Automotive Programme 2017
Group Project
New open research and teaching facilities to support the development of autonomous transport vehicles and related systems are being built at Cranfield. These will consist of:

- MUEAVI (Multi-User Environment for Autonomous Vehicle Innovation). A full-scale industry specified living lab in the form of a mile of instrumented roadway.
- IMEC (Intelligent Mobility Engineering Centre) Centre of excellence for the UK delivering education, training and skills for the burgeoning global transport systems sector workforce.

These are multi-million pound capital and infrastructure developments being established as national assets by Cranfield University, co-funded through regional and national Government agencies.

Cranfield is intending to develop autonomous minibuses for the campus. The vehicles are going to operate on MUEAVI road, with four stops in-between.

Find out more about MUEAVI at www.cranfield.ac.uk/mueavirelease or IMEC at www.cranfield.ac.uk/imecrelease

The project brief

Several teams of students are competing to be awarded the design and systems integration role for the autonomous minibuses by specifying a valid vehicle concept to a sufficient level of detail.

The scenario is that they are competing for a publicly announced tender; hence they must offer the best solution possible in order to win the contract.

Automotive Engineering teams
Project emphasis is on electric powertrain design/specification and their control: motor/s, batteries, inverter/drive, driveline, steering, and brakes.

Automotive Mechatronics teams
Project emphasis is on “autonomous (self driving)” system design and integration, including but not limited to: sensor selection, sensor fusion, object detection, localisation, perception, path planning, decision making and supervisory control, safety monitoring, HMI and data storage, processing and networking, and tele-communication.

Group design project
Design of an autonomous (self driving) electric vehicle
The main requirements of the tender are:

• The vehicle is to use electric motor/s only, with no IC engine or hybridisation.
• Passenger capacity should be eight with one extra seat provided for the ‘guide/driver’ if required.
• The vehicle must be able to accommodate one disabled passenger, in which case the number of other passengers can be reduced to six.
• The vehicle can use batteries and/or other electrical sources, such as ultra-capacitors. No permanent connection to the grid is possible.
• The vehicle must operate in all weather conditions typical for Cranfield Campus.
• The vehicle should have suitable heating and cooling systems (not necessarily A/C) for the passengers.
• Envisaged operating times are 8am to 6pm.
• The vehicle will only operate on ‘private land’ but must remain safe and road legal, with all assemblies and systems delivering the required performance (i.e. drive, steering, braking etc.).
• The solution can be based on an existing vehicle or a completely new design, developed by the team.
• The systems, assemblies and components used must be either available on the market (with known price and delivery times) or specifically designed and manufactured for this vehicle.
• Design confidence/competence, robustness, cost and reliability are vital elements of this tender.
Automotive Engineering
Automotive Engineering
Group one

Alejandro Alfonso Puig
Automotive Engineering MSc

Michiel Du Pree
Automotive Engineering MSc

Torrin Fairholme
Automotive Engineering MSc

Vincent Laprérie
Automotive Engineering MSc

Florian Petiot
Automotive Engineering MSc

Kevin Regnault
Automotive Engineering MSc

João Ribeiro
Automotive Engineering MSc
Cranfield Autonomous Transport
Vehicle Concept Design

CRanfield University Student Autonomous Driven Electric Rover

8 passengers + 1 wheelchair

60 kWh Battery:
full day autonomy,
long life expectancy

Reduced running costs with overnight charging

School of Management

Every 3 min at peak times
7 min each way
Martell House

Suspensions and brakes carried-over for cost savings

Regenerative braking: reclaims up to 34% energy

Axial flux electric motor:
compact and lightweight
45.5 kW, 130 Nm

36% savings after 5 years compared to a conventional minibus

60 kWh Battery:
full day autonomy,
long life expectancy

8 passengers + 1 wheelchair

60 kWh Battery:
full day autonomy,
long life expectancy

Reduced running costs with overnight charging

36% savings after 5 years compared to a conventional minibus

Mr Alex Alfonso Puig (a.alfonso-puig@cranfield.ac.uk)
Mr Torrin Fairholme (torrin.d.fairholme@cranfield.ac.uk)
Mr Vincent Laprérie (vincent.lapriere@cranfield.ac.uk)
Mr Florian Petiot (florian.petiot@cranfield.ac.uk)
Mr Michiel du Pree (m.du-pree@cranfield.ac.uk)
Mr Kevin Regnault (k.m.regnault@cranfield.ac.uk)
Mr João Ribeiro (j.ribeiro@cranfield.ac.uk)

Team AE-1
www.cranfield.ac.uk
Automotive Engineering

Group two

Miguel Bellido López
Automotive Engineering MSc

Karl Farrugia
Automotive Engineering MSc

Matthew Herbert
Automotive Engineering MSc

François Humbert
Automotive Engineering MSc

Hugo Lambert
Automotive Engineering MSc

Chris-Oliver Sagnard
Automotive Engineering MSc

Ioannis Sklias
Automotive Engineering MSc
Cranfield Autonomous Transport
Vehicle Concept Design

Non-stop Commute

P2POD
Driverless Technology
Reinventing the Future

Concept Advantages

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Solution</th>
<th>Autonomous Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelters</td>
<td>Included in the pods</td>
<td>Have to build them</td>
</tr>
<tr>
<td>Time for one way</td>
<td>205 seconds</td>
<td>308 seconds</td>
</tr>
<tr>
<td>Energy Consumption per Vehicle (Same Number of Trips)</td>
<td>25.8 kWh</td>
<td>27.4 kWh</td>
</tr>
<tr>
<td>Capacity</td>
<td>Up to 16 passengers</td>
<td>Up to 8 passengers</td>
</tr>
<tr>
<td>Productivity</td>
<td>144 trips</td>
<td>93 trips</td>
</tr>
</tbody>
</table>

Team AE-2
Automotive Engineering
Group three

Álvaro Bermejo Rubio
Automotive Engineering MSc

Asier Errazti Txintxurreta
Automotive Engineering MSc

Efstathios Fragkos
Automotive Engineering MSc

Louis Ladreit De Lacharrière
Automotive Engineering MSc

Zhihao Liang
Automotive Engineering MSc

Yann Thiriet
Automotive Engineering MSc
Cranfield Autonomous Transport
Vehicle Concept Design
CranBus

Fully Electric Autonomous Bus
• Capacity 13 passengers
• Range 7 to 12 hours
• Weight 3,500 kg
• Dimensions 5m x 2m x 3.5m
• Price £ 85,850 + VAT

Power demand calculation

- Maximum Power 25 kW, water-cooled
- Front wheel drive & regenerative braking
- Single gear reduction with differential

- Capacity 34 kWh, Voltage 340 V
- 2 packs, 12 modules each
- Air-cooled and heater integrated

- Four wheel disc brakes
- 2 electric over hydraulic actuators
- Electric parking brake

- Front wheel steering
- Maximum turning radius of 11m
- Electric steering. 1.5 kW motor
- Front and rear MacPherson strut

Passenger capacity: 13
- 10 seats, including 2 foldable
- Able to accommodate a disabled person
- Heating and cooling system
- Equipped with ramp

Team AE-3
Álvaro Bermejo Rubio alvaro.bermejo-rubio@cranfield.ac.uk
Asier Errazti Txintxurreta a.errazti@cranfield.ac.uk
Efstathios Fragkos stathis.fragkos@cranfield.ac.uk
Louis Ladreit de Lacharrière louis.ladreit-de-lacharriere@cranfield.ac.uk
Tristan Chigros t.chigros@cranfield.ac.uk
Yann Thiriet yann.thiriet@cranfield.ac.uk
Zhihao Liang zhihao.liang@cranfield.ac.uk
Automotive Engineering
Group four

Elodie Blanchard  
Automotive Engineering MSc

Isaac Alejandro Carmona Luna  
Automotive Engineering MSc

Paul Lenormand  
Automotive Engineering MSc

Zhijing Liu  
Automotive Engineering MSc

Diego López Izquierdo  
Automotive Engineering MSc

Jean Michelin  
Automotive Engineering MSc

Michael Tchorzewski  
Automotive Engineering MSc
Cranfield Autonomous Transport
Vehicle Concept Design

STRATEGY

- **Guideline:** Offer a simpler and less expensive Autonomous Shuttle than EasyMile and Navya (>170k€)
- **Target:** University, Airports, City centres
  - 10 with 8 capacity
  - Design based on existing vehicle

POWERTRAIN

- **EMRAX 188 - Electric Motor**
  - Axial flux brushless synchronous motor
  - 70kW peak power, mount in clutch housing
- **OptimumNano (LiFePO4) Battery**
  - CAPACITY: 37.7 kWh
  - VOLTAGE: 403.2 V
  - 110 km or 8 hours of drivability on campus
  - Increase by 33% with an easy-to-add battery pack

CHASSIS

- **IVECO DAILY Chassis**
- **Shuttle Dimensions**
  - LENGTH: 5.2 m
  - HEIGHT: 2.5 m
  - WIDTH: 2 m
  - Wheelbase: 3 m
  - G.V.W.: 3,500 kg
- **Chassis Lowering + Roll Cage**
- **Re-use of Components**

INNOVATIVE FEATURES

- **Laser Beam**
  - Interaction with pedestrians to increase safety and comfort
- **Disabled Ramp**
  - A ramp with a rotating disc
  - Operating without assistance
- **Eco-friendly solar panels**
  - Up to 3.5kWh per day in summer
  - Renewable energy lowering the carbon footprint

AUTOMATISATION

- **Steering**
  - Electric Power Assisted Steering
  - Electric motor connected with U-joints to the existing steering system’s pinion
  - Steering maps
- **Braking**
  - Actuator E/H1600 with linear response
  - ABS included
  - SKF Electronic Parking Brake

Prototype Price
from £ 55,000

Team AE 4

Elodie Blanchard  e.c.blanchard@cranfield.ac.uk
Isaac Carmona  isaac-alejandro.carmona-luna@cranfield.ac.uk
Paul Lenormand  p.lenormand@cranfield.ac.uk
Zhijing Liu  zhijing.l.u@cranfield.ac.uk
Diego López  d.lopez-izquierdo@cranfield.ac.uk
Jean Michelin  jean.michelin@cranfield.ac.uk
Michael Tchorzewski  m.tchorzewski@cranfield.ac.uk

www.cranfield.ac.uk
Automotive Mechatronics
Automotive Mechatronics
Group A

Sahil Rajeev Desai
Automotive Mechatronics MSc

Moyen Mishra
Automotive Mechatronics MSc

Guillaume Rousseau
Automotive Mechatronics MSc

Daniele Santantonio
Automotive Mechatronics MSc

Todd Watts
Automotive Mechatronics MSc

Salih Yousif
Automotive Mechatronics MSc
Cranfield Autonomous Transport
Autonomous Driving System

- Automation using Visual and LIDAR sensors
- Design for versatility & adaptability
- Sensor redundancy for blind spot cancellation
- Complete working solution at £ 11,000
- Partnership with Tier-1 supplier Nvidia

Desai, Sahil Rajeev  
Mishra, Moyen  
Rousseau, Guillaume  
Santantonio, Daniele  
Watts, Todd  
Yousif, Salih  

www.cranfield.ac.uk
Automotive Mechatronics
Group B

Jordan Ankpong
Automotive Mechatronics MSc

Eun Sang Cha
Automotive Mechatronics MSc

Saeed Falowo
Automotive Mechatronics MSc

Giacomo Molino
Automotive Mechatronics MSc

Paramjeet
Automotive Mechatronics MSc
Development and implementation of a cost effective control system solution for autonomous shuttle proposed to be operation at Cranfield University’s Multi-User Environment for Autonomous Vehicle Innovation (MUEAVI) facility.

**NEXT Mobility and Clients**

The project team is based in School of Aerospace, Manufacturing and Transportation at Cranfield University, UK.

NEXT Mobility is currently working in coordination with and developing controls for our clients CranBus and Alva.

**Market for Autonomous Vehicles**

- **$77 BILLION** Market for vehicles with partial and full autonomy by 2035
- **12 MILLION** Vehicles with full autonomy to be sold per year globally by 2035
- **18 MILLION** Vehicles with partial autonomy to be sold per year globally by 2035
- **25%** Percentage of vehicles in market with autonomous driving feature by 2035

*Boston Consultancy Group, London*

**Sensors**

‘Eyes’ of our concept. Sensor stack allow for perception of the ambient environment with high degree of robustness and safety.

- Lidar and Cameras for Mapping.
- Radars for Obstacle detection.
- Ultrasonic sensors for parking assistance

**Object Classification for Control**

- **LaneID**: Classification based on object’s location with respect to vehicle’s lane.
- **MotionID**: Sub-classification based on object’s direction of motion.

**Navigation**


- **Localization**: Performed using an IMU + visual odometry from a stereo camera. Kalman filter for sensor fusion. Can be obtained from mapping. (e.g. AMCL)
- **Mapping**: Performed by input from LIDAR or 3D point cloud from stereo camera. Performed with SLAM algorithms - Hector SLAM or G-mapping.

**Operation Modes**

- **Metro Mode**: Stops at all pre-defined stops. No infrastructure at stops needed.
- **Bus Mode**: Stops at pre-defined stops at user request.
- **Elevator Mode**: Operate upon request. Halts, and waits until request issued. Energy efficient.

**Safety**

- **Zone based control**: Additional limits & priority operations while operating in different zones.
- **Adaptive Cruise Control & Crash Avoidance**: Regulate vehicle’s velocity with respect to vehicle ahead. Stop within predefined distance upon encountering immobile obstacle.
- **Emergency Stop**: Abort vehicle’s mission and open all door.

**Questions/Suggestions ??**

We would love to interact with you!
Find out more about our Automotive courses:

Automotive Engineering MSc
www.cranfield.ac.uk/courses/taught/automotive-engineering

Automotive Mechatronics MSc
www.cranfield.ac.uk/courses/taught/automotive-mechatronics