

THE INSTRUMENTED CITY: MONITORING TRANSPORT AND THE ENVIRONMENT

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ABSTRACT

The Instrumented City (IC) is a suite of research facilities dedicated to transport and environment issues. Facilities include an extensive range of state-of-the-art traffic, vehicle emission, meteorological, noise and air pollution monitoring instrumentation. The complimentary facilities are allowing researchers to study traffic flow and congestion – emission generation – dispersing air-flows – atmospheric chemistry - noise and air pollution simultaneously. The real excitement of the Instrumented City Facility, is that it is multidisciplinary, bringing together researchers from the disciplines of traffic engineering, dispersion modelling, atmospheric chemistry and noise.

Key facilities, that are in continuous operation include: an 'instrumented junction' and a 'roadside laboratory'. At the urban 'instrumented junction' research site simultaneous measurements are collected over a 1km² area including: traffic, speed and journey times (ANPR entry/ exits), synoptic and in-street wind speed/ direction/ turbulence, broadband noise levels, air pollution (NO/NO₂/NO_x, O₃, Particle Number Count) at three roadside and one local background site. These co-ordinated measurements lend themselves to detailed urban traffic, junction and street canyon studies, including the development/ calibration and validation of micro-scale traffic, noise and dispersion models. The 'roadside laboratory' facility provides researchers with a platform to operate prototype and emerging instrumentation, such as particle size analysers.

With facilities in continuous operation, there is capacity to support and under-pin a wealth of research projects. Researchers interested in using these facilities or datasets for their works, or wish to make additional complimentary measurements, are invited to contact the facility manager James Tate (j.e.tate@its.leeds.ac.uk).

Keywords: *Transport and environment research facilities: traffic, meteorology, noise and air pollution*

1. A HIGHLY 'INSTRUMENTED JUNCTION'

The Instrumented City Facility has setup a new experimental site, in Headingley, Leeds UK. Semi-permanently installed instruments are routinely collecting measurements of local traffic, meteorology, air and noise pollution around a heavily congested signalised traffic junction. The instrumentation deployment is illustrated in Figure 1, with further details provided in Table 1. The novelty and excitement of the research site is:

- not only are traffic flows, fleet composition and 'spot' speeds measured, but number plates are automatically recorded (ANPR) at entry/ exit points to the junction. By matching ANPR records, journey times, turning movements and the day-to-day variability in traffic conditions across the 1km² study area can be quantified. This is allowing researchers to further our understanding of congested urban traffic networks, and provide high quality/ resolution data to calibrate/ validate detailed traffic models;

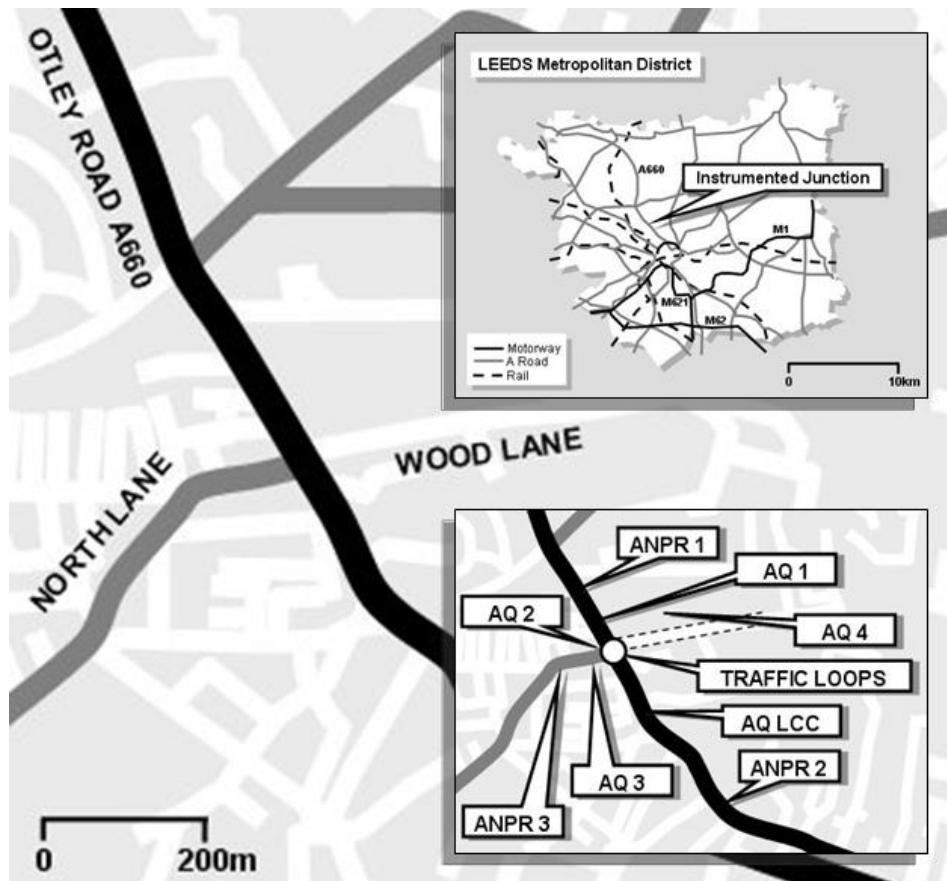


Figure 1: Schematic of 'Instrumented Junction' area (from Ropkins et al, 2006)

(Inserts: Top, Junction location in Leeds Metropolitan District; Bottom, Instrument deployment within junction area. Station abbreviations: ANPR, automatic number plate recognition; AQ - Air Quality; LCC - Leeds City Council).

- both synoptic (above roof-top) and in-street wind speed, direction and turbulence is being monitored simultaneously. Researchers are using this information to explore how prevailing weather systems interact with building and street geometries, to generate complex in-street dispersing air-flows, such as 'street canyon' and 'helical' vortices;
- a dense network of air pollution stations are in-use, studying the spatial and temporal variations in key pollutants around the junction. The mini-network includes one station at the heart of the junction, three on adjoining arms of the junction and one local back-ground site. The be-spoke 'compact' stations are monitoring Oxides of Nitrogen (NO/ NO₂/ NO_x), Ozone (O₃) and ultra-fine Particle Number Count (PNC), using Chemiluminescent, UV photometer and Water-based Condensation Particle Counters (CPC) respectively. Analysis has demonstrated surprisingly large variations in concentrations between stations, largely influenced by the prevailing wind direction and speed/ street and building geometries, but also tidal traffic flows;
- two noise monitoring stations are also included, one at a roadside location, and one at a background site. Both stations include 1/3rd octave measurement systems – in order to capture continuous spectral information, and include digital event recording, triggered by threshold criteria, allowing a posteriori analysis of significant events;

- sample vehicle trajectory datasets from multiple Instrumented Vehicles simultaneously circulating the study site are also available. Instrumented Vehicle data (Tate, 2005) includes vehicle speed, position (GPS), front/ rear headways from ACC radar sensors, fuel consumption and tail-pipe emissions at 1Hz (Ropkins et al, 2008); and
- not simply the separate measurements and research areas, but the multi-disciplinary facility as a whole.

Table 1: ‘Instrumented junction’ summary

TRAFFIC Systems	Supplier: Golden River, http://www.goldenriver.com/
Key Components:	Marksman 665 Loop Vehicle Classifier, 2-loops per lane ANPR system, including M800 camera system, outstation and software Equipment housing - MtPole System
ANPR1	1 North-bound Lane with 1 MtPole, 2 loops, 1 ANPR camera. 2 South-bound Lanes with 1 MtPole, 4 loops, 2 ANPR cameras.
ANPR2	1 North-bound Lane with 1 MtPole, 2 loops, 1 ANPR camera. 1 South-bound Lane using North-bound MtPole, 2 loops, 1 ANPR camera.
ANPR3	1 East-bound Lane with 1 MtPole, 2 loops, 1 ANPR camera. 1 West-bound Lane using East-bound MtPole, 2 loops, 1 ANPR camera.
AIR QUALITY Systems	Supplier: Enviro Technology, www.et.co.uk/
Key Components:	NO _x – API M200E Chemiluminescent analyser
	O ₃ – API M400E “LT” UV Absorption analyser
	Particle Number Count (PNC) – Water-based CPC, TSI 3785, configured range 5 – 250nm
	Noise Monitoring Systems, Brüel & Kjær 2260F analyser, ‘events’ audio recording, outdoor microphone kit
	Sonic Anemometer (Met) – Gill WindMaster, Data-logger - Campbell Scientific CR1000 (20 Hz)
AQ1	NO _x , O ₃ , PNC, Anemometer (Met)
AQ2	NO _x , PNC, Noise, Anemometer (Met)
AQ3	NO _x , PNC, Anemometer (Met)
AQ4	NO _x , O ₃ , PNC, Noise, Anemometer (Met), Rain-fall
AQ LCC	Leeds City Council Station, NO _x , PM ₁₀ (TEOM), PNC

2. A ROADSIDE LABORATORY

The Instrumented City Facility has also setup a ‘Roadside Laboratory’ for studying traffic-related pollution. The Laboratory is located at the roadside of Kirkstall Road (Leeds, LS4 2QT, UK). Kirkstall Road is a heavily-trafficked urban arterial, with peak hour flows exceeding 1200vehs/hr per lane. The Roadside Research Laboratory has been in continuous operation since August 2007. Instrumentation in the ‘walk-in’ style enclosure includes:

- Traffic Monitoring – The Traffic Monitoring Unit (TMU) uses 2 inductive loops per lane to provide classified traffic flow, speed and headway information. The loop detectors are located adjacent to the ‘Roadside Laboratory’. Raw data is collected for each individual drive-by ‘event’, or 1, 5 and 15 minute averages are also available. The instrumentation is supplied by Golden River (www.goldenriver.com/);

- Meteorological Station – Simultaneous measurements of the local meteorological conditions are also collected at a 1-minute time resolution. Located in the sampling cage on the station roof, sensors are monitoring: wind speed and direction (2D sonic anemometer), ambient temperature and relative humidity, incoming solar radiation. Leeds City Council also kindly make available synoptic (background) wind speed and direction measurements from a local 35m meteorological mast;
- Noise levels – Are recorded with a B&K broadband instrument;
- Air pollutants - Supporting measurements of Carbon Monoxide (CO), Oxides of Nitrogen (NO/NO₂/NO_x), Ozone (O₃) and Hydro-Carbons (HCs) are made by certified gaseous analysers at a 1-minute time resolution, operated in accordance with the UK National Network Local Site Operators manual (6-monthly service and maintenance visits, fortnightly manual calibrations and automatic nightly checks). Particle measures include PM_{2.5} (TEOM) and PNC (Particle Number Count, CPC).

Collaborating researchers in the Energy Resources Research Institute (ERRI) and Institute for Transport Studies (ITS) have for example been using the station as a platform to study the factors influencing particle number concentrations (PNC), size distributions and modal parameters (Agus et al, 2007).

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