Dr Thomas Edgar Woolley Ms Lucy Henley, Mr Josh Moore and Mr Tim Ostler – Written Evidence (LBC0048)

Author introduction

The authors are doctoral students and a faculty member of Cardiff University. The authors took part in a Natural Environment Research Council (NERC) COVID-19 "Hackathon" through which they developed a public transport seat optimiser. Not only did the student team win first prize of £3,000, but they also have used the app to generate evidence regarding situations under which public transport is more polluting than private transportation.

MESSAGE

This work should be used as evidence for the correlation between social distancing methods with emission targets. Critically, it should act as a warning and as a stimulus for investment in cleaner public transport.

Key points

- Under current social distancing measures diesel trains cannot, generally, contain enough commuters to make themselves more environmentally favourable than small cars.
- Similar results are true for buses.
- The suggested preference order of mode of transportation should be:
  - Stay at home;
  - Walk/ use a bike;
  - Use small electrical single person carriers (e.g. escooters, or electric bikes);
  - Use a small car;
  - Use public transport;
  - Use a large car (as a last resort).
- A team of Cardiff University doctoral students have created a user-friendly app to inform the public/government/environment agencies/public transport companies as to optimal passenger packing.
  - App details: https://bit.ly/App-details
  - App interface: https://bit.ly/App-interface

Background

During lockdown, restrictions on travel led to large reductions in the use of cars and public transport across the UK. By 12th April 2020 use of cars fell as low as 22%, compared to a typical day in 2019. Public transport use also fell, with ticket sales from National Rail and busses outside of London reduced to 4% and 10%, respectively [1].

This reduction in travel contributed to overall reductions in emissions, but as lockdown measures are relaxed, personal vehicle usage has increased again, approaching 70% of typical values from 2019 by mid-June 2020 and 80% of typical levels by mid-July [1]. Unfortunately, use of public transport remains low, with National Rail and busses outside of London running at 8% and 14% of normal usage, respectively [1]. This suggests that people are choosing to use

personal motor vehicles, as opposed to public transport and, due to safety concerns, this could be a possible long-term consequence of the COVID-19 pandemic.

To solve this problem, Phd researchers from Cardiff University have designed an app (see Appendix 1) that optimises the number, and seating arrangement, of people who can safely use public transport to encourage its use, as an alternative to commuting by car. The app allows the user to see the optimal spacing strategy in various scenarios of social distancing and includes the option of using plastic shielding, for increased isolation. The research group have used the app to isolate specific combinations of measures needed to make diesel powered public transport have lower emissions than using cars under specific assumptions (see Appendix 2).

Results

To calculate and quantify the effect of capacity of public transport on overall emissions, we use data relating to the emissions of cars used for commuting to work. A train uses a fixed amount of energy to run irrespective of the number of passengers using it (to a first approximation), so train emissions per passenger fall as passenger capacity increases [3]. Car emission data is taken from measurements of the emissions generated by cars used for commuting [4].

As a worst-case scenario, we assume that all passengers who cannot fit onto a train would instead choose to commute by car, meaning that they now contribute to the car emission data. Based on these assumptions, we can plot the emissions per passenger for a train, a small car and a large car, and, thus, effectively denote how many passengers are required on a mode of public transport to make them more efficient, with regards to emissions, than a method of personal transport. The emissions per passenger for diesel trains and small and large cars is shown Figure 1.
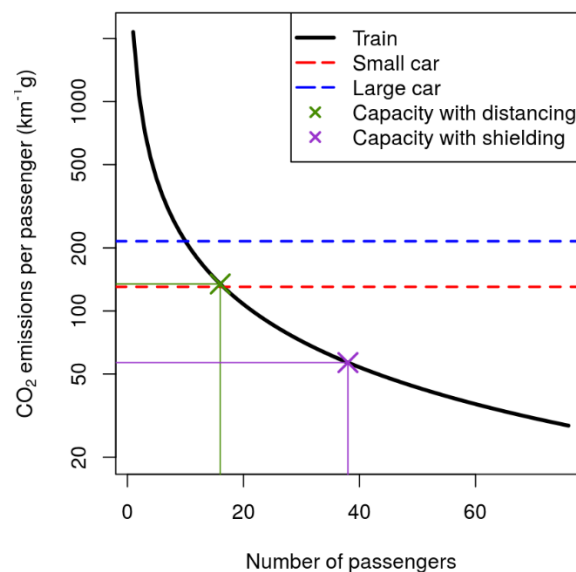

Figure 1. Emissions per passenger of a variety of modes of transport with a social distance of 2 metres.

Firstly, from Figure 1, we note that if a train company can encourage at least 10 Passengers per carriage to use their service then they will be more efficient than a large car. However, trains using diesel engines require a minimum of 17 passengers to be more efficient than a small car (green line). Unfortunately, without the use of plastic shielding a train carriage can only support a maximum of 16 socially distanced passengers, as seen in the top image of Figure 2.

However, if plastic shielding is included (bottom image of Figure 2), we can increase the maximum number of passengers in a single carriage to 38, making the emissions per passenger much lower than a small car (see the purple line of Figure 1).

Available seats with social distancing measures
Capacity of 1 train carriage is 16 passengers with social distancing.

Available seats with social distancing measures and shielding
Capacity of 1 train carriage is 38 passengers with shielding.

● Unsafe seat   ● Available seat   ● Safe radius   ── Shields

Figure 2. Optimal seating with plastic shielding (top) and with plastic shielding (bottom).

Conclusion

Reducing emissions from travelling is a key component of the UK's strategy in meeting the Paris Accord and net zero emission targets, as road transport makes up around 20% of UK greenhouse emissions [2]. Encouraging people to choose public transport, instead of personal vehicles, leads to a reduction in emissions per person, so we need some way of facilitating the usage of public transport to prevent an increase in emissions from travel. This work demonstrates that for public transport to be more efficient than a small car either:

- Social distancing measures must be decreased, (alongside an increase in personal protection, such as masks).
- Public shielding must be added to train and bus carriages.
- Investment must be made into lower emission engines.

References

[1]   https://www.gov.uk/government/statistics/transport-use-during-the-coronavirus-covid-19-pandemic

[2]   https://www.ons.gov.uk/economy/environmentalaccounts/articles/roadtransportandairemissions/2019-09-16

[3]   https://laqm.defra.gov.uk/documents/AEAPTEGCarbonFootprintingfinalversion2009.pdf

[4]   http://www.aef.org.uk/downloads/Grams_CO2_transportmodesUK.pdf

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Appendix 1
Online app user information

The user friendly app, on which this work is based, can be found at: https://bit.ly/App-interface

The app uses a Graphical User Interface (GUI) to allow easy manipulation of input variables and can run on smartphones and tablets as well as on computers. There are sliders for:

- the number of social distancing shields used;
- the length of the shields;
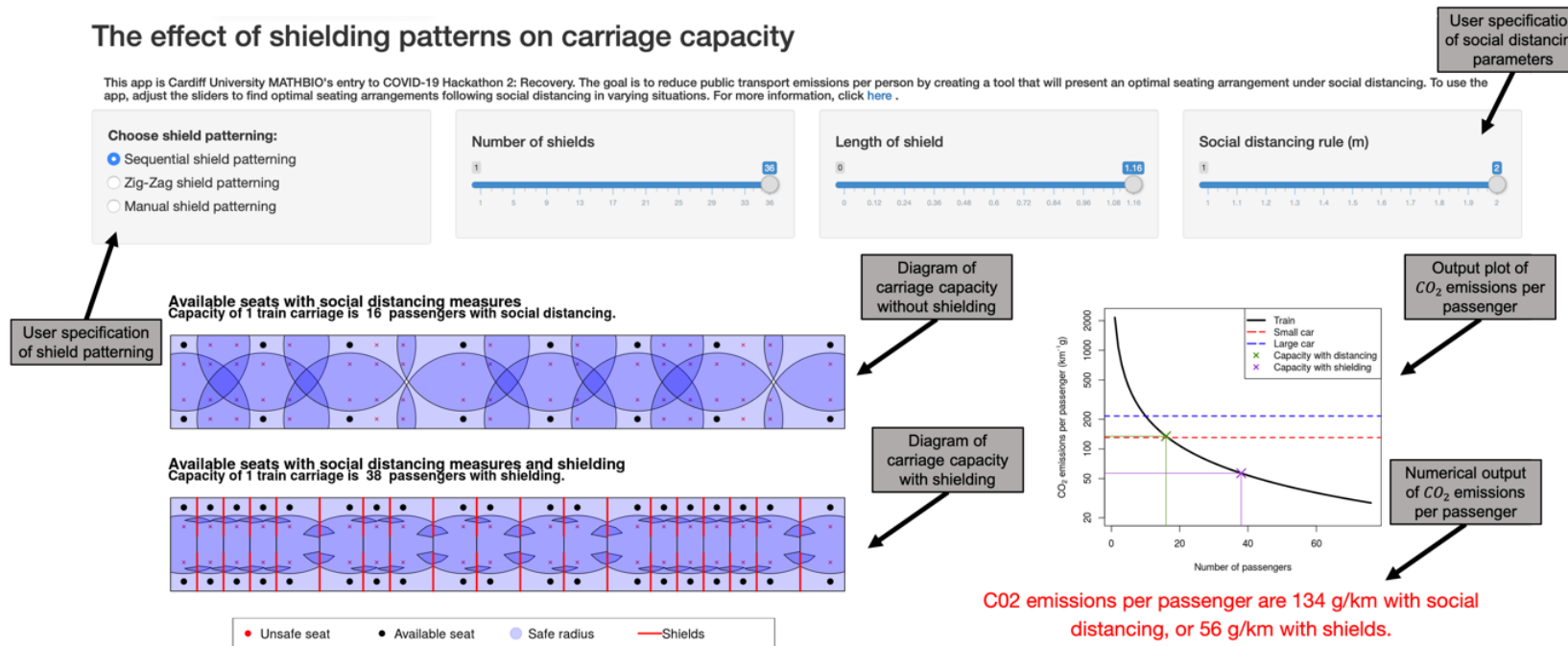- and the social distancing distance.

Figure 3. The Graphical User Interface schematic.

Given these input values, the app reports the optimal number of seats which can be used in the train, their locations within the train and the emissions per passenger. Usable seats are displayed as points surrounded by a blue circle, denoting the social distancing radius around them. Safe seats will be inside only one circle.

Graphics are included which demonstrate the emissions per person, dependent on the number of passengers who can fit safely into the carriage. We also plot the emissions per passenger of small and large cars, so that we can identify the exact number of passengers required per carriage to make public transport a lower-emission method of travel.

- Further app information can be found here: https://bit.ly/App-interface

Appendix 2
Modelling assumptions

- All people travelling are commuters. If they cannot travel by train then they will travel by car instead of finding another alternative method of transport.
- All commuters take separate cars to their destination, since, due to social distancing, they cannot share cars with other passengers.
- Trains are running at full capacity and therefore any unfilled seats on train correspond to a commuter who must drive to work.
- Passengers must be seated on the train, and so are restricted to being in the seat locations.
- Train carriages have an 'exit' and 'entrance', thus, flow into the train at stations is uni-directional. People must fill up the train from the back and sit only in allocated 'safe' seats.