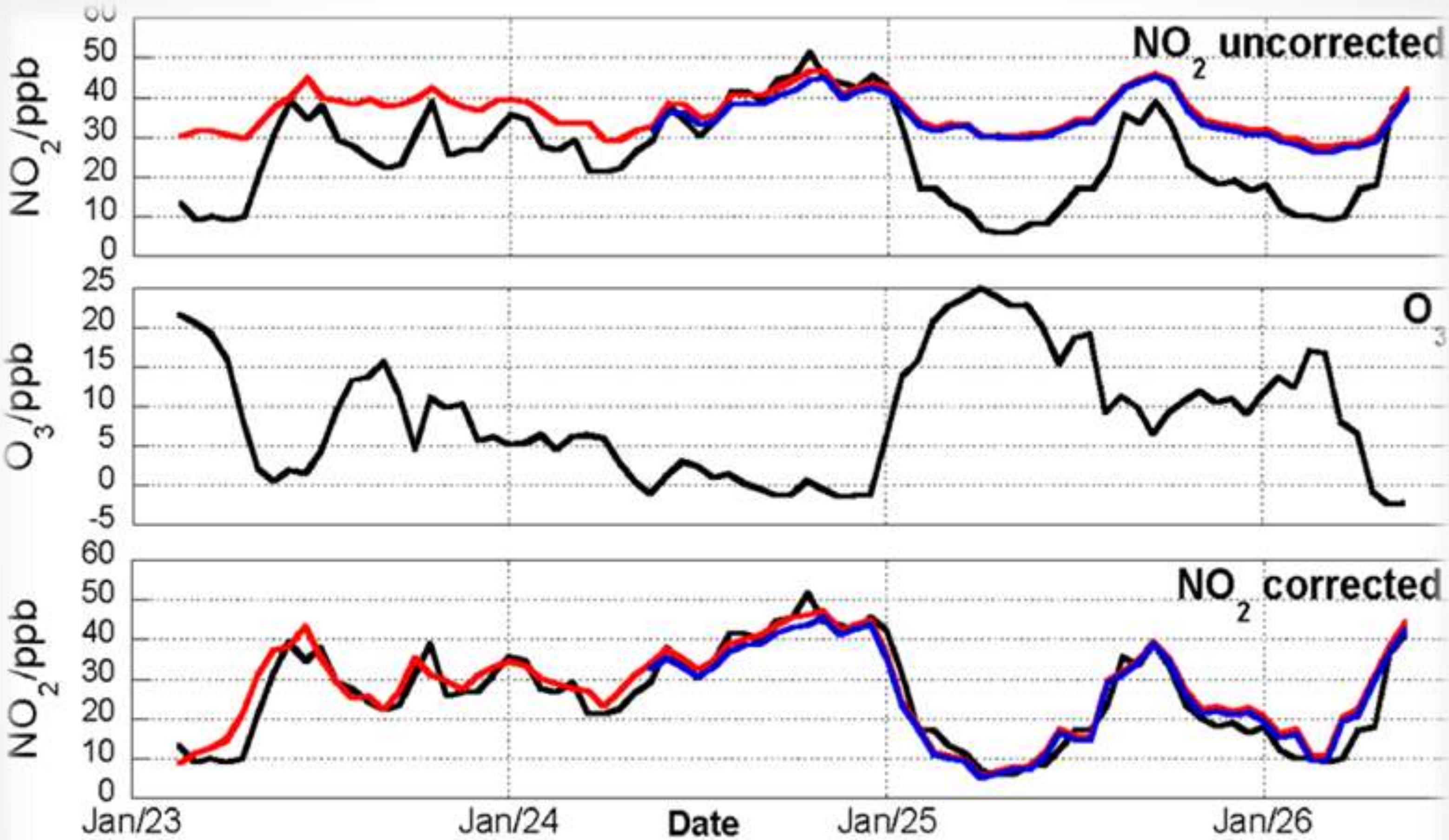
Cross interference (NO2/O3) + comparison with reference monitor (1 hr averages)



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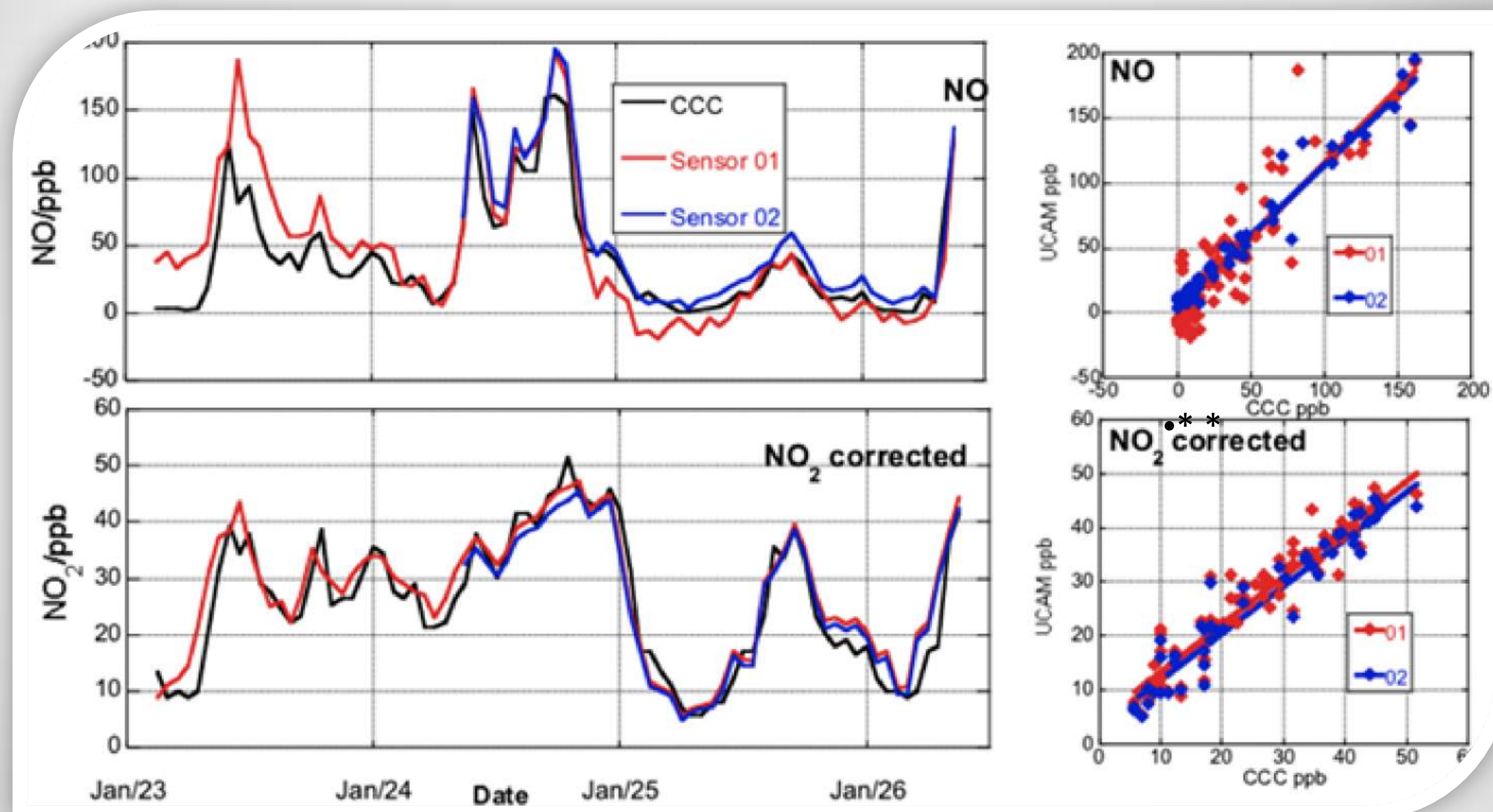
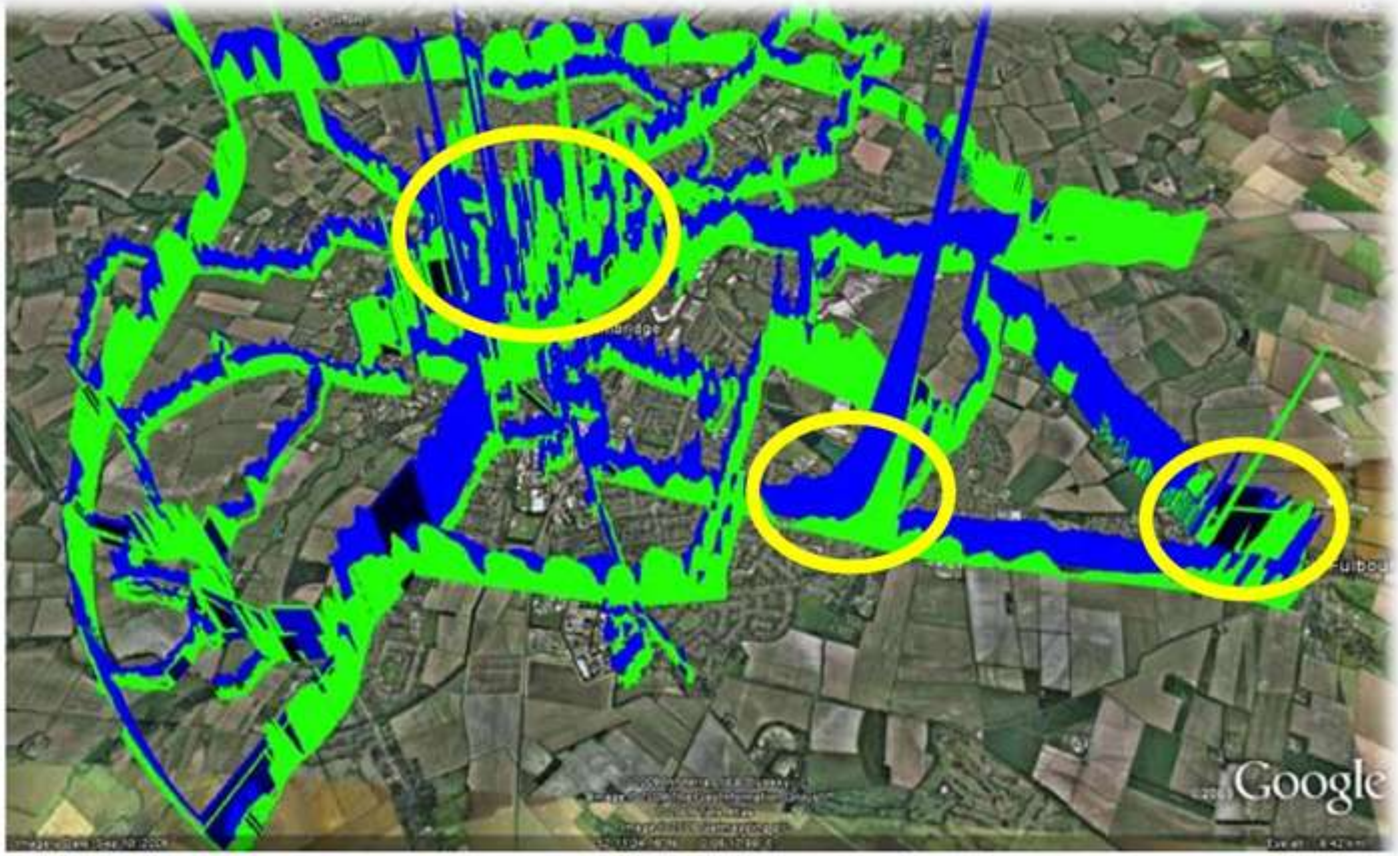
Field comparison of NO2 and NO with ratified reference site



Hot Spot Identification



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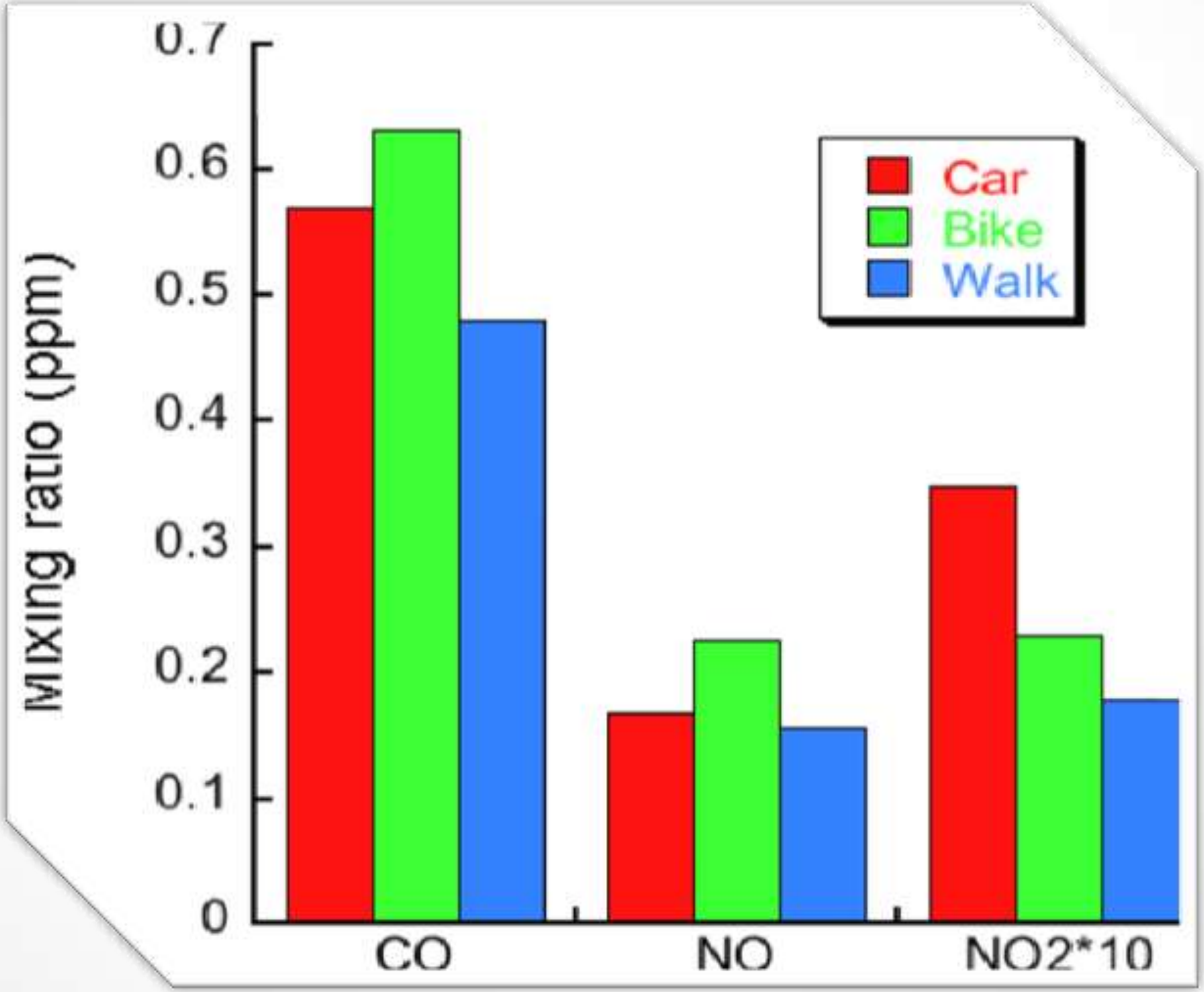
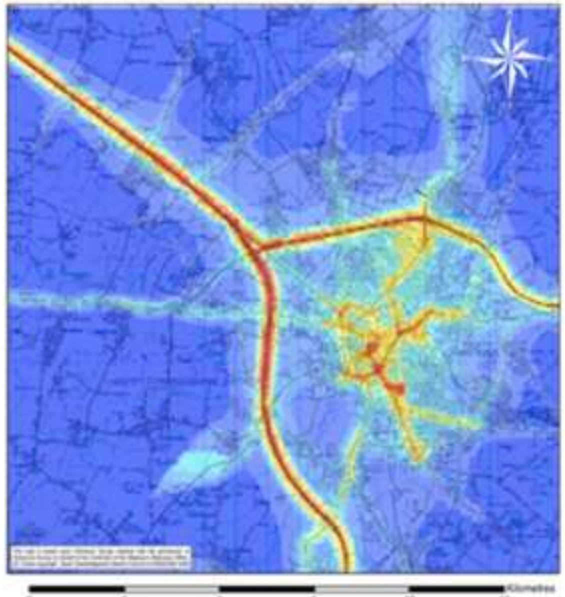
Statistical assessment of mobile air quality data by transport mode (simplest possible!)

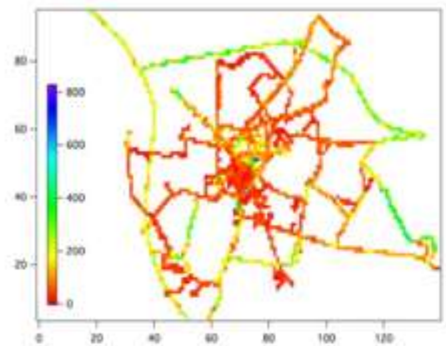


Verification of Models



Allows for calculation of

- Canyon Effects
- Personal Exposure
- Spatial and Temporal Variations



•CERC ADMS model (David Caruthers)

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On Going Trials

UK Nationally funded high density sensor network system at UK Heathrow airport (2011-2013)

- NO, NO_2, CO, CO_2, SO_2, O_3, PM (x) and VOC's
- Source attribution/model validation for airport area
- Development of software tools for presentation and data mining

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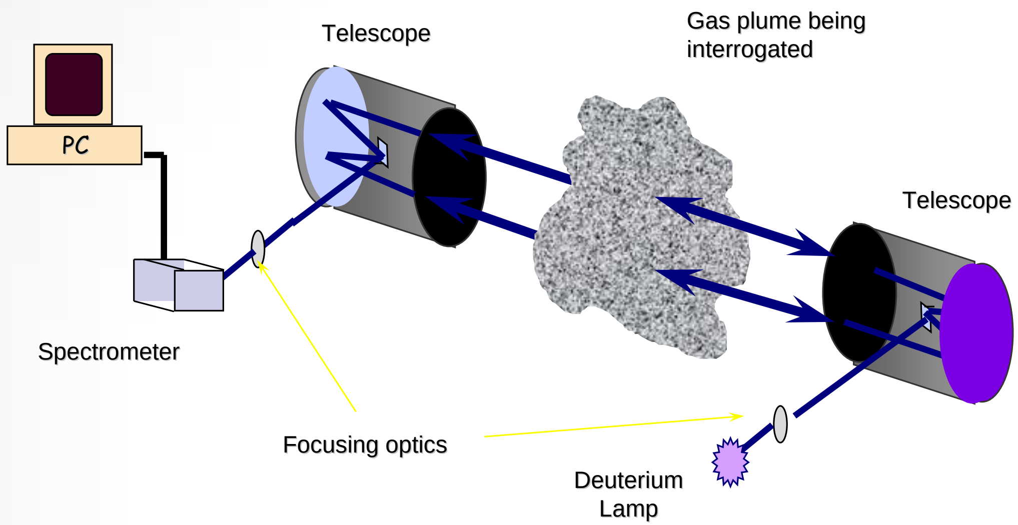
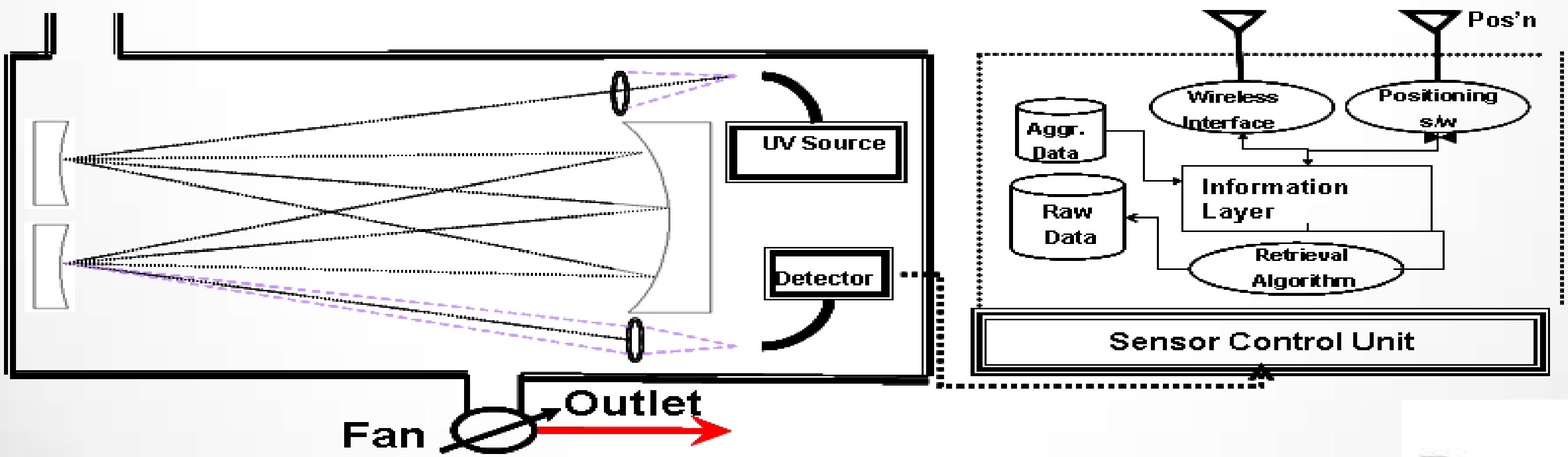
Portable Technology DUVAS



$$T = \frac{I_1}{I_0} = e^{-\int \alpha' \, dz} = e^{-\sigma \int N dz}$$

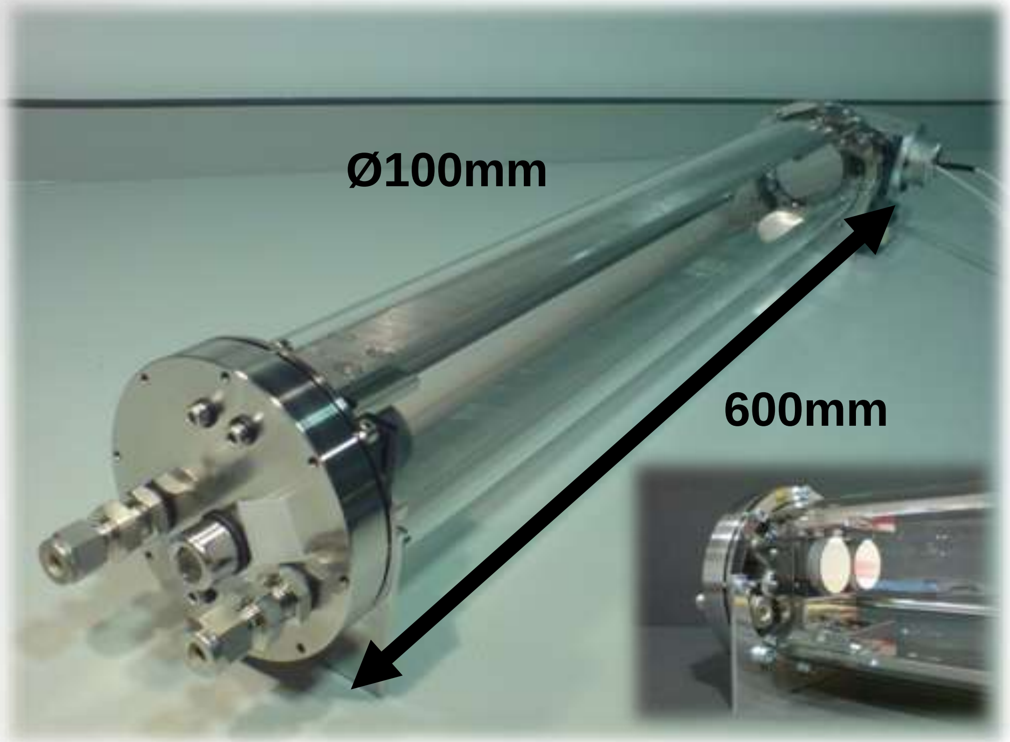
Beer-Lambert Law

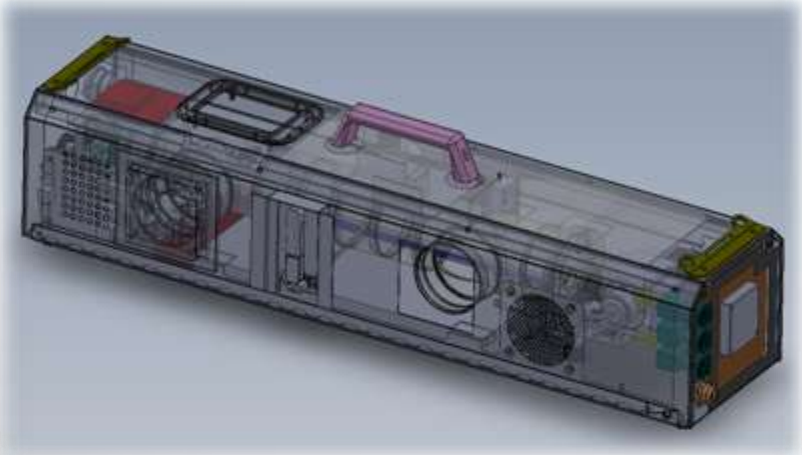


Duvas Technologies

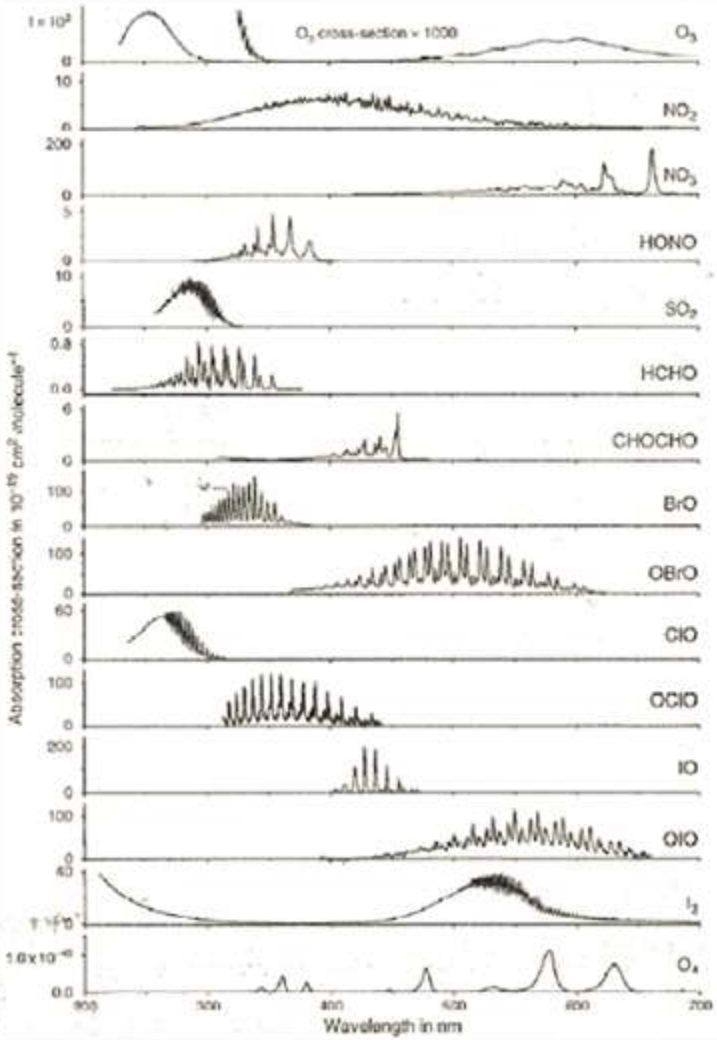
www.duvastechnologies.com

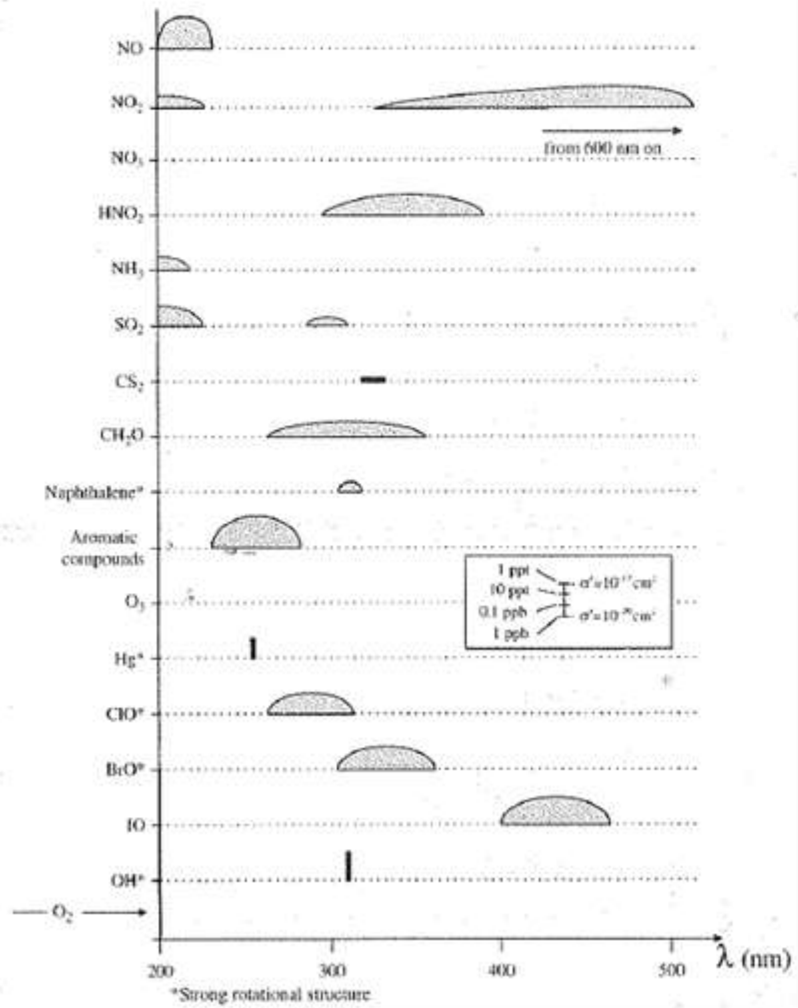
DUVAS Cell Design



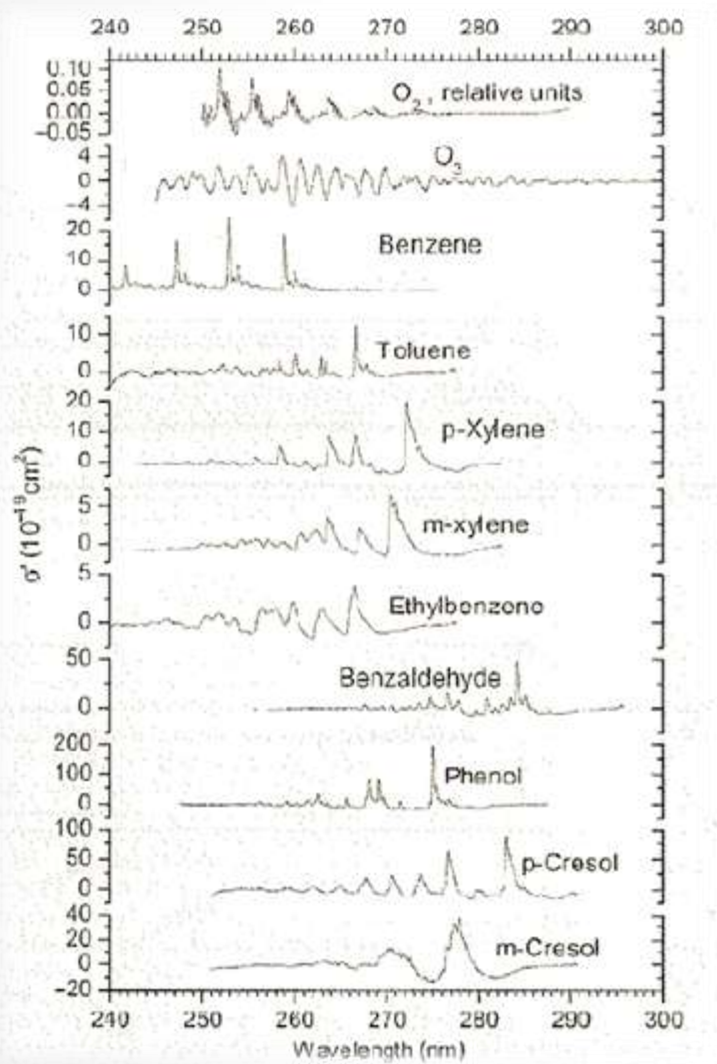


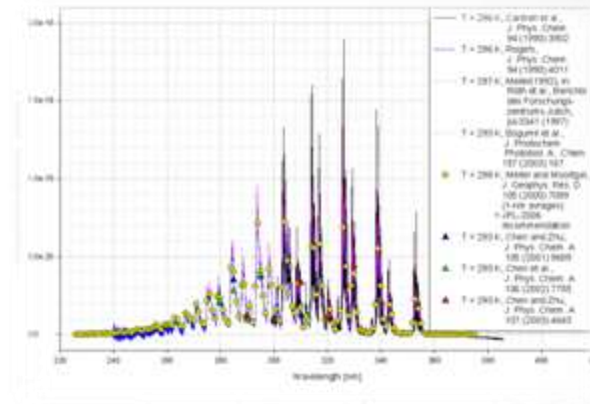
Typical Gas Signatures

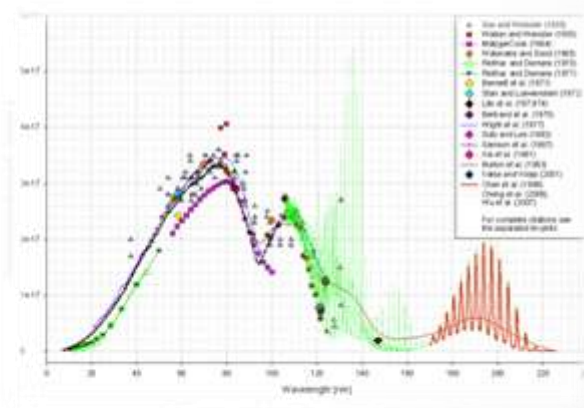




Typical Differential Signatures







Performance Assessment (NO)

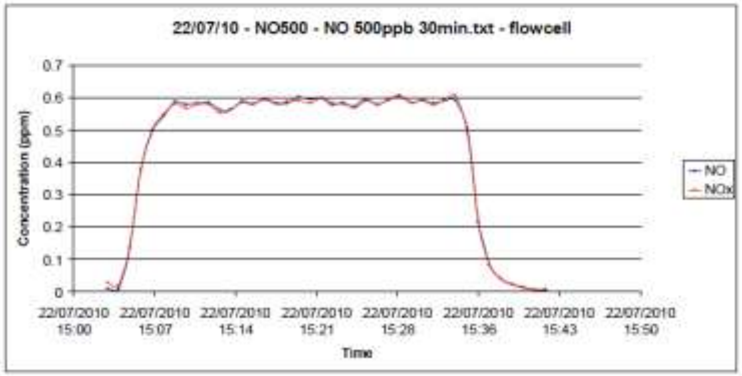


Figure 5 Ecotech Analyser exposed to NO mid concentration
NO = 587 ± 9ppb

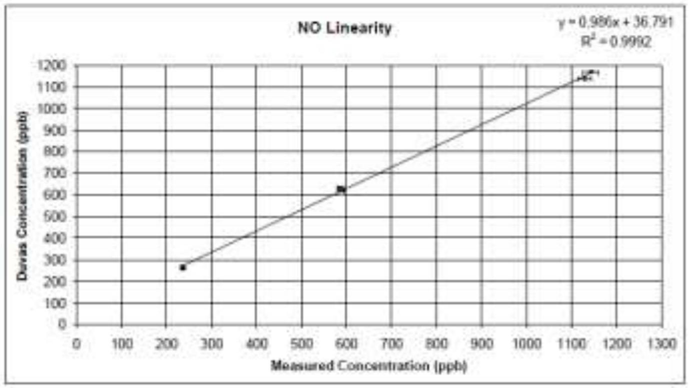


Figure 13 Duvas NO linearity

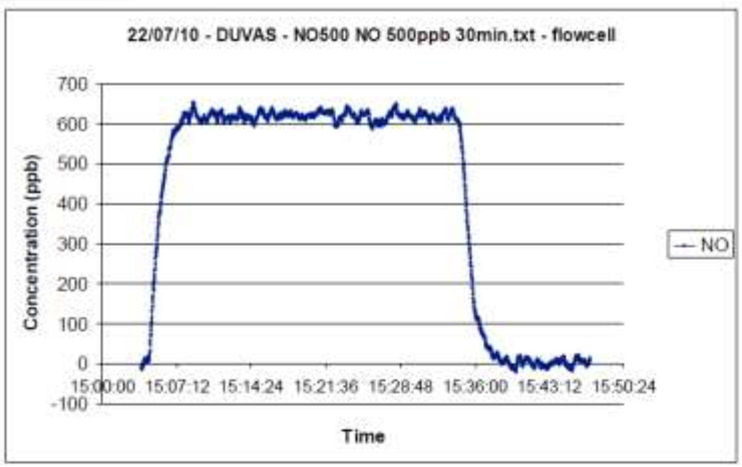


Figure 6 Duvas device exposed to NO mid concentration
Duvas NO = 619 ± 11ppb
Rolling length = 20 seconds

Performance Assessment (NO_2)

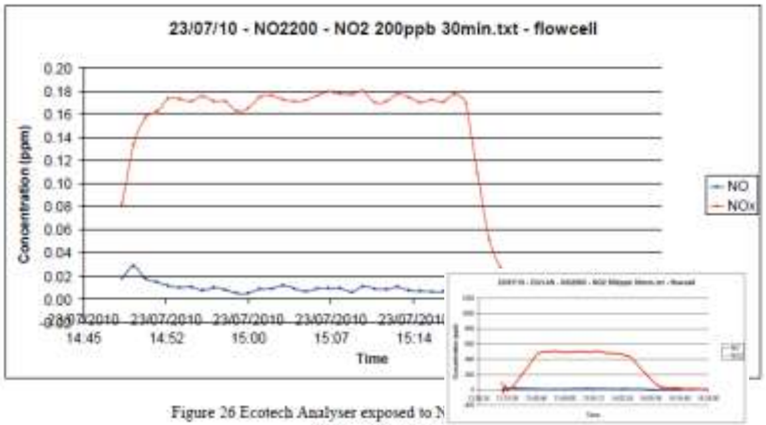


Figure 26 Ecotech Analyser exposed to N
NO_X = 174 ± 4ppb

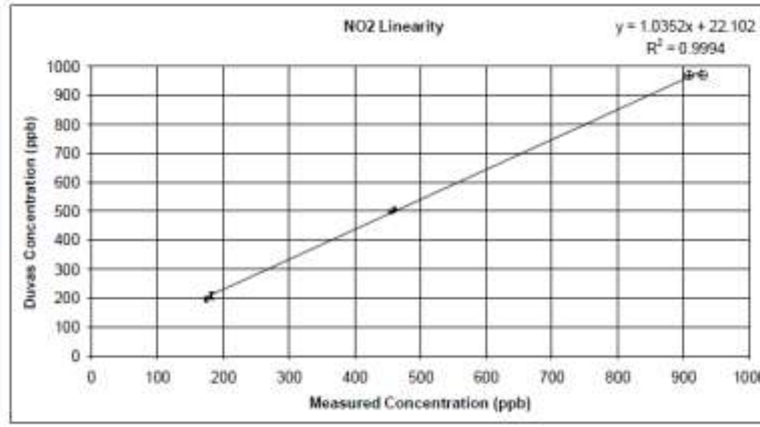


Figure 28 Duvas NO2 Linearity

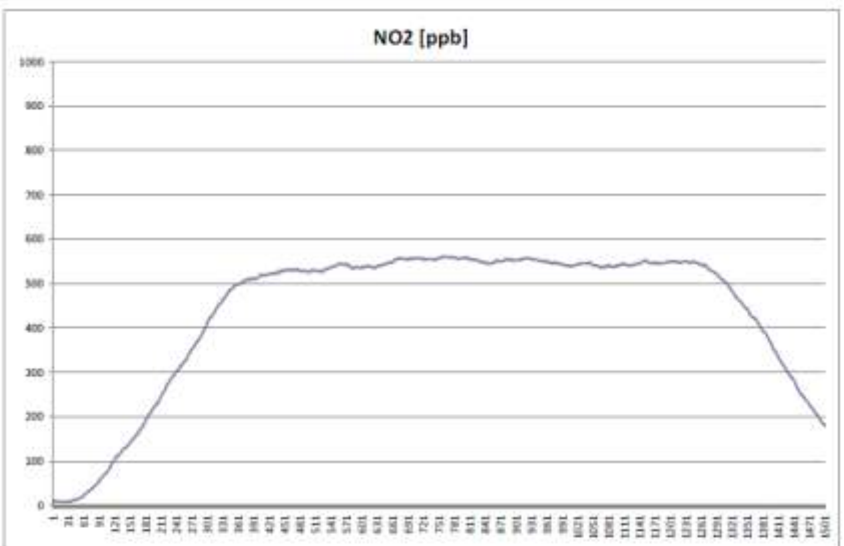
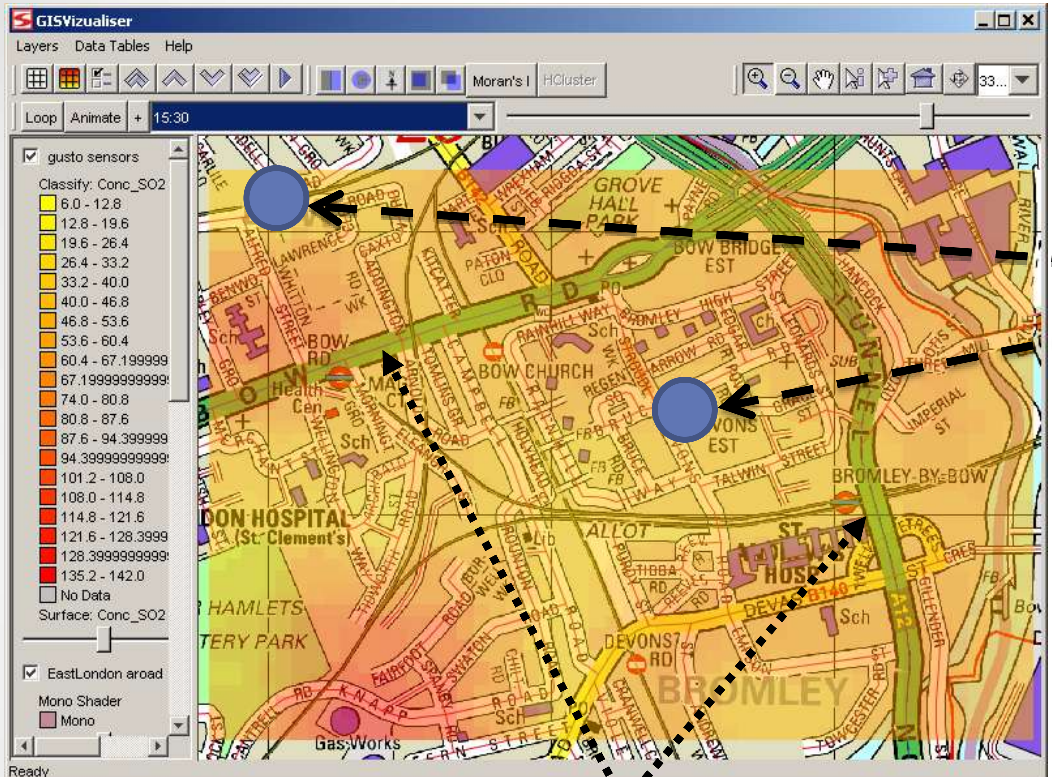


Figure 3 Duvas solving at ~500ppb set point

Figure 2 Duvas screenshot at ~500ppb setpoint showing NO2 differentials

Product Use-Case Illustration



Portable unit for local 'hotspot' mapping and monitoring

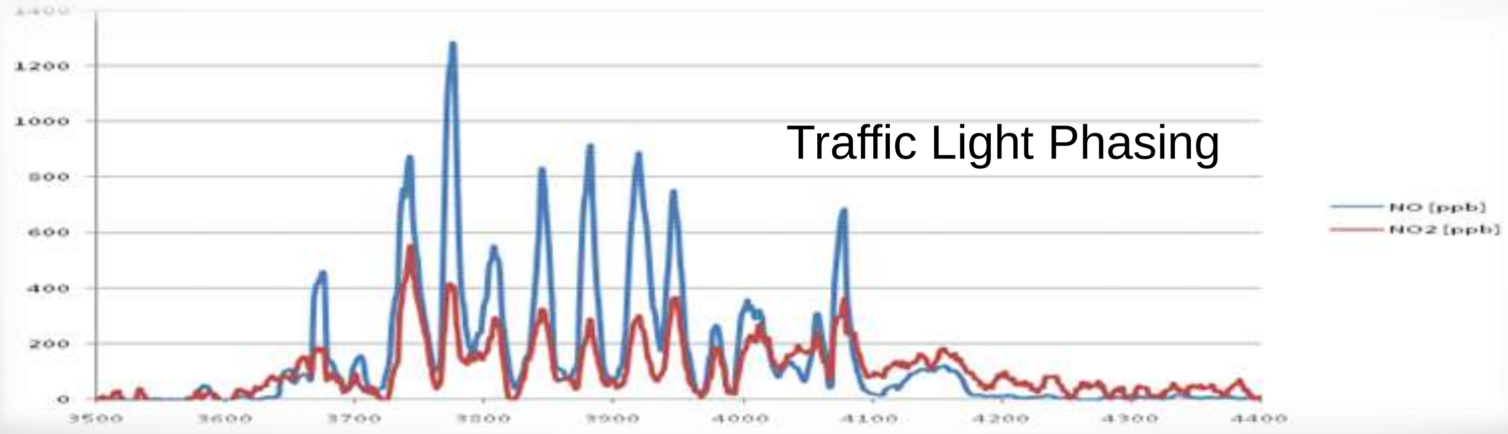
City buses

Taxis, LA, public services

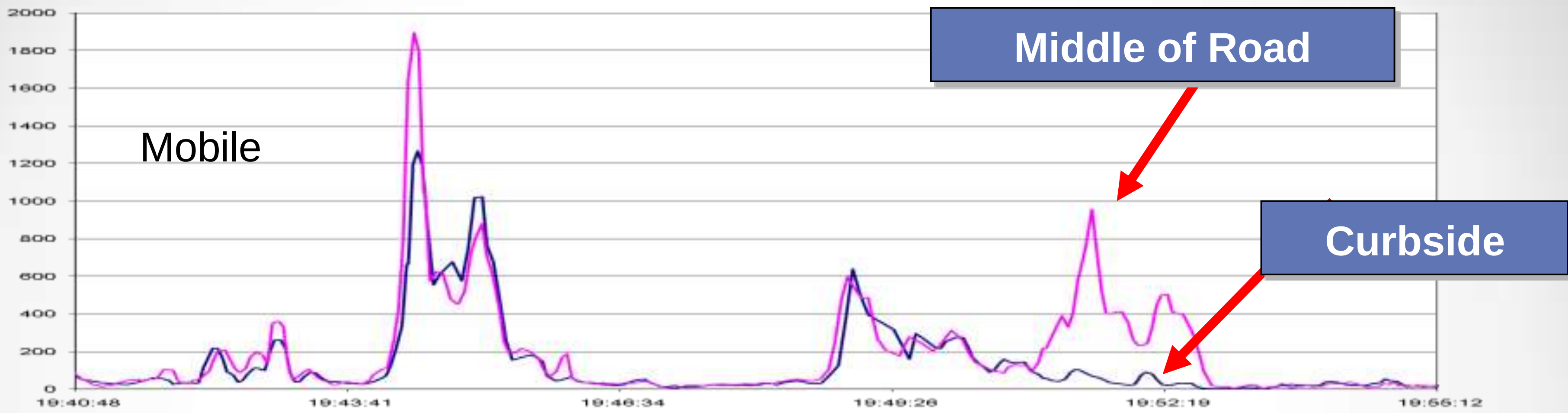
Vehicle-mounted Mobile unit for area pollution mapping from data measured on route

Mobile & Static Dataset

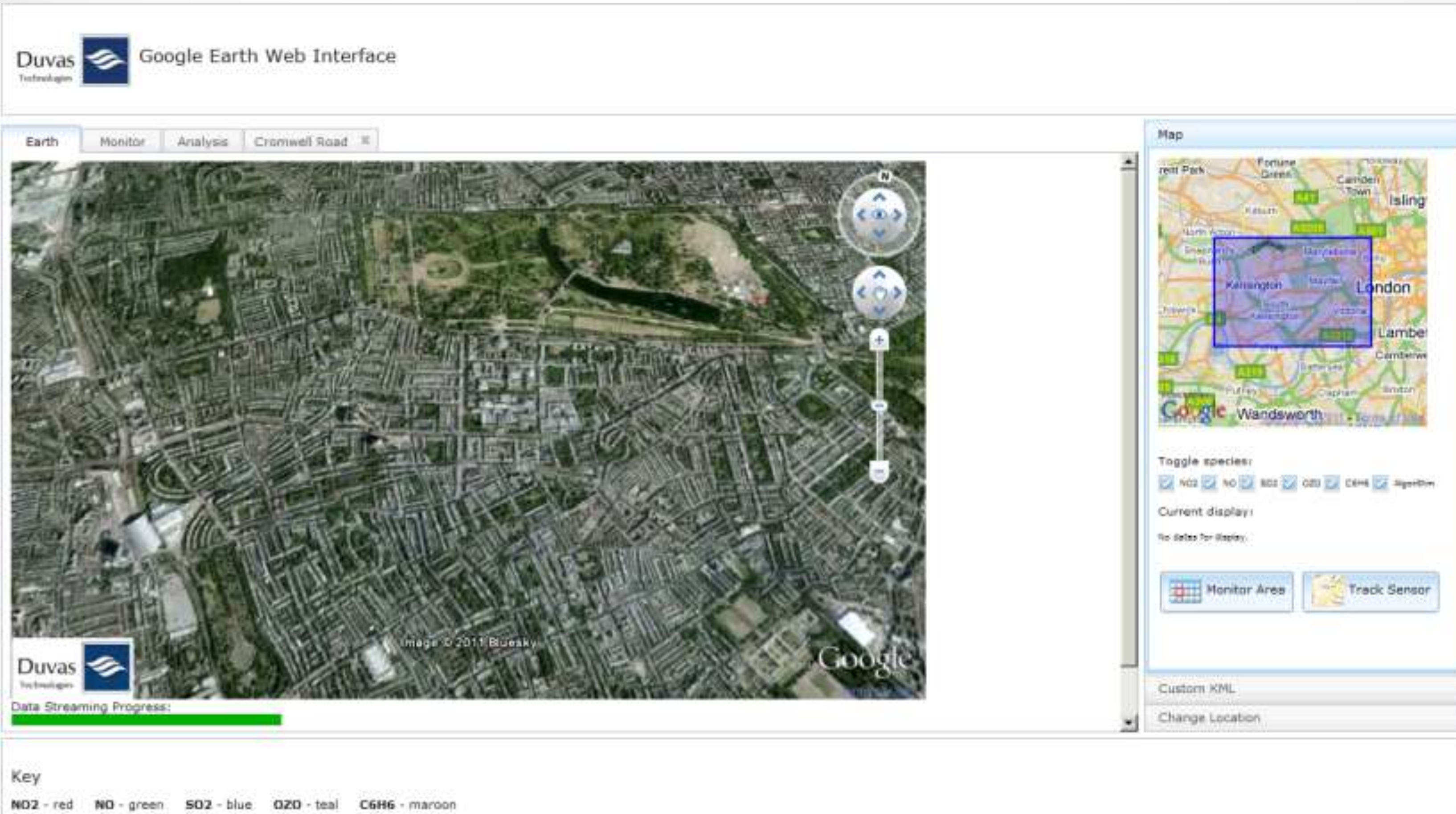
Levels of Nitric Oxide/Dioxide



Spatial Information and Accuracy



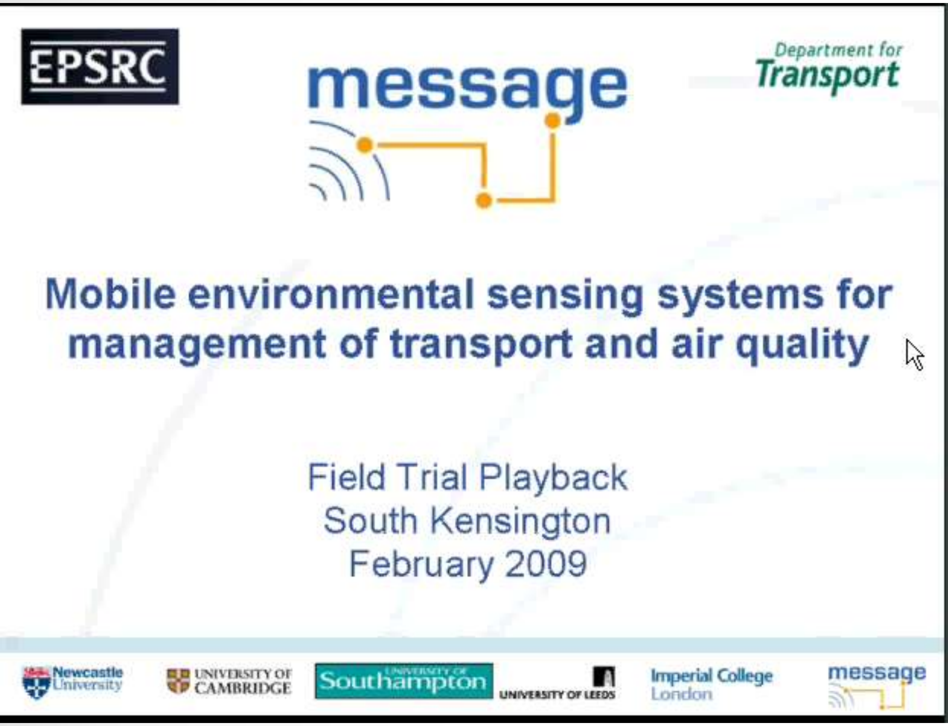
Concentrations on Google Maps



DUVAS LIVE

Video

Air Quality Index (AQI) NO



Duvas Technologies

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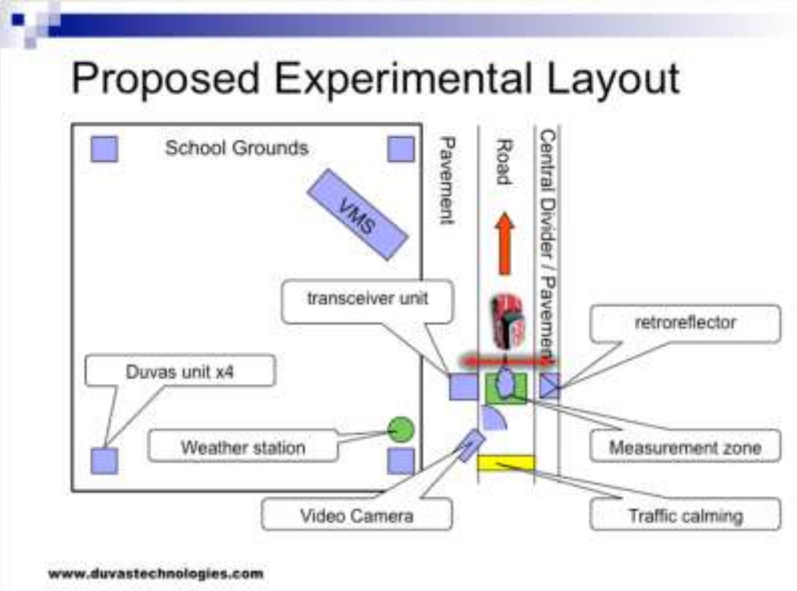
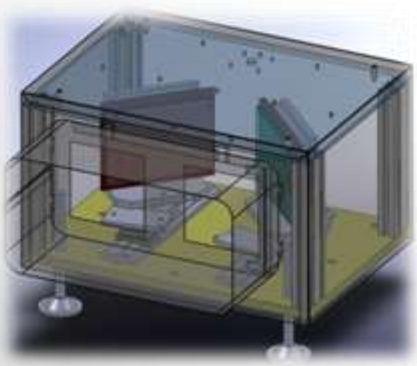
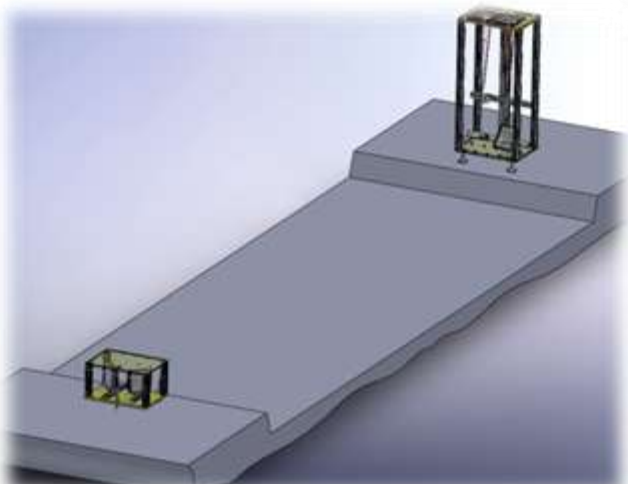
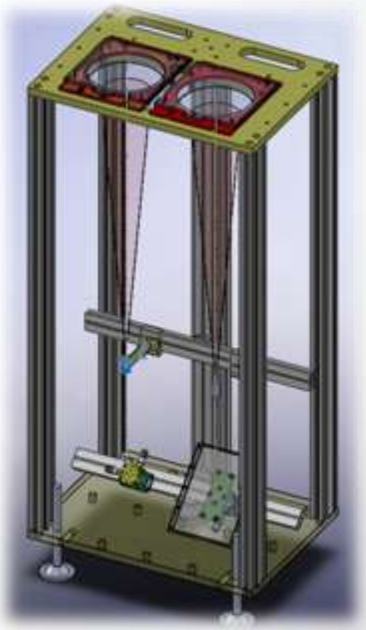
Open Path Development



Duvas Technologies







Open Path Deployment





Thank You

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