

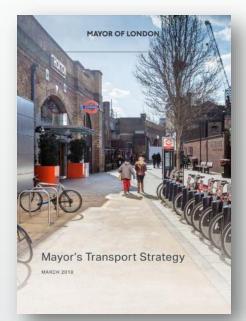


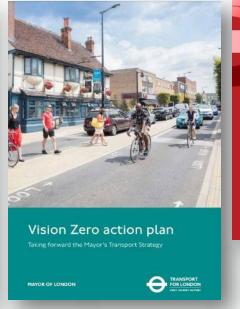
# Pedal Application Error



Apollo Vehicle Safety

## TfL's Vision Zero Strategy









Vision Zero targets

2030

No one killed on or by a London bus

2041

No one killed or seriously injured on or by a London bus





### TfL's Bus safety programme

#### Safe System approach



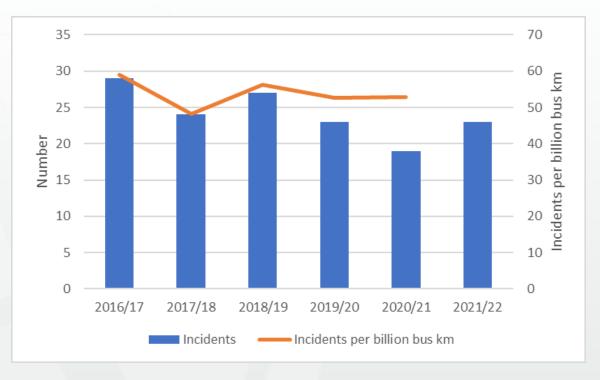
#### Safe Vehicles: Bus Safety Standard (BSS)

#### Driver assist Occupant protection Helping the driver to avoid or mitigate Reducing severity of injuries for the severity of incidents: people on board the bus: · Advanced Emergency Braking Occupant-friendly interiors Intelligent Speed Assistance · Slip protection · Improved direct and indirect vision Pedal application error Runaway bus prevention Partner assist Partner protection Helping other involved road users Reducing severity of injuries for road - the collision partners - to avoid users outside the bus in a collision: the collision: · Vulnerable road user · Acoustic conspicuity frontal crashworthiness · Visual conspicuity

### Quantifying the problem

- Incidents are rare but potentially severe when they do occur.
  - 54 cases/billion bus km, or
  - one event every 18.5 million bus km.





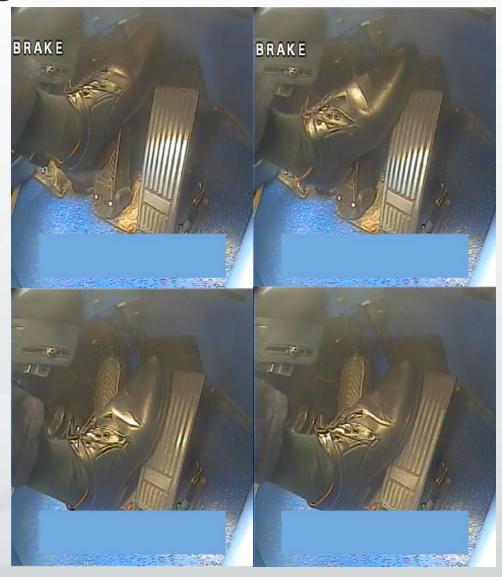
### CCTV footage of normal driving

- CCTV of normal driving
  - Foot movement was variable
  - Most cases "lift & place"





Some evidence of sliding between pedals ----->



#### CCTV of incidents

- Small number of cases (<20) reviewed</li>
- Incident CCTV showed:
  - Most incidents do <u>not</u> involve foot movement between pedals (contrary to much behavioural research)
    - One incident appears to show foot moving right to 'ghost' accelerator and back left to initial position as if to move from accelerator to brake.
  - Most low speed incidents (< 10km/h)...some up to 30km/h</li>
  - Some involve vehicle "creeping" along prior to incident
  - Some form of head, body, steering movement present in most, but not all, cases
    - Potential for distraction and/or cognitive load to be a factor?





## Characterising the problem

Cause of PAE

Recovery from PAE

Mitigating consequences of PAE

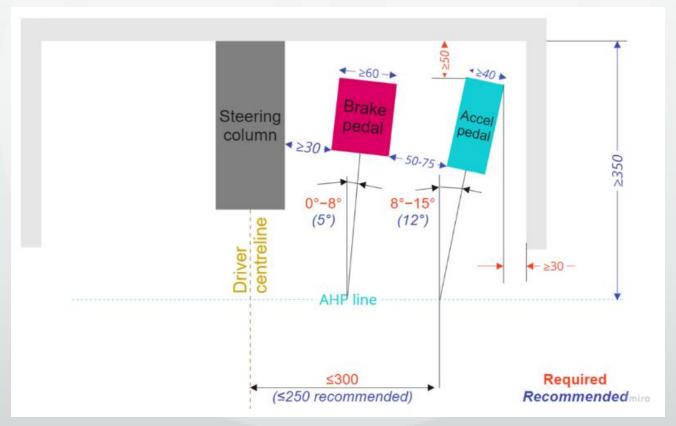
- Driver actions
- Variation in pedal layout
- Effect of regenerative braking

 Acceleration potential of electric vehicles



## Pedal layout – ISO 16121

- Defines position and arrangement of pedals
- Not a mandatory standard but bus manufacturers cite this as the basis for their pedal designs



## Pedals, pedals

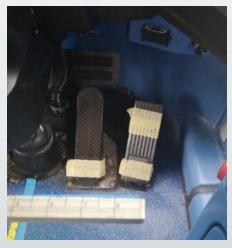


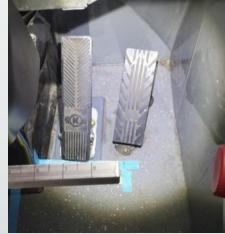


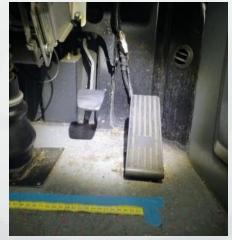






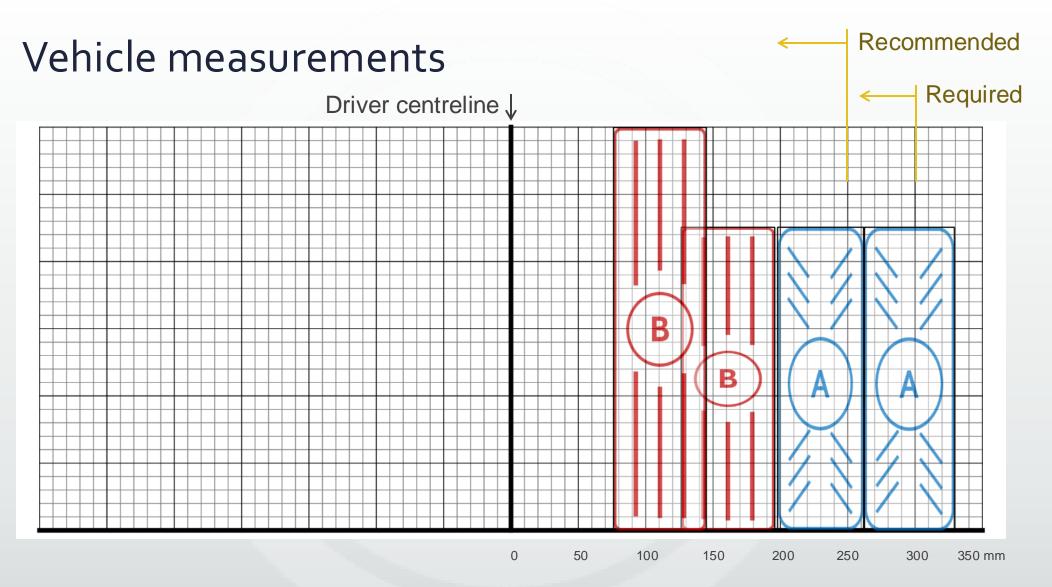








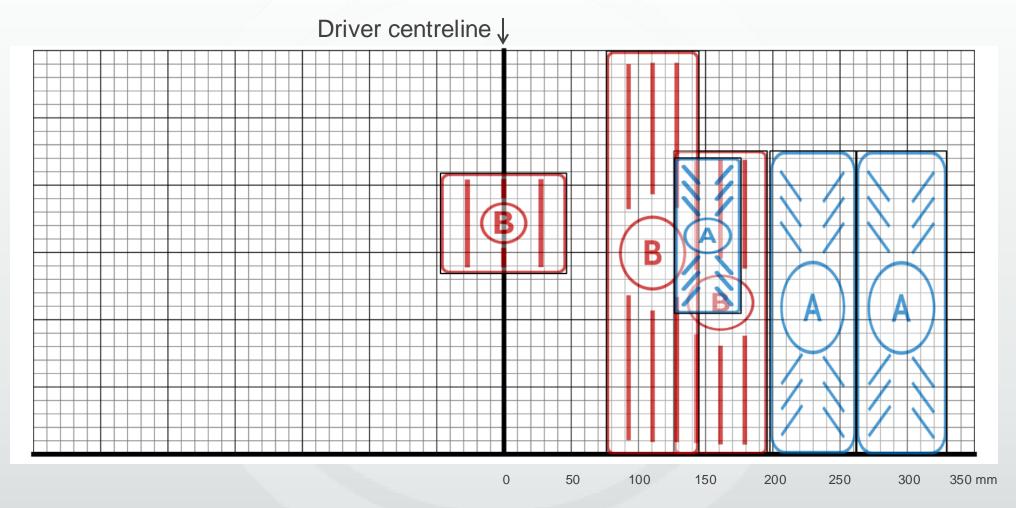




Leftmost and rightmost pedals



#### Vehicle measurements



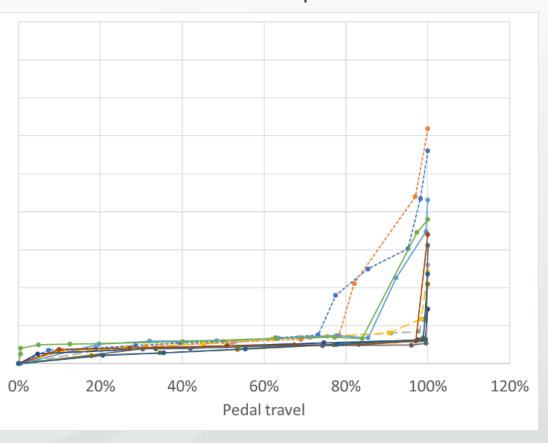
Leftmost and rightmost pedals and a typical car layout



#### Pedal feel

#### Brake pedal 45 40 35 30 Pedal force 25 20 15 10

#### Accelerator pedal



Over 99% of brake applications are very gentle

60%

Pedal travel

80%

100%

120%

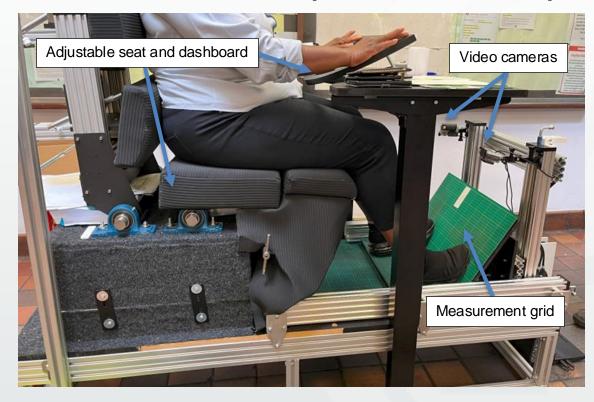
40%



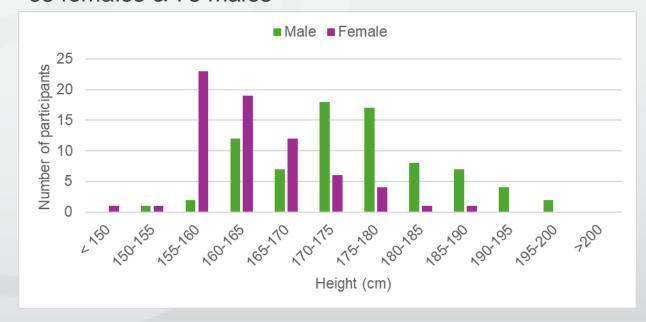
0%

20%

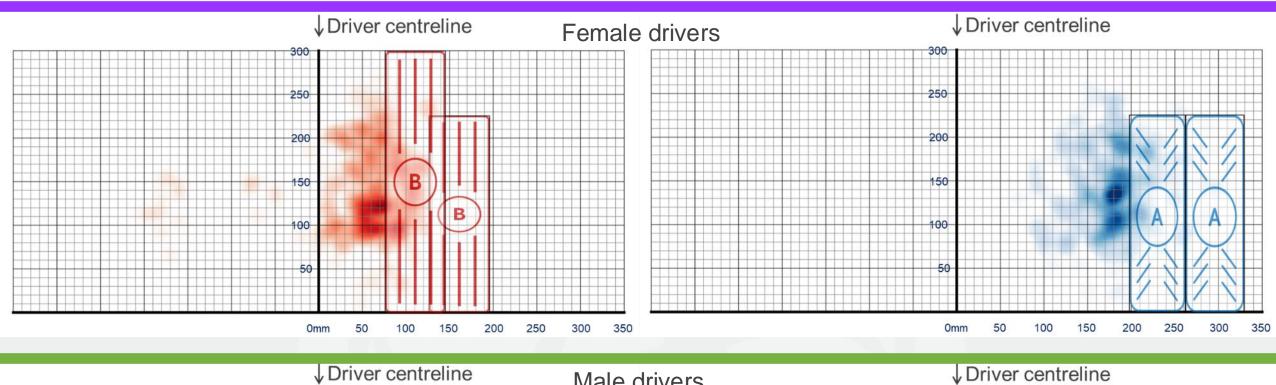
### Driver expectation of pedal position

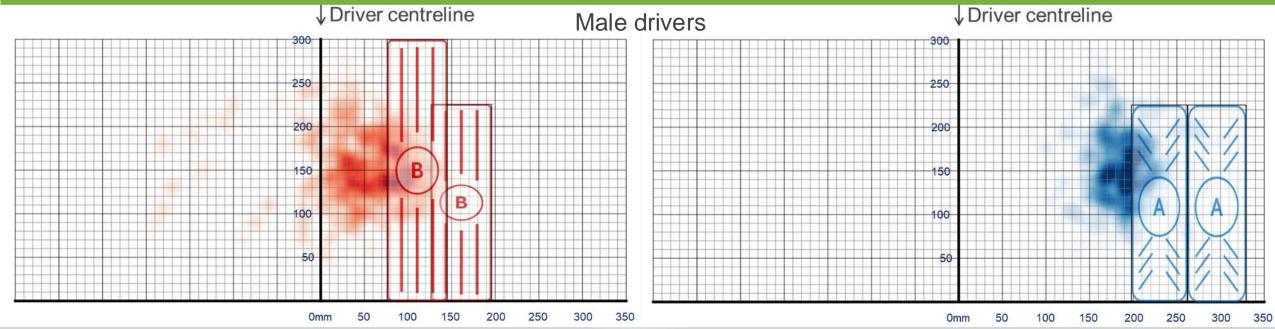


146 drivers 68 females & 78 males











#### Pedal layout - summary

- Some variation in pedal position evident across buses
- Some potential to reduce variation by using recommended values in ISO 16121

- Pedals likely feel very similar for the majority of day-to-day driving
- Could improve differentiation by using different pedal types

Various options currently under consideration by TfL



## Characterising the problem

Cause of PAE

Recovery from PAE

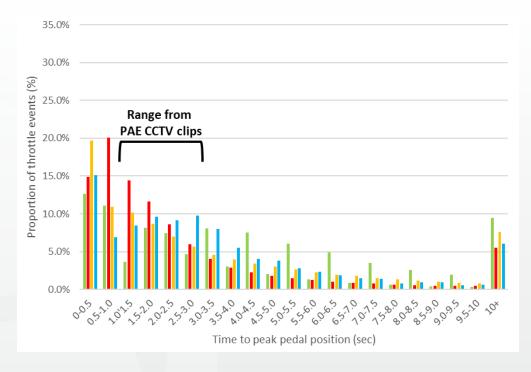
Mitigating consequences of PAE

- Driver actions
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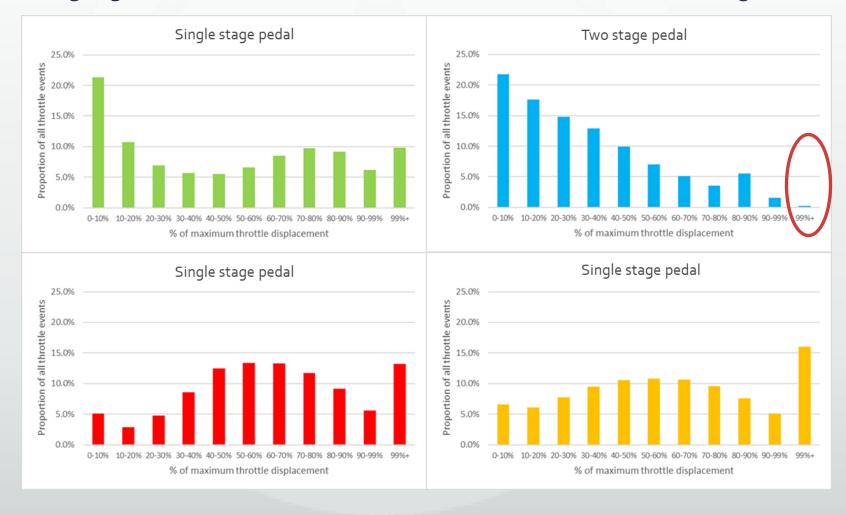
- How best to detect a PAE incident?
- Pedal speed
  - CCTV footage shows relatively slow pedal application
  - Considerable overlap to distribution for normal driving



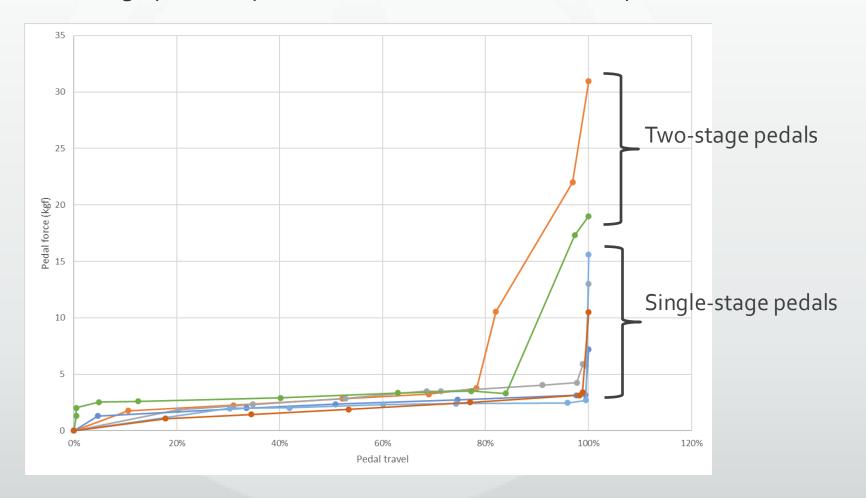
- Pedal force
  - CCTV shows drivers often "standing" or "squirming" on the accelerator pedal, thinking it's the brake

• Pedal data highlighted far fewer full throttle events for buses with two-stage accelerator

pedal

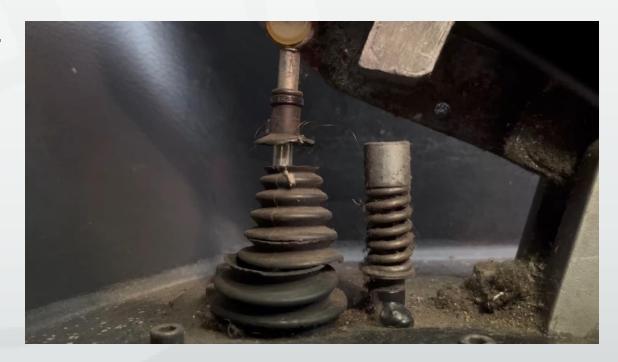


• Buses with two-stage pedal require more force to reach 100% displacement





- If drivers press the accelerator pedal hard during PAE, but rarely press hard during normal driving...
- Can the second stage of the accelerator pedal travel be used to activate an acceleration suppression system and stop prolonged PAE events?
- Initial trial underway to investigate further.





### High level trial plan

1

• 10 buses - Configure telematics & calibrate pedals

7

• Gather data with current pedal layout (~1 month)

Collect CCTV footage of full throttle events

3

Modify spring stiffness (replace spring or change pre-load)

L

• Gather data with modified spring(s) (~1 month)

• Collect CCTV footage of full throttle events

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Decide next steps: More data? Wider rollout? Address any technical issues

Stakeholder engagement



# Thank you

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