

# Wireless Environmental Sensor Networks

*Case study on the MESSAGE  
project*

School of Electrical,  
Electronic and  
Computer Engineering



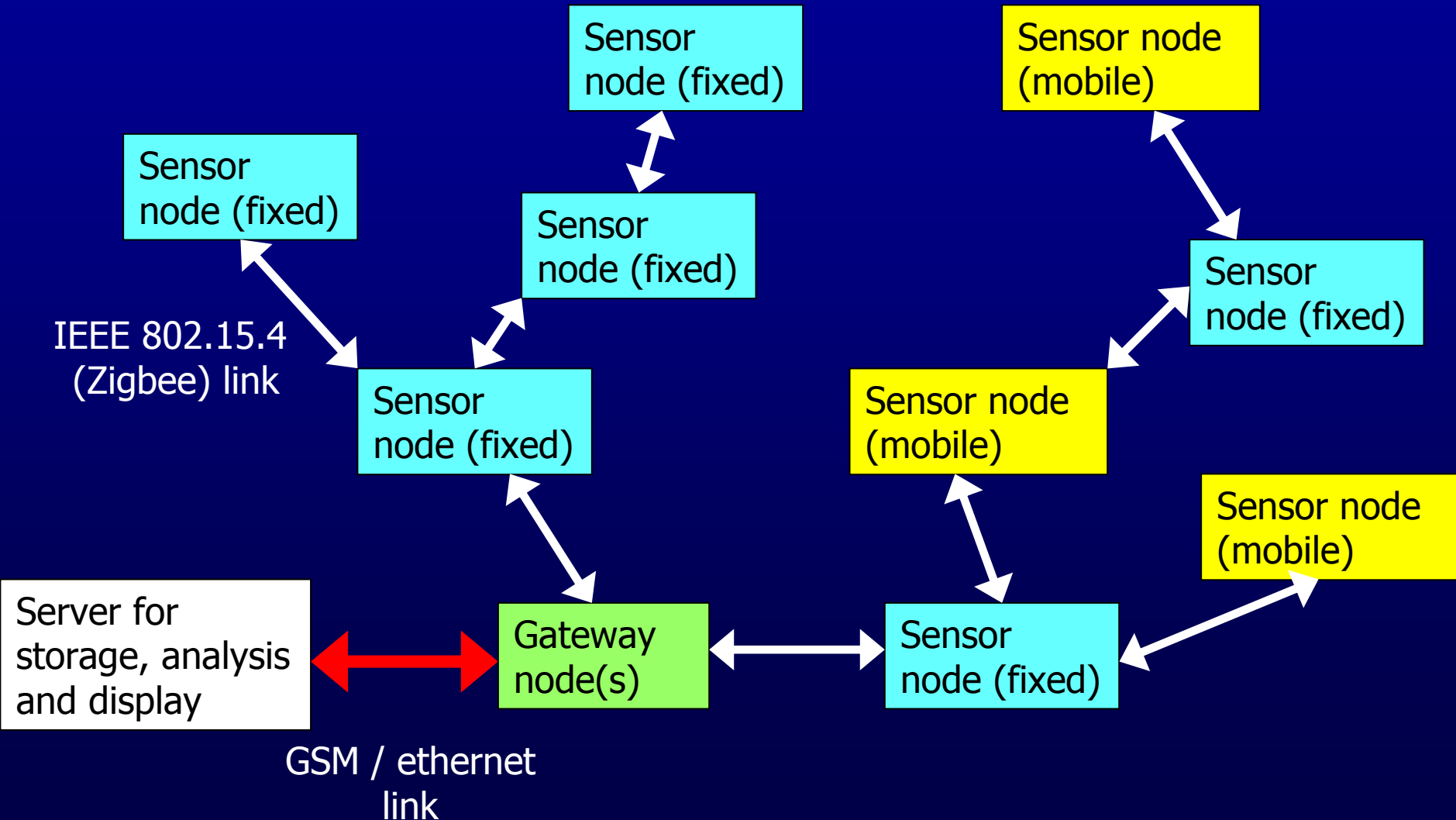
# The MESSAGE Project - Objectives

- Alternative approach to high cost environmental & traffic monitoring infrastructure.
- Existing installations give poor spatial & temporal resolution.
- Project aimed to develop and deploy lower cost, wireless sensors that could gather high resolution data over a wide area.

# MESSAGE consortium activities

- Newcastle focussed on very low cost, wireless sensors (MOTEs) to be deployed in large numbers on street furniture or vehicles.
- Imperial focussed on novel multi-gas analysers for deployment on vehicles e.g. buses, taxis.
- Cambridge focussed on low cost pedestrian/cyclist mounted sensors.
- Partners jointly developed an e-science architecture to store, analyse and display sensor data from these sources.

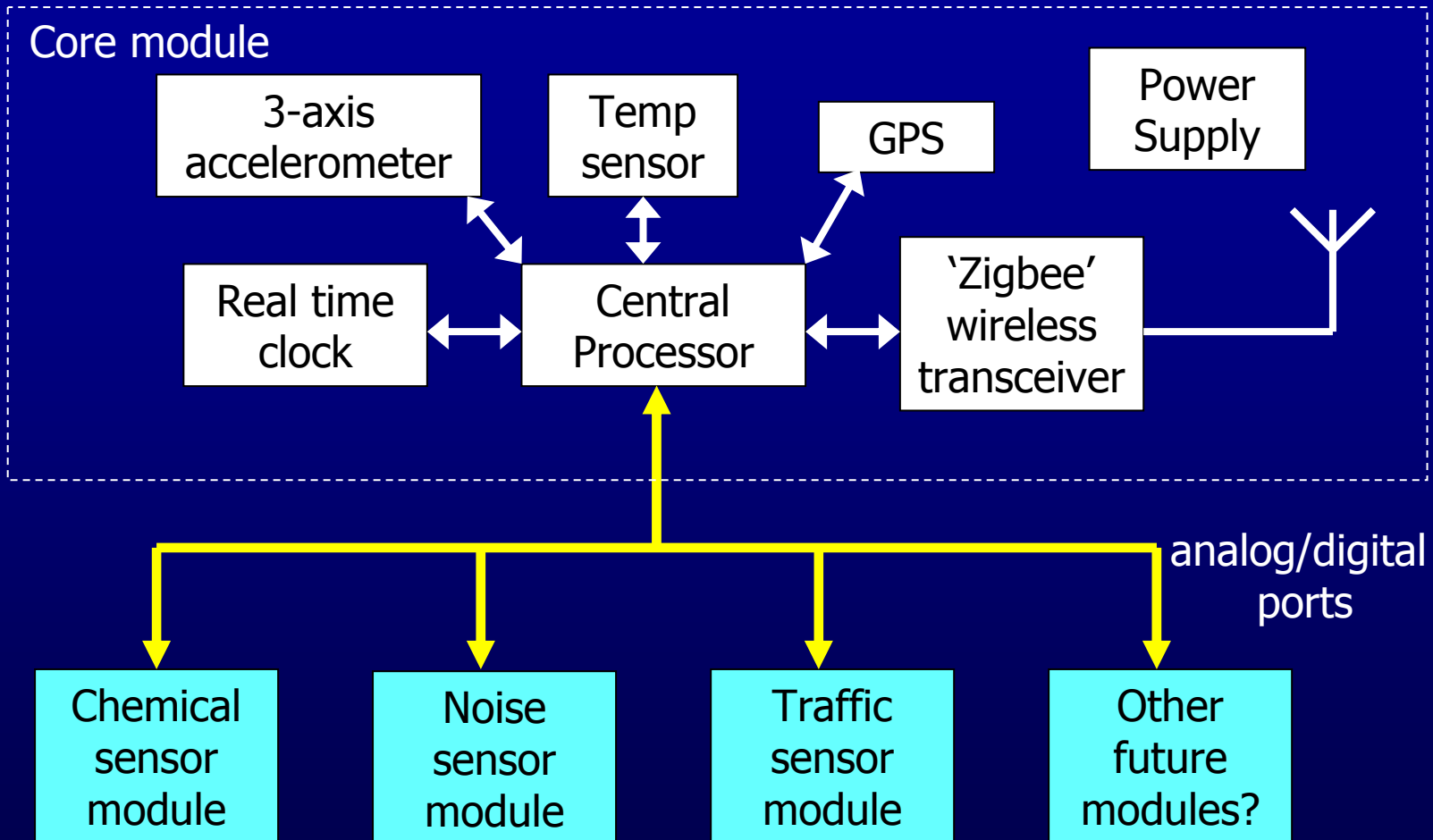
# Newcastle Sensor Network Architecture



# MOTE Design Strategy

- Highly modular approach to design.
- Standard CPU and comms module.
- Add on modules for sensor payload.
- Several power supply options e.g battery, solar.
- Target component cost of <£200 per node.

# Sensor node architecture



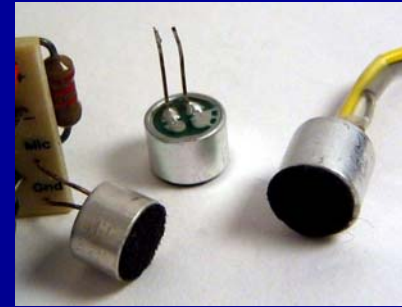
# Chemical sensors



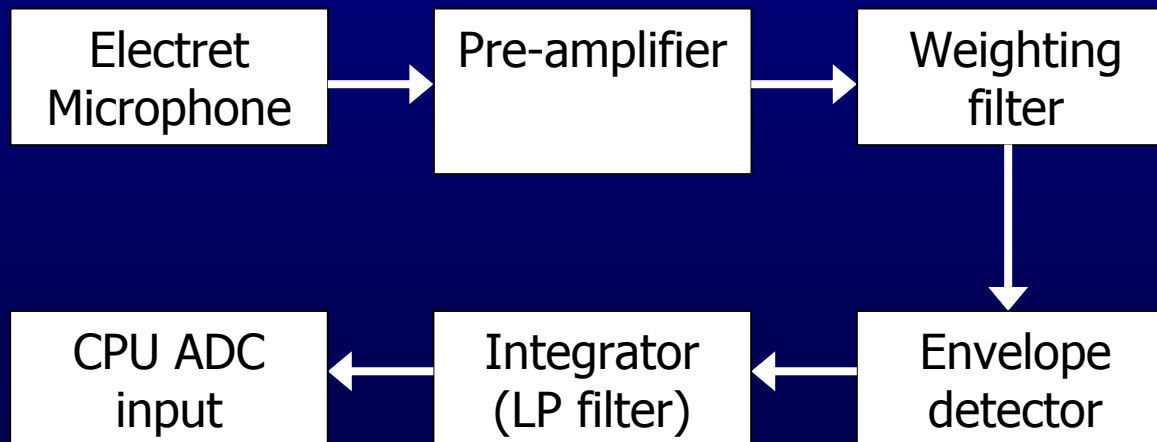
- CO and NO<sub>2</sub> are principle gases to be measured.
- For our budget semiconductor sensors or electrochemical cells are only realistic options.

	Electrochemical	Semiconductor
Cost	~£40	<£10
Operating life	>2 years	5-10 years
Power consumption	Few $\mu$ W	100-300mW
Performance	Good sensitivity but drift & cross sensitivity issues.	Less sensitive than electrochem.

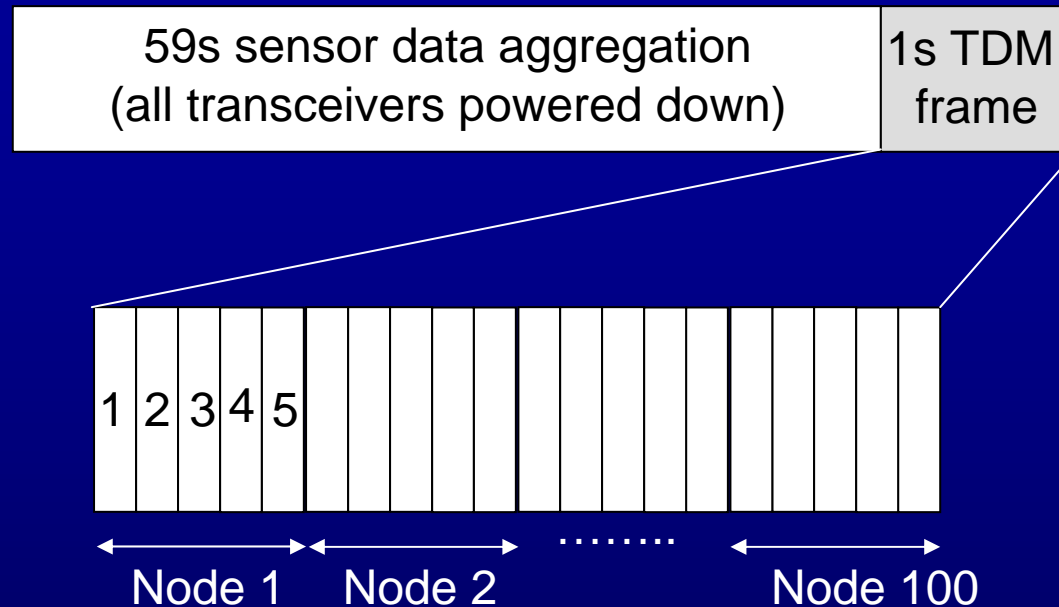
# Noise sensor module



- A low cost electret microphone and signal conditioning circuits have been designed to implement an integrating sound level meter.



# Network Protocols & Power Saving



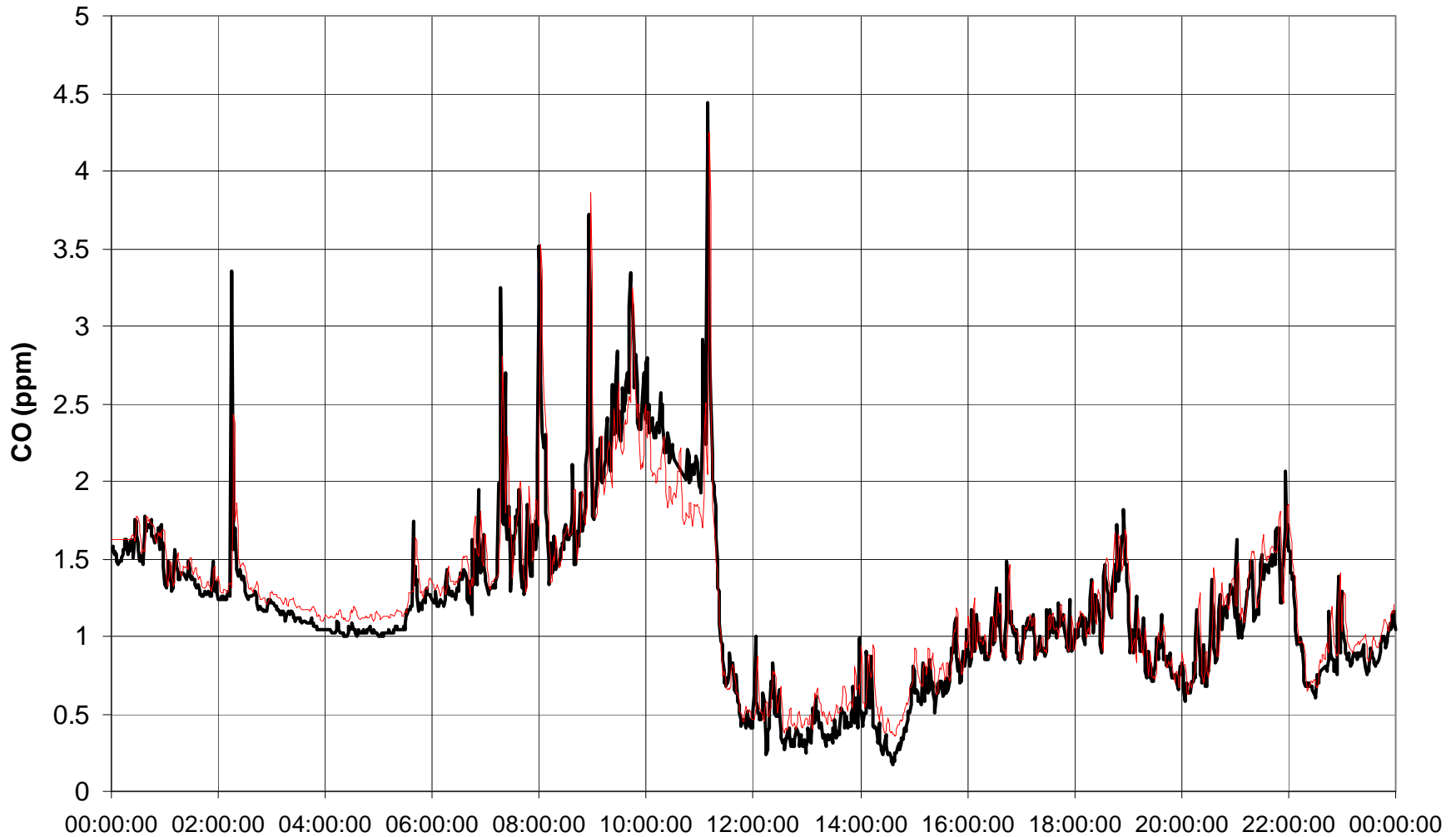
- Beacon enabled TDMA enables very low power consumption.
- Zero overhead routing algorithm optimised for tree topology.

# MOTE Housing & Electronics

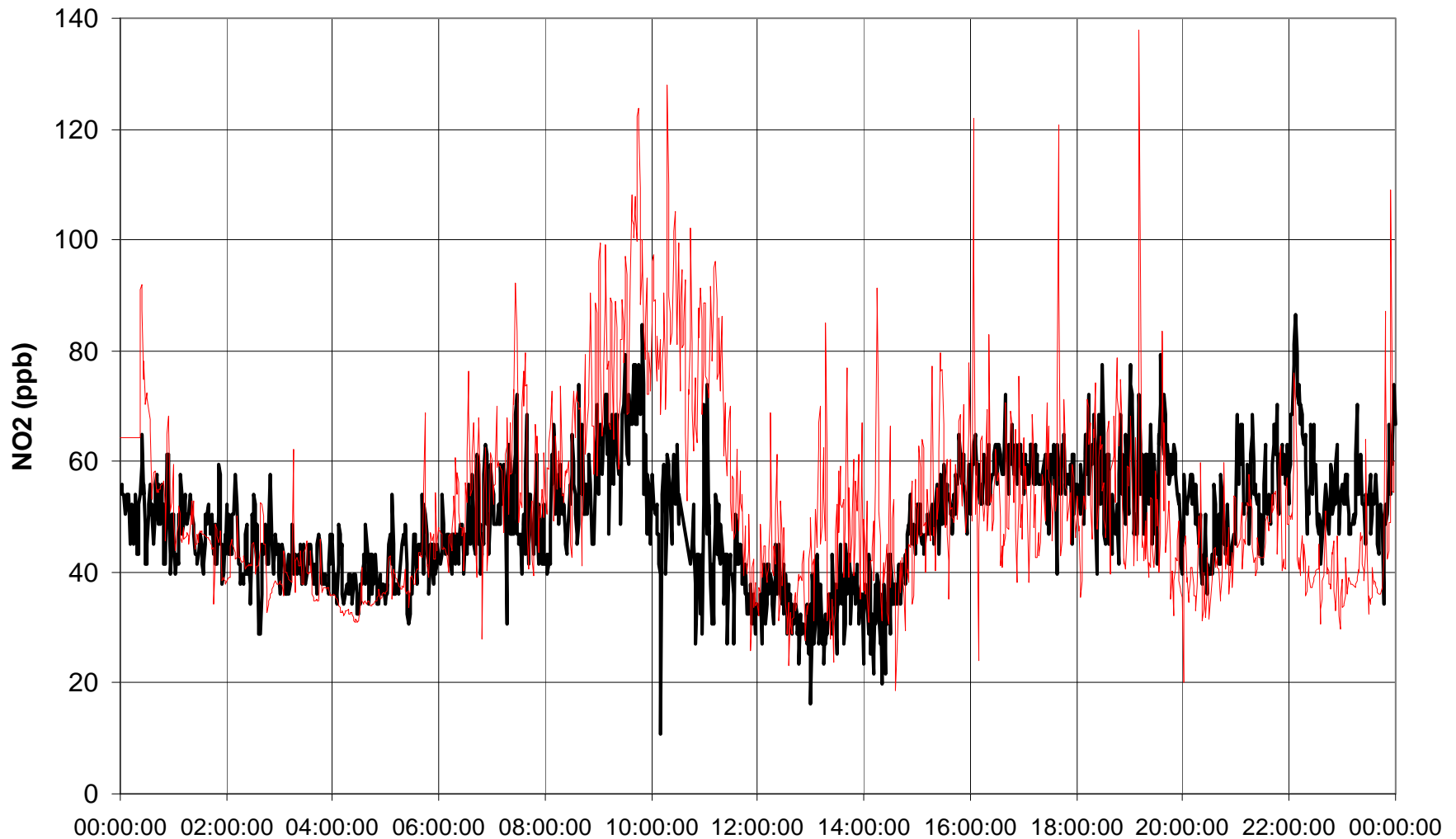
- Dimensions 140 x 85 x 65mm
- IP67 weatherproof housing
- Mean power consumption approx 20mW (4 months from a Li D cell)



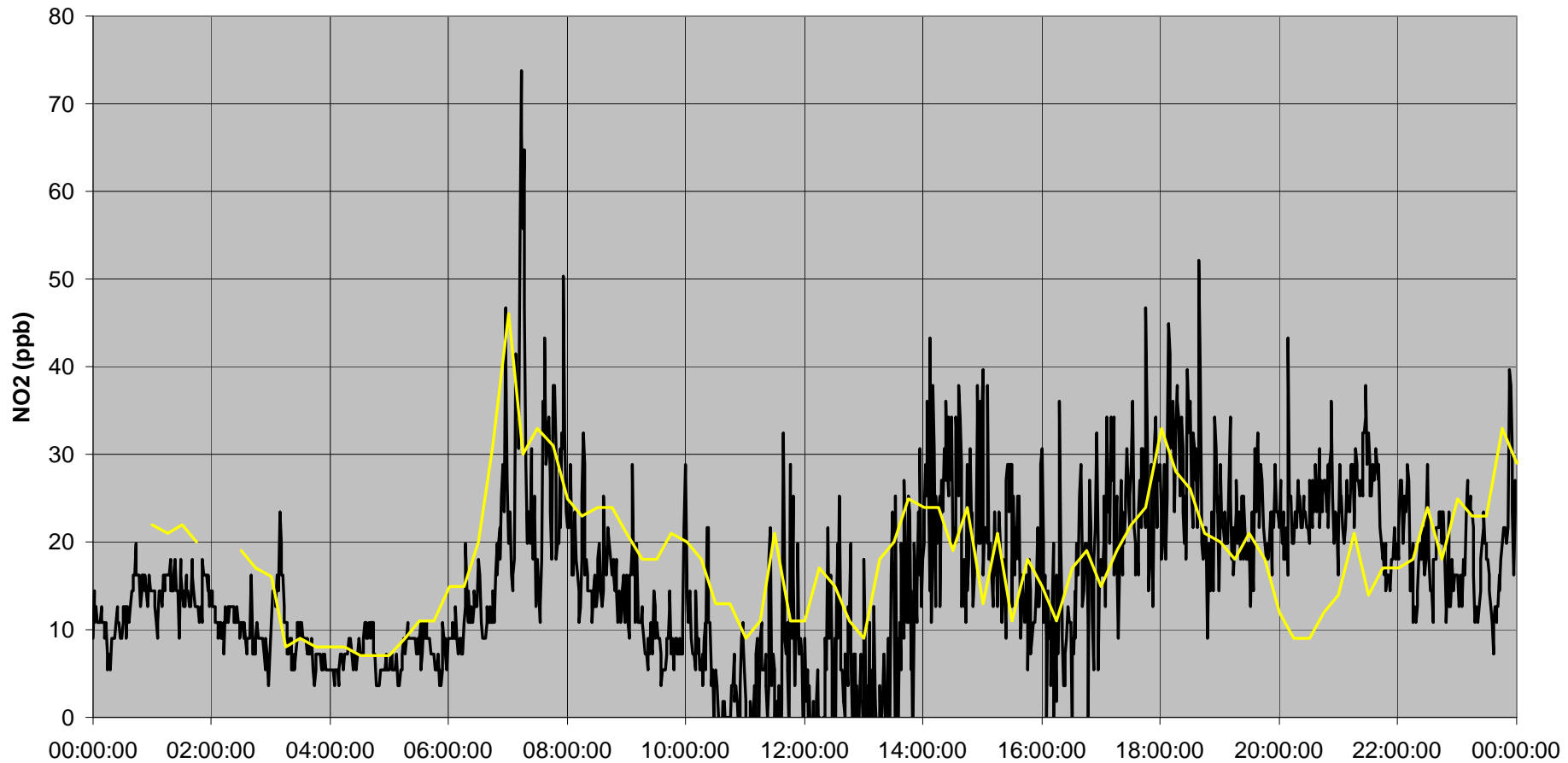
# Typical CO Sensor Co-location result



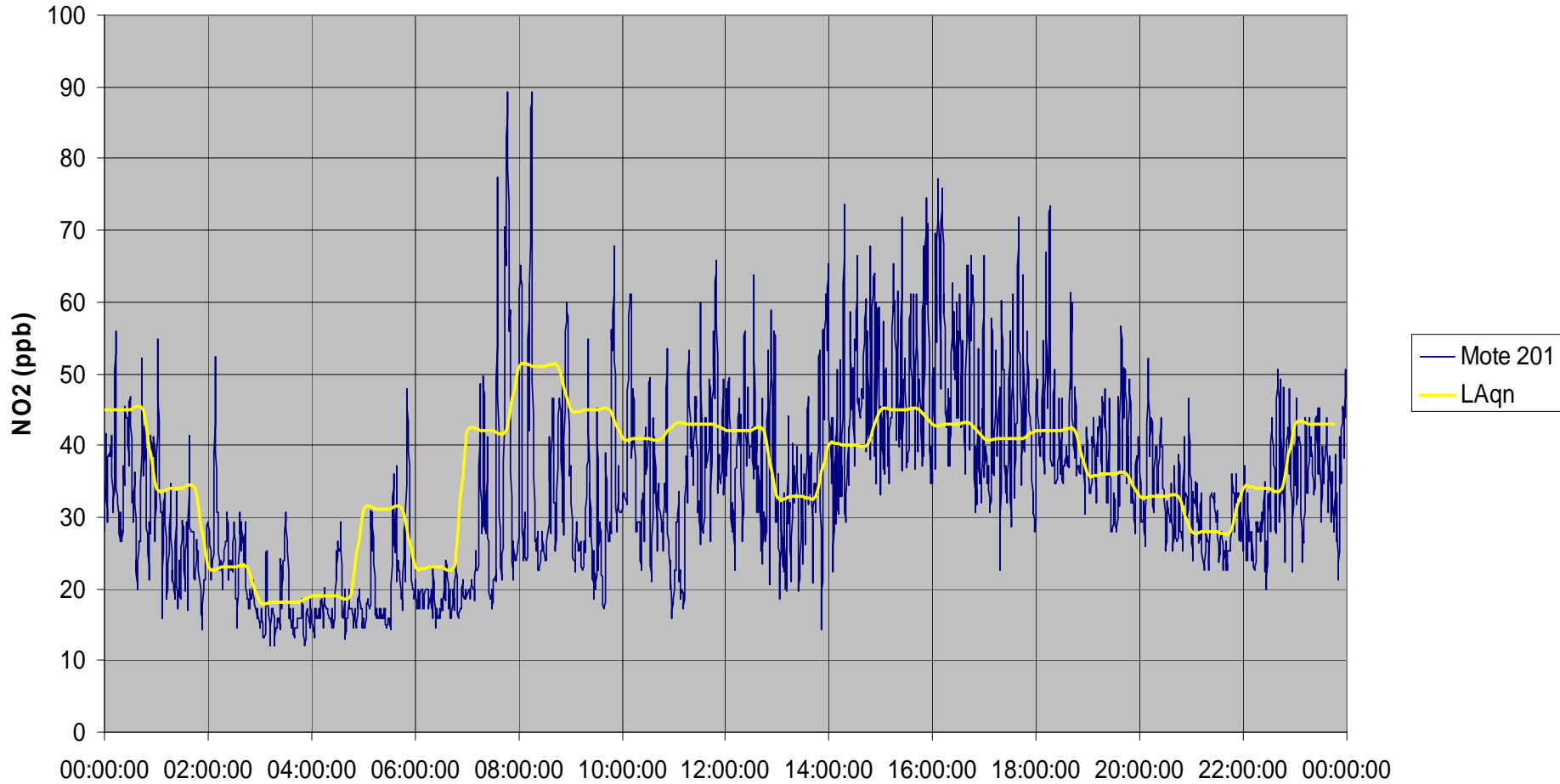
# Typical NO<sub>2</sub> Sensor Co-location Result



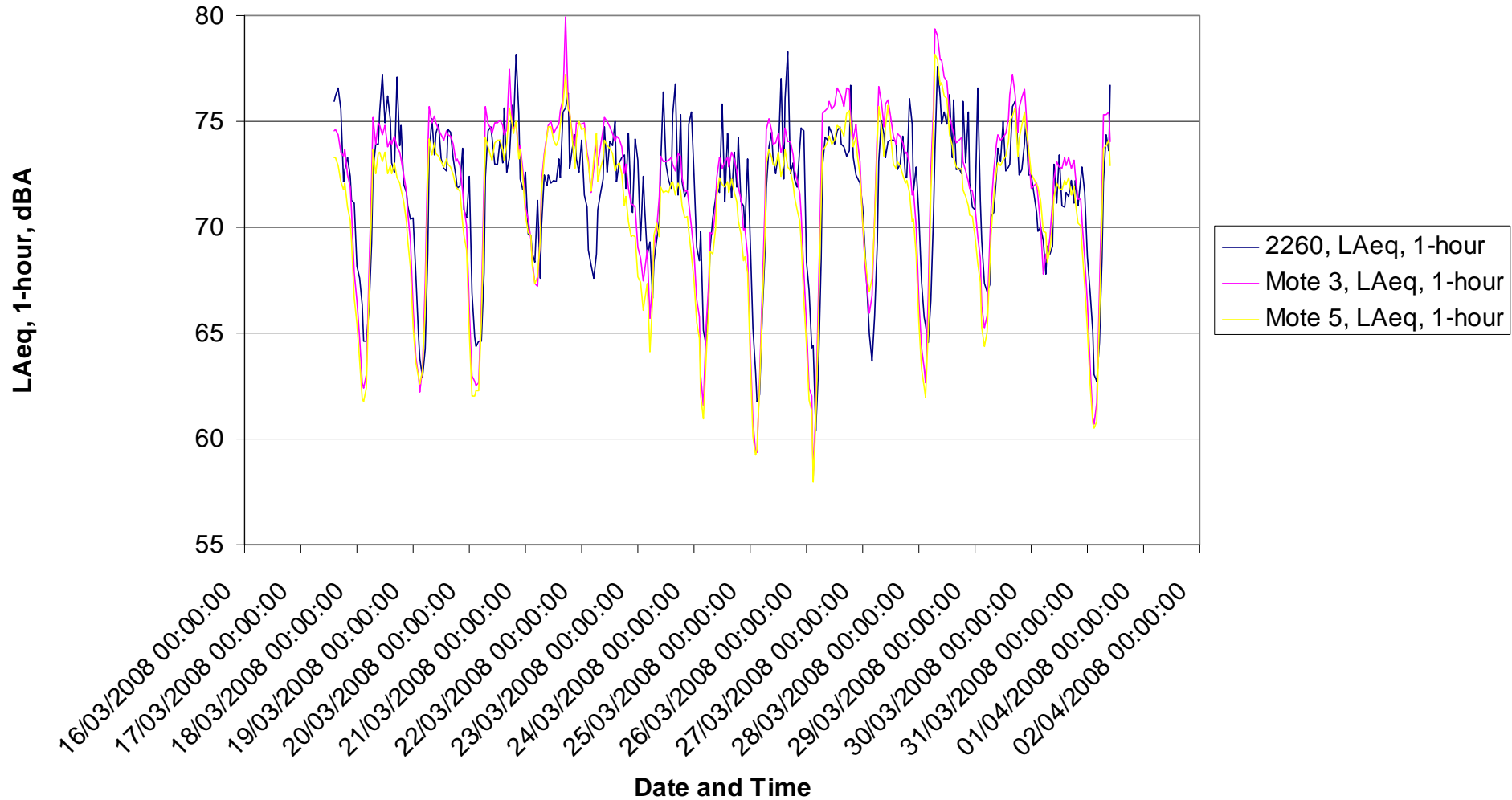
# Mote NO<sub>2</sub> versus Gateshead AQM data



# Mote NO<sub>2</sub> versus London AQM data



# Noise Co-location with 2260 SLM



# Online Visualisation tools

## Demonstration



Last Updated TIME: 20-NOV-08 08.01.22.664000  
Sensor ID: 00005  
[CO \(ppm\)](#) : .366 (provisional)  
[NO2\(ppb\)](#) : 7.94 (provisional)  
[Noise\(dBA\)](#): 072  
[Traffic Occupancy \(%\)](#): 000  
[Relative Humidity \(%\)](#): 071  
[Temperature \(deg C\)](#): 08.4



# Deployment (motes and gateway)



# Deployments to date

- 40 static + 10 mobile motes in Newcastle
- 50 static motes in Leicester
- 15 motes in London
- Small deployment in Palermo, Italy
- Small deployment in India
- >1000 mote-months in total

# Conclusions – low cost gas sensors

- Low cost electrochemical sensors have been shown to have adequate sensitivity for environmental measurements.
- However significant post-processing is also required to correct for temperature.
- Cross sensitivity e.g. ozone-NO<sub>2</sub> is an issue with these sensors.
- There is still huge room for improvement in low cost gas sensors but manufacturers are making progress.

# Conclusions – wireless communication

- It is definitely feasible to construct robust, wireless data gathering networks using modern transceivers and network protocols.
- IEEE 802.15.4 (Zigbee) can form dense networks of up to  $1\text{km}^2$  ( $\sim 100$  nodes).
- Other wireless standards can be employed to scale up the area coverage.

# Conclusions – deployment and design

- Careful design of mote circuits and protocols can enable life of many months from batteries or indefinitely with small solar cells.
- Mechanical design has proved robust to weather etc.
- Don't ignore "social" issues – motes at eye level had a very high incidence of vandalism!

# Thanks for listening

Jeff Neasham

Senior Lecturer

School of EECE

Newcastle University

[j.a.neasham@ncl.ac.uk](mailto:j.a.neasham@ncl.ac.uk)

0191 222 8850