for CONNECTED / SHARED / AUTONOMOUS VEHICLES

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SIMULATION MODELS
Research in Connected, Shared & Autonomous Vehicles

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Transport Emissions,
Energy Recovery Systems,
Connected Vehicles
ACES Simulation – Modelling Streams

**Traffic & Dynamics**
- Operational / Tactical Level
- **Tools:** VISSIM, Advisor CarMaker, etc.
- Driver behaviour and vehicle dynamics
- Traffic control & ITS
- Vehicle emissions, Energy consumption

**Logic & Interactions**
- Tactical / Strategic Level
- **Tools:** Delos (bespoke & developed at ICL)
- Emphasis on Agent Logic & Interactions
- Concept of Operations Driven
- Infrastructure Interdependencies
Model Development – Data Collection

**Tailpipe Emissions (CO₂, NOₓ, PM)**

**Acceleration/Speed Sensors**

**Engine Behavior (OBD / CAN Bus)**

**GPS Location**

**Road Type (camera)**

- **Ride Comfort Model**
  \( f(\text{road, speed, acceleration}) \)

- **Vehicle Emissions Model**
  \( f(\text{speed, acceleration, vehicle}) \)

- **Kinetic Energy Recovery**
  \( f(\text{acceleration, vehicle}) \)

**Vehicle Behaviour Model**

**AV Traffic Simulation Model**
Model Development – Data Collection

- Emission data (PEMS)
- Ride comfort data (HVM200)
- Driver perception (Questionnaires)
- GPS Traces (Speed, Trajectories)
- CAN bus / OBD feeds (Vehicle Systems)
PEMS Emissions – Data Analysis

![Graph showing the relationship between speed (km/h), acceleration (m/s²), and NOx output (mg/s).]
Ride Comfort– Data Analysis

Basicentric Axes

Weighted RMS acceleration

\[ a'_{w} = \left( \frac{1}{T} \int_{0}^{T} a_{w}^{2}(t) \, dt \right)^{1/2} \]
Model Calibration - Emissions

Network Geometry

NOx emissions

CO2 emissions
Model Calibration - Vehicle Dynamics

**Acceleration / Speed Profile**

**Deceleration / Speed Profile**

![Graph showing acceleration and speed profile](image1)

![Graph showing deceleration and speed profile](image2)
Penetration Rate Modelling

O% CAV

100% CAV
Hybrid – Electric Propulsion for HGVs
Hybrid – Electric Propulsion for HGVs
# (A)CES Platform Design Aspects

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<th>Description</th>
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<td>Mode Choice, User Preferences, Vehicle Dynamics</td>
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<td><strong>Competitive Behaviour</strong></td>
<td>Market Structure (Monopoly / Competition)</td>
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<td><strong>Tariff Structure</strong></td>
<td>Pricing Mechanisms – Surging Behaviour</td>
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<td><strong>Interaction with Public Transport Modes</strong></td>
<td>Integration, Competition, Mode Choice</td>
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<td><strong>Energy Management</strong></td>
<td>Refuelling, Recharging, Infrastructure Interactions</td>
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Information Flow Modelling

- Vehicle Behaviour
- Assignment
- Travel Behaviour
- Trip Pricing
- Charging
- Mode Choice
- Public Transport
Ongoing Case Study – TNC Pricing

**Assignment**
- Optional Ride-Matching

**Pricing**
- Adaptive Surge Pricing Heuristic

**Mode Choice**
- Nested Logit (Private, Shared, PT)

**Market Structure**
- TNC Monopoly + Public Transport

**Routing**
- ClusterStar

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**Graph**

AV TNC Mode Share by Total Vehicle Number

- **AV TNC Mode Share [%]**
- **Vehicles**

- Line A
- Line B

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CENTRE FOR TRANSPORT STUDIES | TRANSPORT SYSTEMS & LOGISTICS GROUP
# Ongoing Case Study – TNC Pricing

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<tr>
<th>ASSIGNMENT</th>
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## Pricing Heuristic

- Adaptive Surge Pricing Heuristic

## Market Structure

- TNC Monopoly + Public Transport

## Mode Choice

- Nested Logit (Private, Shared, PT)

## Assignment

- Optional Ride-Matching

## Diagram

### AV TNC Mode Share per Scenario

- A (average)
- A (all scenarios)
- B (average)
- B (all scenarios)

**Time**

- 10:00
- 12:00
- 14:00
- 16:00
- 18:00
- 20:00
- 22:00

**May 31, 2018**

**AV TNC Mode Share [%]**

- 0
- 10
- 20
- 30
- 40
- 50
- 60
Ongoing Case Study – TNC Pricing

**Assignment**
- Optional Ride-Matching

**Pricing**
- Adaptive Surge Pricing Heuristic

**Mode Choice**
- Nested Logit (Private, Shared, PT)

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**Average Waiting Time for Scenario A**

- A - Private (average)
- A - Private (all scenarios)
- A - Shared (average)
- A - Shared (all scenarios)

Average Waiting Time [Minutes]

Time

May 31, 2018
THANK YOU

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