Imperial College London

The Centre for Transport Studies and The Urban Systems Laboratory

Prof. John Polak
Chairman, Centre for Transport Studies
Director of Research, Department of Civil and Environmental Engineering
Director, Urban Systems Laboratory
j.polak@imperial.ac.uk

Imperial College London

The Centre for Transport Studies and The Urban Systems Laboratory

Prof. John Polak

Chairman, Centre for Transport Studies

Director of Research, Department of Civil and Environmental Engineering

Director, Urban Systems Laboratory

j.polak@imperial.ac.uk

Overview

- Centre for Transport Studies
- Urban Systems Laboratory
- Examples of relevant recent projects

Imperial College
London

Overview of Transport Research at Imperial

- Imperial has one of the largest and most broadly based transport research communities anywhere in the world
- All the major Departments and Institutes of College have significant transport research interests e.g.,
  - Aeronautical Engineering
  - Chemical Engineering
  - Civil and Environmental Engg.
  - Computing
  - Mechanical Engineering
  - Earth Science Engineering
  - Electrical and Electronic Engg.
  - Physics
  - Mathematics
  - Business School
  - Medical School
- In total, the community comprises upwards of 120 Faculty and researches throughout College

Imperial College
London

Centre for Transport Studies

- The Centre for Transport Studies is the hub of this research community, with twin objectives
  - To deliver transport teaching and research of the highest international quality
  - To link together and catalyse transport research activities throughout College
- CTS comprises
  - 8 core academic staff (including 5 Professors) with backgrounds in engineering, economics, environmental science and mathematics
  - 6 Visiting Professors from industry
  - ~ 70 post doctoral researchers and PhD students
  - ~ 90 Masters students on 3 MSc courses
  - Network of 30+ associated Faculty throughout College

Imperial College London

CTS – Research Mission

"CTS undertakes internationally leading research into all aspects of the planning, design, financing, regulation, operation, maintenance and management of transport and communications systems, services, products and technologies.

Our work covers all modes of transport and communication and addresses the needs of government, business and individual citizens."





Imperial College London

CTS – Principal Areas of Research

- Research in CTS is highly multidisciplinary in nature, involves extensive collaboration with industry (~40% of our research income) and covers a wide range of subject areas:
  - Analysis and modelling of travel demand (London Data Centre)
  - Transport network operations
  - Transport and the environment
  - Intelligent transport systems (Intelligent Infrastructure and Transport Laboratory
  - Transport economics, policy and regulation
  - Transport risk, safety and security (Lloyds Register Trust Transport Risk Management Centre)
  - Public transport operations and management (Railway and Transport Strategy Centre)
  - Engineering geomatics (IC Engineering Geomatics Group)
  - Air transport and air traffic management
  - Port operations and planning (Port Operations Technology and Research Centre)

Imperial College London

CTS – Principal Areas of Research

- Research in CTS is highly multidisciplinary in nature, involves extensive collaboration with industry (~40% of our research income) and covers a wide range of subject areas:
  - Analysis and modelling of travel demand (London Data Centre)
  - Transport network operations
  - Transport and the environment
  - Intelligent transport systems (Intelligent Infrastructure and Transport Laboratory
  - Transport economics, policy and regulation
  - Transport risk, safety and security (Lloyds Register Trust Transport Risk Management Centre)
  - Public transport operations and management (Railway and Transport Strategy Centre)
  - Engineering geomatics (IC Engineering Geomatics Group)
  - Air transport and air traffic management
  - Port operations and planning (Port Operations Technology and Research Centre)

Imperial College
London

Urban Systems Laboratory

- We will shortly be launching the **Urban Systems Laboratory** that will linking the work of over 200 Faculty and researchers across College in the area of urban systems, under a coherent banner, to promote and extend:
  - Internal and external collaboration
  - Industrial engagement
  - Research and thought leadership
  - Training and skills development
  - Demonstration, translation and exploitation
- Industrial participation via direct support, subscription or collaborative research

Imperial College London

Urban Systems Laboratory – challenge & mission

- Re-align and re-focus world-leading academic creativity to address the urgent problems of cities
- Create a new, holistic and cross cutting inter-disciplinary field of “Urban Systems Engineering”
  - Engineering (e.g. ICT, systems, infrastructure)
  - Natural sciences (e.g., materials, fuels, complexity)
  - Business (e.g., economics, innovation, planning)
  - Medicine and healthcare (e.g., primary care, public health, medical science)
- Methodological outlook is analytical, quantitative and business focused
- And brings to bear a *seriousness & scale* commensurate with the societal challenges and business opportunity

Examples of major existing projects (>£2m)

- Intel Institute for Sustainable Connected Cities
- Cisco Future Cities Centre
- Laing O'Rourke Centre for Systems Engineering and Innovation
- NEC Smart Water Systems Lab
- Climate KIC
- ICT Labs KIC
- Ofgem Low Carbon London
- RCUK Digital City Exchange
- BP Urban Energy Systems

Urban Systems Laboratory – Thematic areas

- The Urban Systems Laboratory will work in eight linked thematic research areas:
  - Low carbon operation and resource efficiency
  - Resilience and adaptability
  - Systemic quality of service
  - Sensing, simulation and modelling
  - Economic performance
  - Advanced materials and processes
  - Health, wellbeing and quality of life
  - Business models and innovation

Imperial College
London

MSc in Urban Systems Engineering

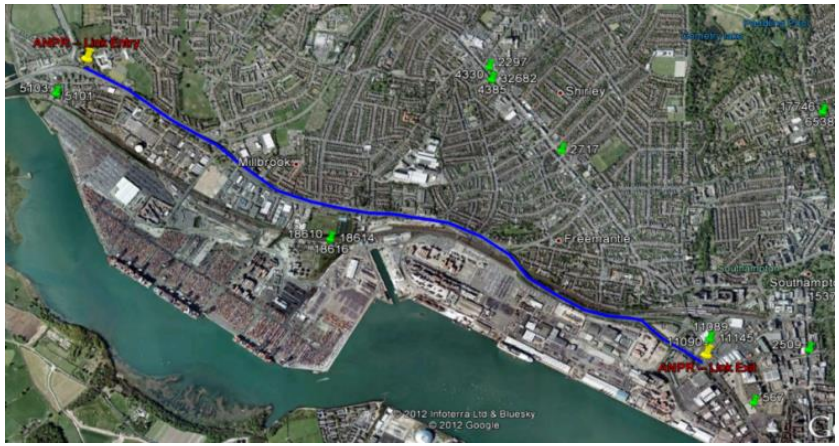
- Aims to equip students to build the discipline and practice of *Urban Systems Engineering*
  - The next generation of urban system integrators
  - Intellectual maturity, disciplinary sophistication
- Aimed at top (quantitative) engineering, science and social science graduates and practitioners, *with experience*
- Emphasis on building out from existing domain-depth knowledge
- Project based; much less conventional classroom time
- 2 short placements plus longer individual research project with industrial partners

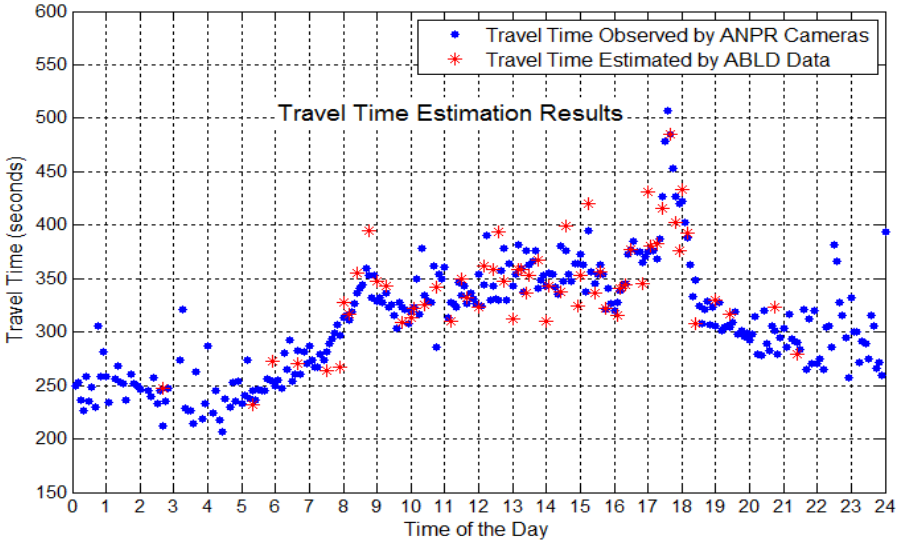
Examples of Existing Projects

Imperial College London

FIREFLY: Network LOS and OD matrices from MND

- **Vision**
  - Develop methods to exploit ‘basic’ mobile network billing data for dynamic link travel time and OD matrix estimation
- **Implementation**
  - Combine MND with models for flow propagation, route choice and OD travel patterns
  - Explicitly statistical models to account for problems of partial observation
  - Begin to understand the relationship between mobile network topology, transport system topology and estimation performance
- **Application**
  - Case study application in Southampton



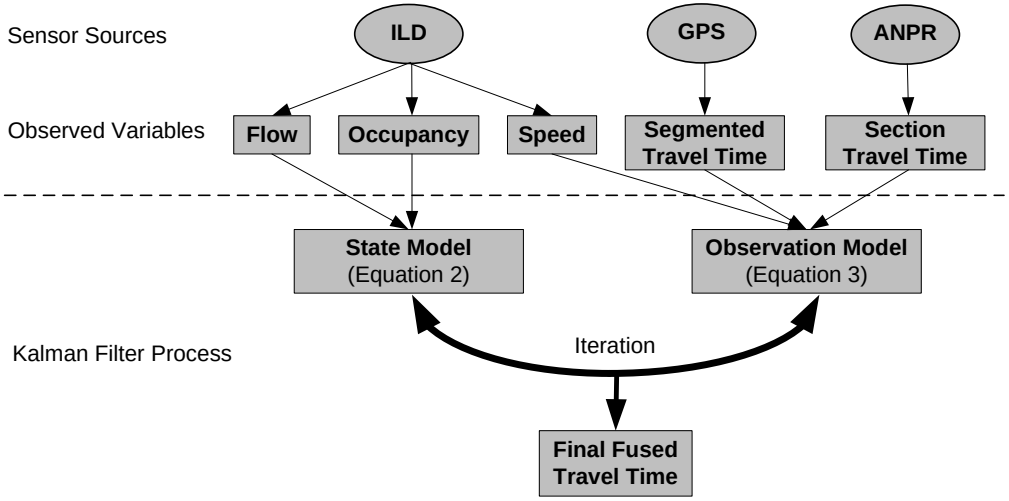


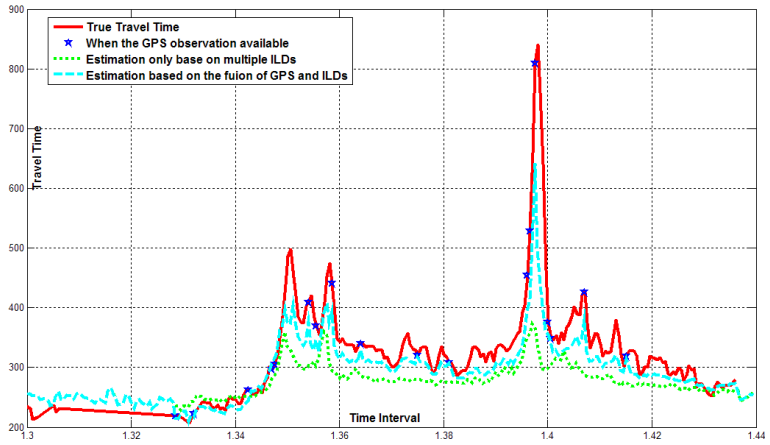
vodafone

Imperial College London

Sensor fusion and state estimation

- **Vision**
  - Develop general sensor fusion framework for multi-sensor traffic data
  - Focus on travel time estimation
- **Implementation**
  - Framework is based on the extended (non-linear) Kalman Filter
  - Integrates traffic propagation models
  - Accommodates general point and line sensor systems
- **Application**
  - Case study application in Maidstone





EPSRC Engineering and Physical Sciences Research Council

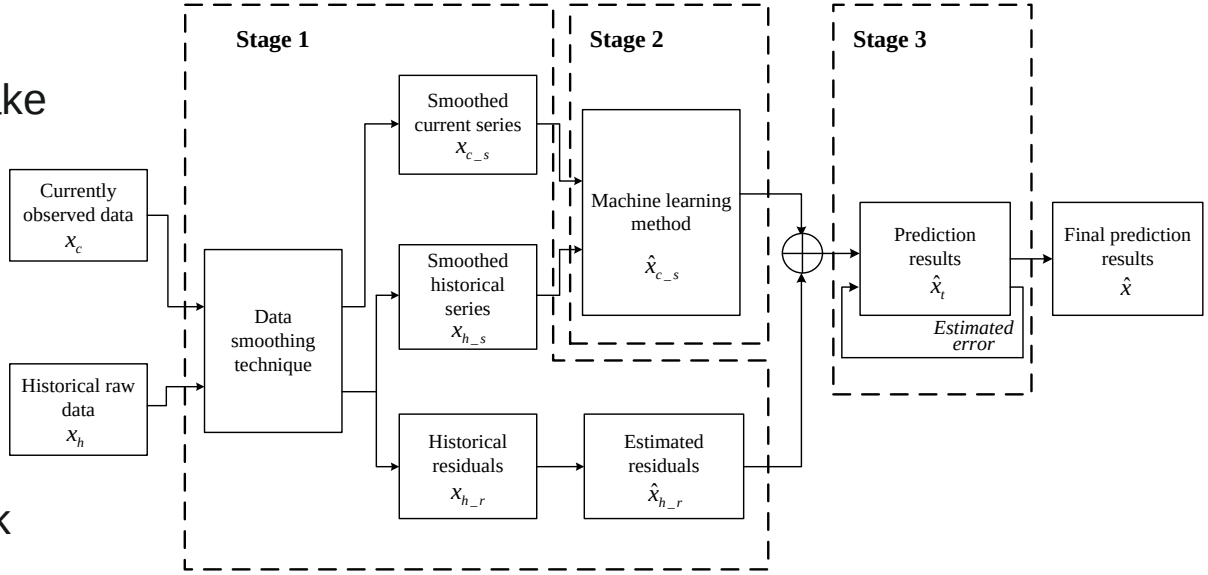
Department for Transport

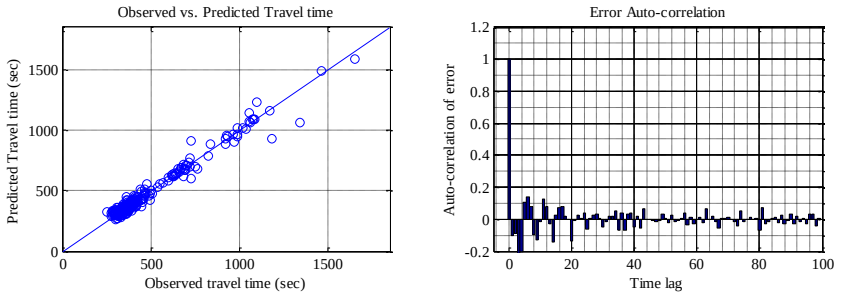
Technology Strategy Board

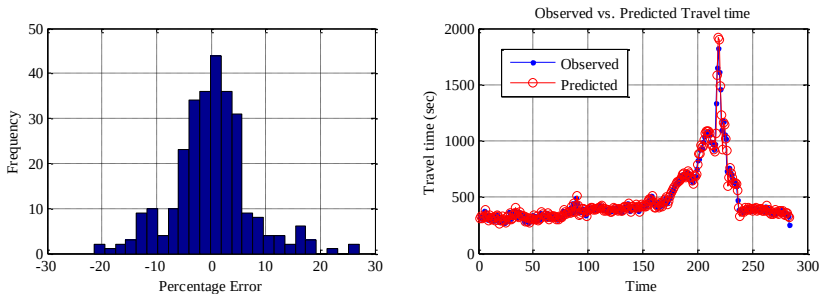
Imperial College London

Short term prediction in abnormal conditions

- **Vision**
  - Develop capability to make short term (15 min) predictions in abnormal traffic conditions
- **Implementation**
  - Based on fast machine learning techniques
  - Novel 3-stage framework including explicit sensor data pre-processing (smoothing), flexible machine learning predictors and error feedback
- **Application**
  - Application to flow and travel time prediction in London and Maidstone





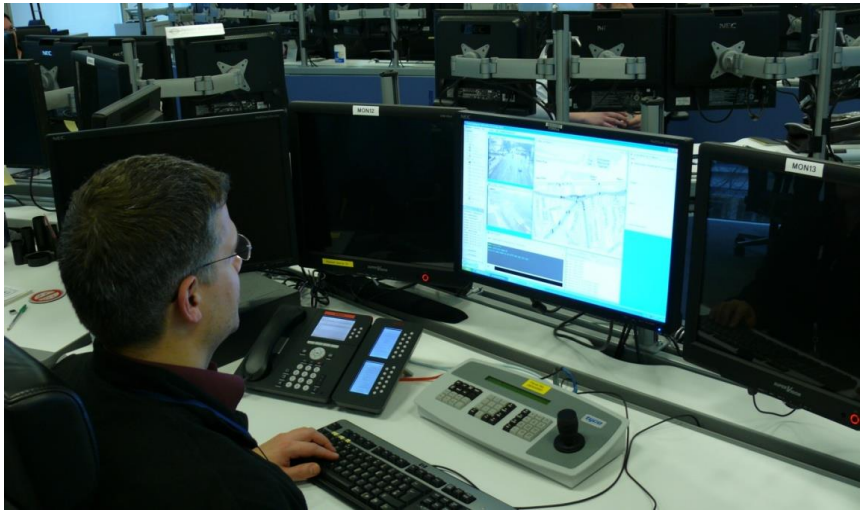


EPSRC Engineering and Physical Sciences Research Council

Imperial College London

FREEFLOW

- **Vision**
  - Develop a platform for traffic intelligence, leveraging military situational awareness technologies
- **Implementation**
  - Traffic sensor processing and data fusion + network state estimation and prediction (e.g., where are the queues/incidents, are they growing or clearing, where will the next problem occur?)
  - Strategy development and selection (e.g., what should we do, what worked in the past, what does modelling tell us?)
  - Tools for integration, visualisation and collaborative decision support (e.g., how do I get at and use all this intelligence?)
- **Application**
  - Case study applications (including London, York and UK motorway network)



EPSRC Engineering and Physical Sciences Research Council

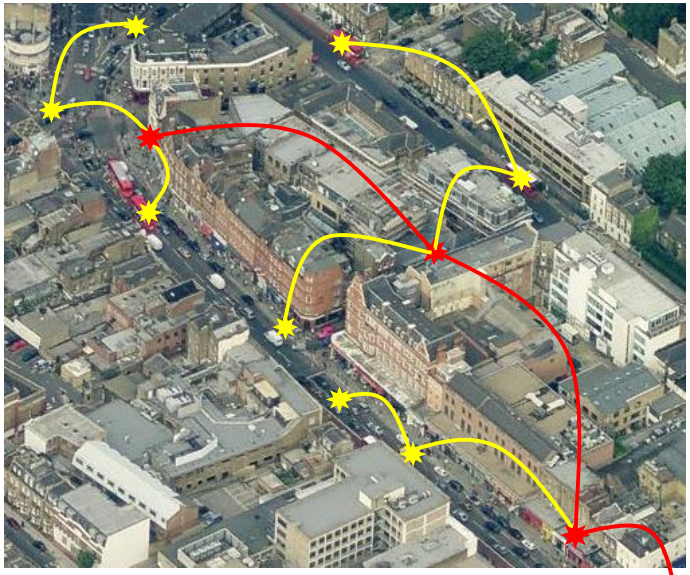
Department for Transport

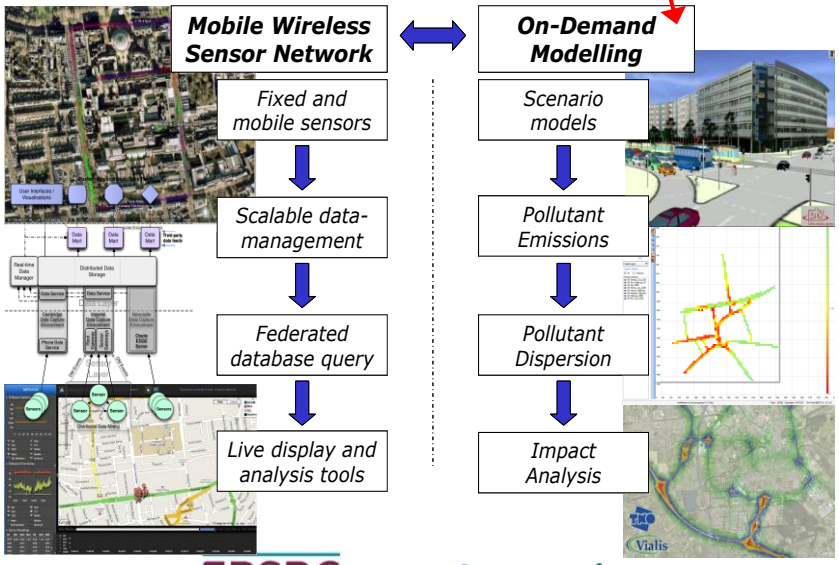
Technology Strategy Board

Imperial College London

MESSAGE

- **Vision**
  - Create an entirely new sort of data collection infrastructure to manage traffic related emissions to support research and practice
- **Implementation**
  - Network of heterogeneous fixed and mobile air quality sensors on infrastructure, vehicles and people
  - Sensors communicate via wireless networks
  - Positioning via GPS + wireless & cellular ranging
  - Integration of processing along the data path
- **Application**
  - Improved pollution hot spot prediction, detection and mitigation for Transport for London
  - Improved air quality information for individual travellers





EPSRC Engineering and Physical Sciences Research Council

Department for Transport

Imperial College

CoMET and Nova Benchmarking: Industry Collaboration to Improve Metro Railway Performance

Imperial College
London

ISBeRG Suburban Railway Benchmarking

Oslo (NSB)

Copenhagen (S-Tog)

London (Overground)

Munich (S-Bahn)

San Francisco (BART)

New York (Long Island Rail Road, Metro-North)

Barcelona (FGC)

Tokyo (JR East)

Sao Paulo (CPTM)

Sydney (CityRail)

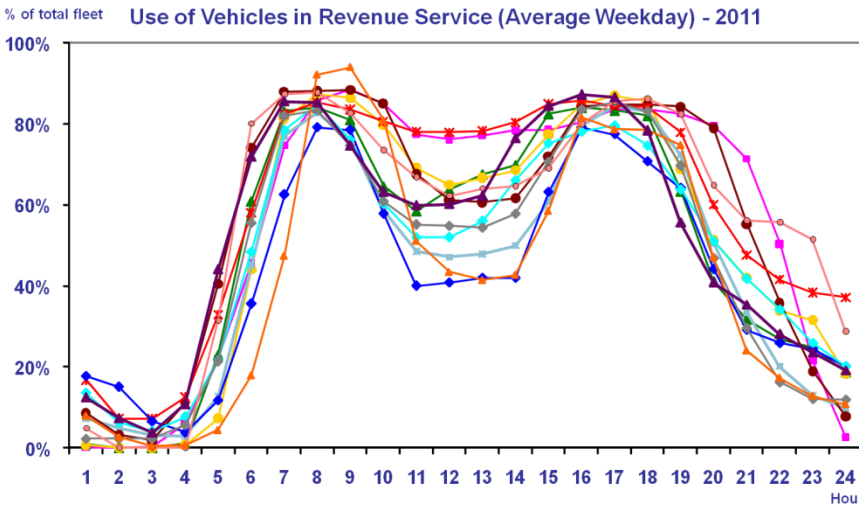
Melbourne (Metro Trains)

ISBeRG

Imperial College London

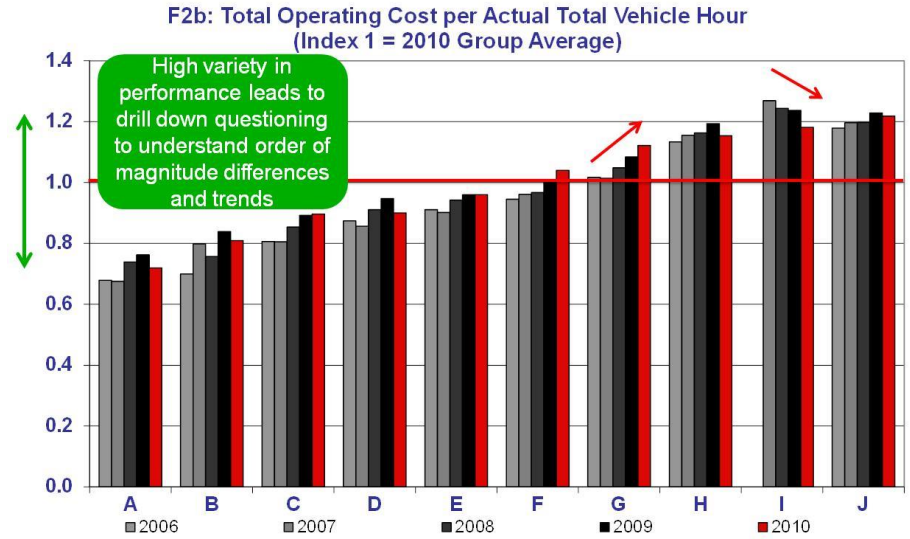
The International Bus Benchmarking Group: Improving Urban Bus Performance Around the World

- Best practices in urban bus operations are found and shared through annual key performance indicator analyses and in-depth research in key improvement areas.
- 12 large size international operators
- 8 years running



Imperial College London

The American Bus Benchmarking Group: Industry Collaboration to Improve American Urban Bus Performance

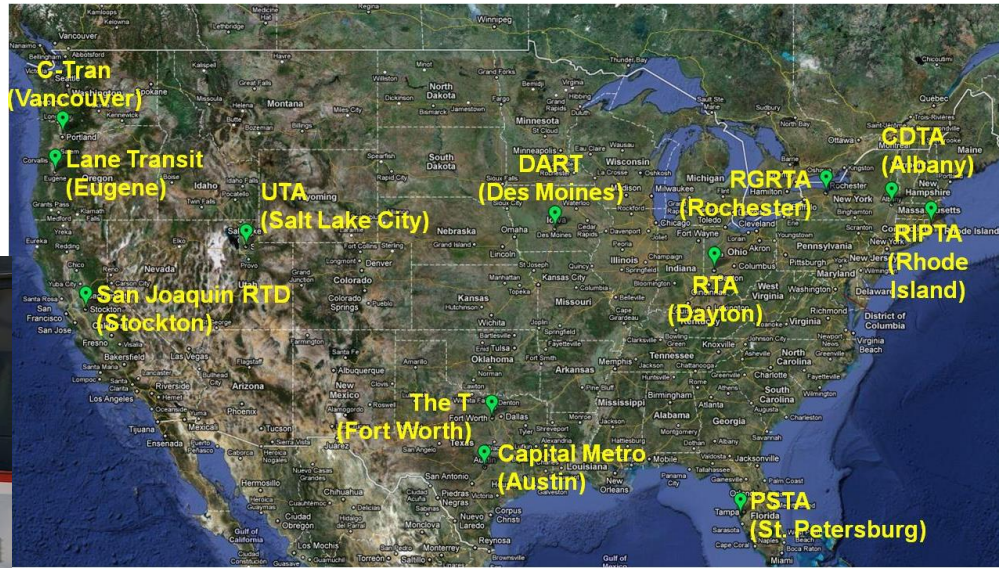


ABBG AMERICAN BUS BENCHMARKING GROUP

Best practices in urban and suburban bus operations are found and shared through annual key performance indicator analyses.

12 mid-sized size US bus operators

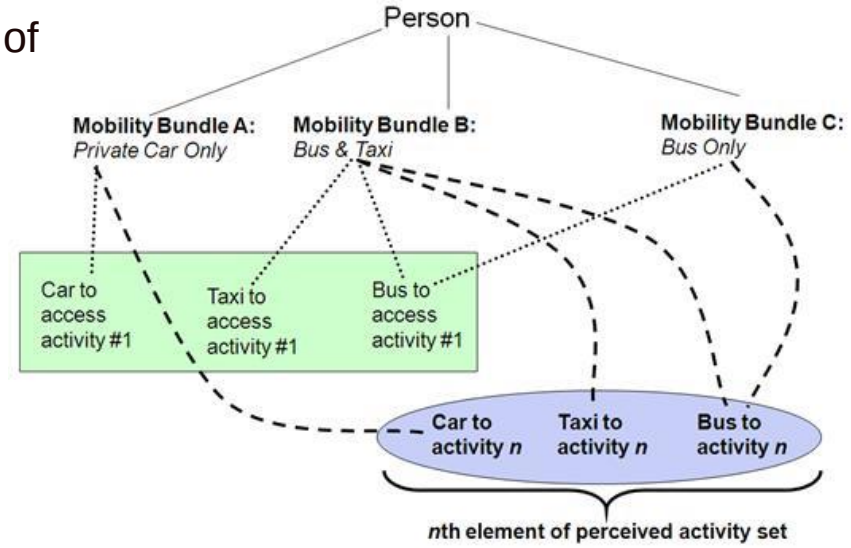
2nd year running

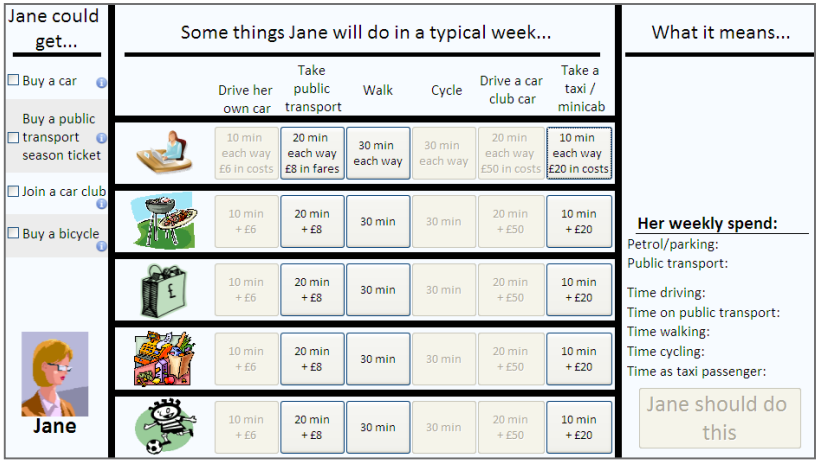


Imperial College London

Adoption and use of shared mobility concepts

- **Objective**: To predict adoption and use of car clubs and related shared mobility concepts, with emphasis on LCV fleets
- Model predicts subscription choice (strategic) and car club use (tactical), in competition with other modes
- Concept is that users choose 'mobility bundles' comprising several modes, on the basis of their expected mobility requirements, and then choose specific modes from these bundles for individual trips
- Data come from a number of existing CC operators, the UK National Travel Survey and a specially designed stated preference survey
- The underlying model structures are discrete choice; novel feature is the conjoing of strategic and tactical choices

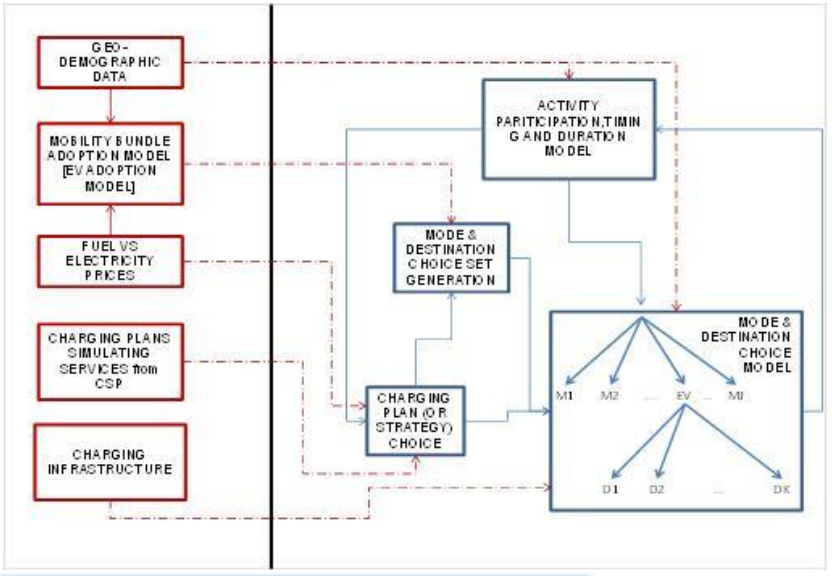


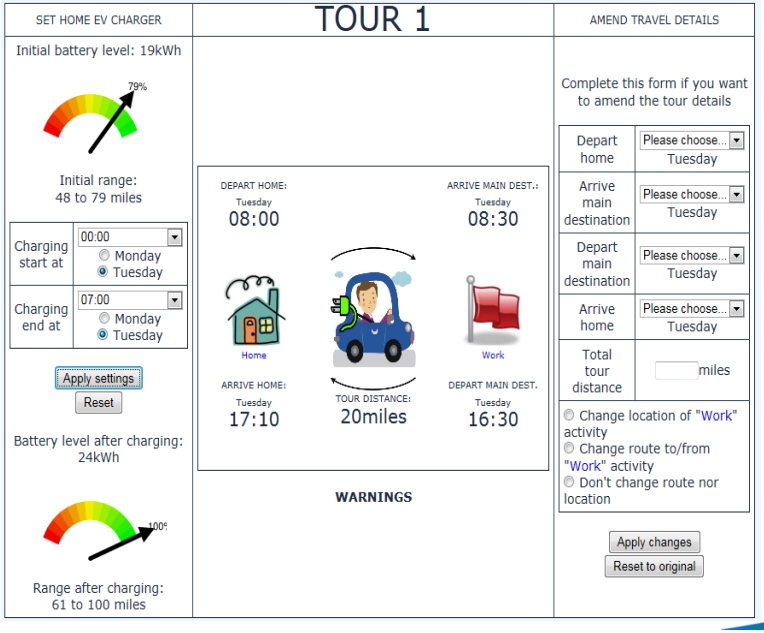


Imperial College London

Modelling joint charging and mobility choice

- **Objective**: To predict how travel patterns will affect and be affected by charging opportunities and charging behaviour and how different tariff structures for charging affect both travel and charging choices
- Model predicts charging behaviour (choice of SOC level achieved and “plug-in time”) and the characteristics of the tour following the charging operation, depending on the cost of the charging operation
- Data come from stated preference survey and TSB Low Carbon Vehicle trials
- The underlying model structure is discrete choice but much more complex than for EV choice alone



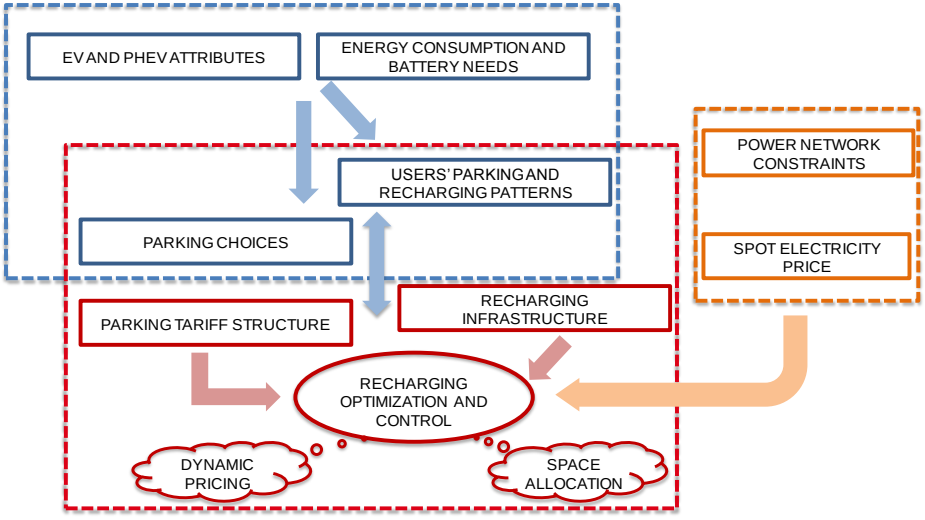


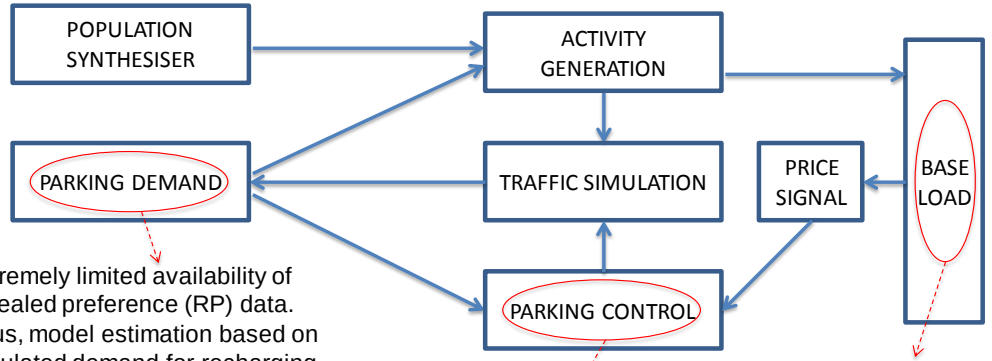
Grantham Institute for Climate Change

Imperial College London

Revenue management for parking and charging

- **Objective**: To develop operational revenue management technology for combined parking and charging operations
- Key questions:
  - Framework for setting dynamic prices to optimise revenue, urban space utilisation and grid operations
  - Need to take into account user's parking search and choice behaviour as well as response to price
  - And power network constraints
- Working with parking industry
- Overall framework combines microsimulation modelling and optimal control
- Builds on existing work in:
  - Demand modelling
  - Optimal pricing
  - Network optimisation





Extremely limited availability of revealed preference (RP) data. Thus, model estimation based on simulated demand for recharging facilities. Validation could be based on ongoing trials in Central London.

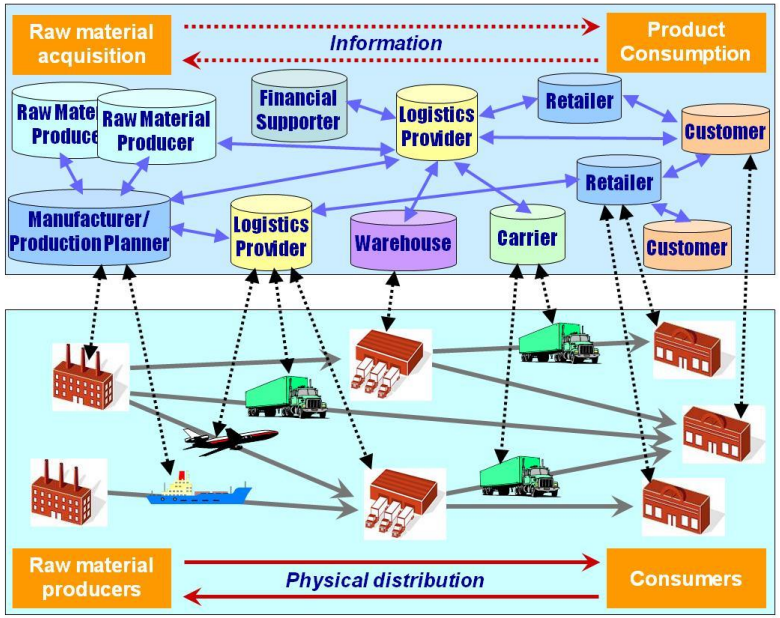
Either empirically or design SP survey to estimate EV users' willingness to pay (or change their habits) under hypothetic scenarios

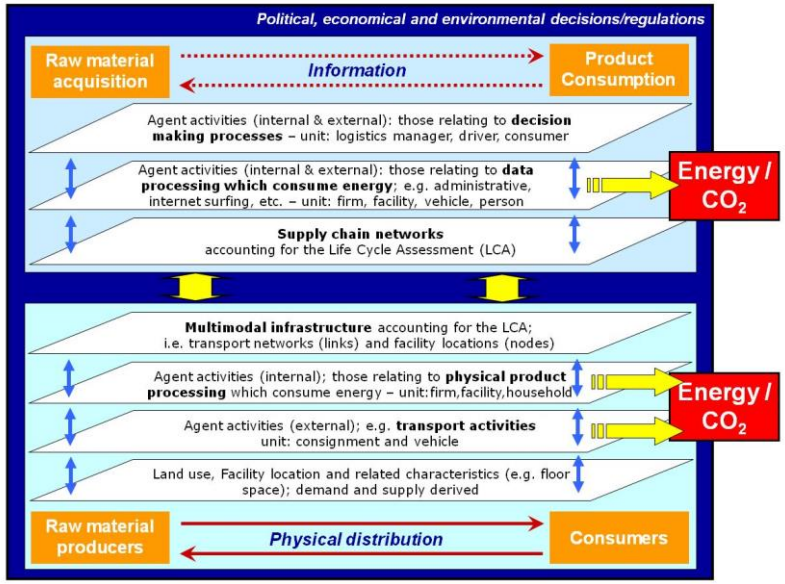
Generic power simulation. Provided the simulated parking demand and available data for electricity base load gives a price signal for the parking operator

Imperial College London

Urban goods and services model

- **Vision**
  - Model of urban goods and services based on explicit production and consumption processes and logistics
- **Implementation**
  - Commodity-based, supply-chain-activity-based and multi-agent-based perspectives
  - Micro-level models with demand-driven approaches, simulating behavioural activities at the personal consumption level
  - Focus on commodity/activities serving the demand within the urban area
  - Account for both inbound and outbound logistics for both upstream and downstream
- **Application**
  - Case study application in London



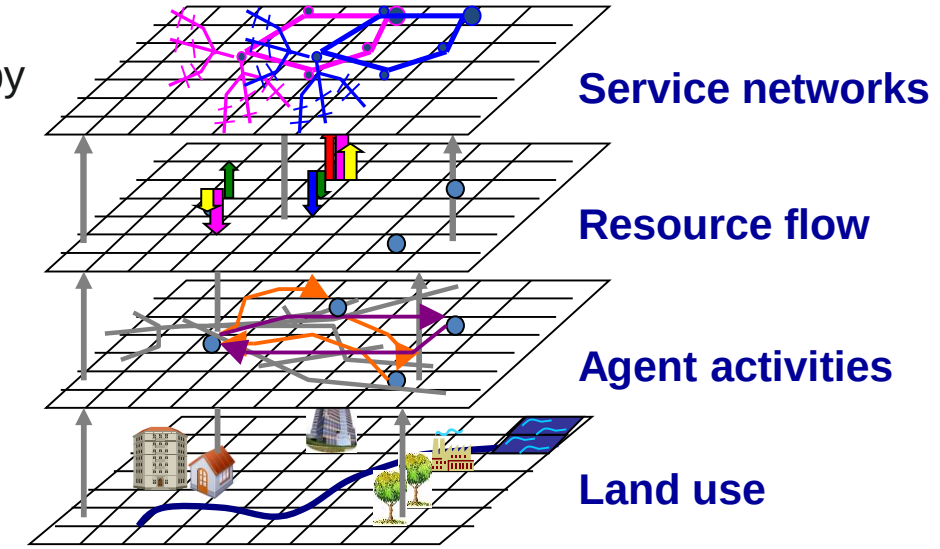


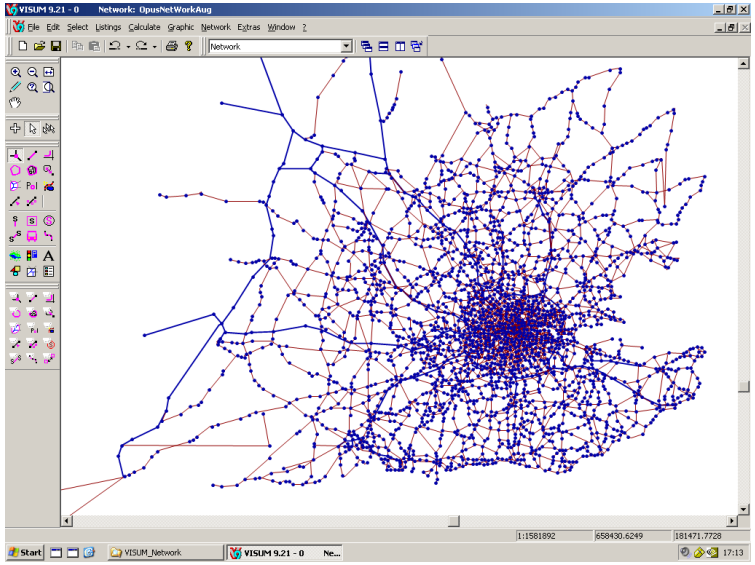
bp

Imperial College London

Urban Energy Systems

- **Vision**
  - 5 year research programme, funded by BP
  - Create integrated model of energy supply, distribution and use in a city
  - Quantify benefits of integrated design
  - Identify pathways to implementation
- **Implementation**
  - Develop novel agent-oriented model linked to design optimiser
  - Leveraging state of the art methods in transport, land use and energy systems modelling
- **Application**
  - A number of case study applications are underway both ‘new build’ and existing cities (including London, Atlanta, Beijing and Lingang)



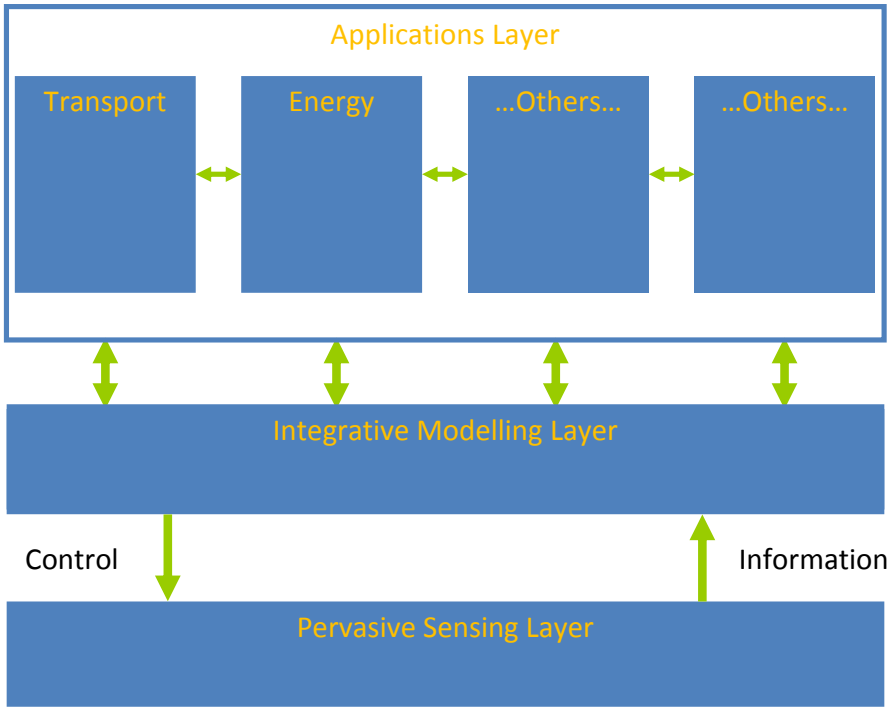


bp

Imperial College London

Digital City Exchange

- **Vision:** Demonstrate how existing and new transport and energy data streams can support the development of new applications and services
- **Implementation**: Develop an *integrative layer* that understands the semantics transport and energy networks ('OS for the city')
  - Coherent but extensible multi-scale model of urban systems
  - Sensor data assimilated into the model
  - Model capable of generating short term predictions
- **Outputs**: IL + business cases + pilot applications for e.g.,
  - Personalised energy management transport and space heating
  - Home delivery scheduling and re-scheduling
- **Partners**
  - Transport for London, Sainsburys, National Grid, Arup and others…

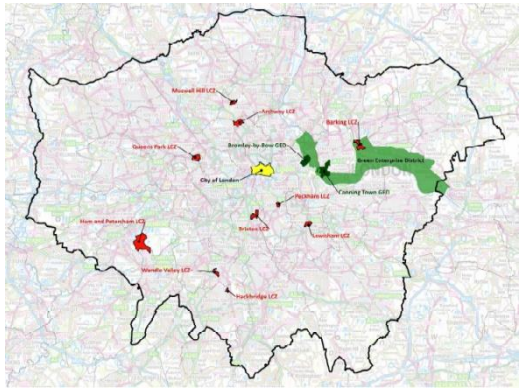


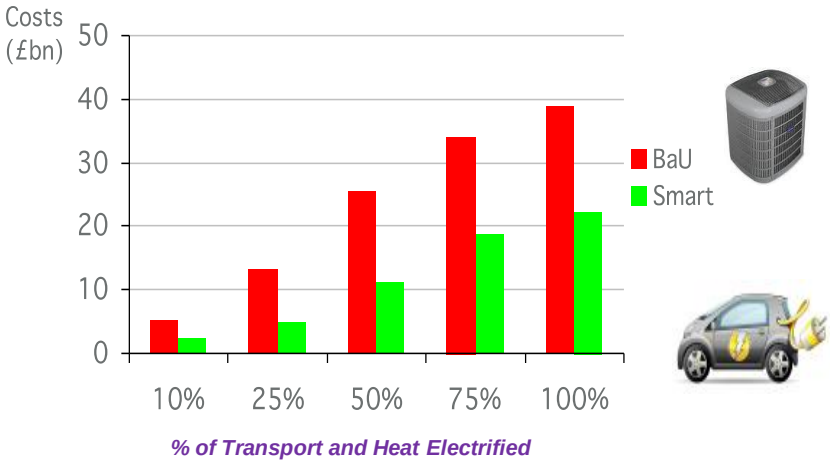
EPSRC
Engineering and Physical Sciences Research Council

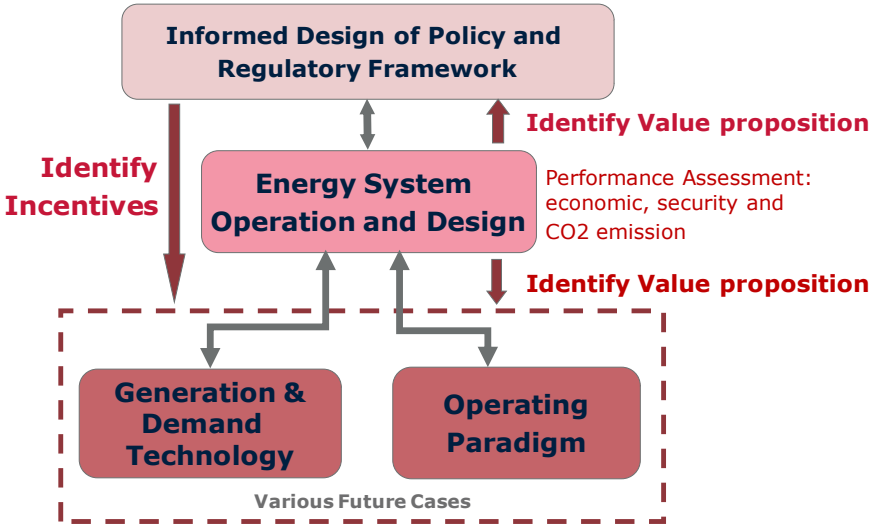
Imperial College London

Low Carbon London

- **Vision:** Learn and demonstrate how energy distribution networks can prepare for transition to a low-carbon future
- **Implementation**: Large scale demonstration of smart meter technology in East London:
  - What information should be collected?
  - What periodicity?
  - How will it affect behaviour?
  - What are the implications for design and operation?
  - How do we make the business case for investments in 'smart' technology…







ofgem

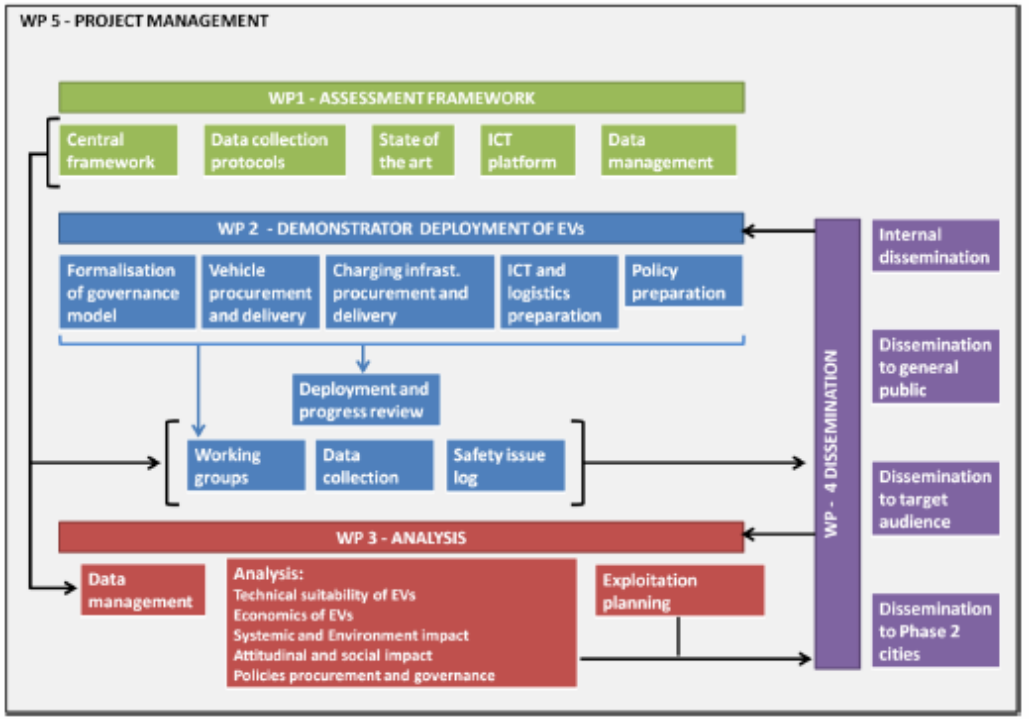
UK Power Networks

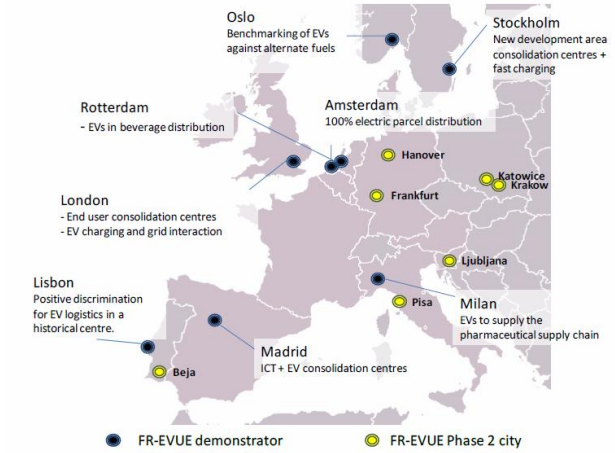
Imperial College London

FR-EVUE

- **Vision:** Understand how to overcome existing barriers to use of electric vehicles for urban freight. Focus is on
  - ICT infrastructure
  - Grid infrastructure
  - Vehicle systems
  - Logistics systems
  - Public policy
- **Implementation**: Large scale demonstration of freight EVs in several European cities:
  - Amsterdam/Rotterdam
  - Madrid
  - Lisbon
  - London
  - Milan
  - Oslo
  - Stockholm

  With cross cutting comprehensive evaluation
- Will produce White Paper





Thank you