DEVELOPING BALANCED DEBATE IN TRANSPORT PLANNING: THE CASE OF LOGISTICS DRONES.

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1. INTRODUCTION

E-Drone is a three-year research project funded by the Engineering and Physical Sciences Research Council. The research brings together different disciplines to evaluate the role of drones in logistics. The use of drones in logistics is currently being explored through trial projects, however longer-term visions of Urban Air Mobility see drones being used for last mile retail logistics as early as 2030 (UKRI 2021). There is currently no definitive policy commitment to make this vision a reality and the shape that this potential transport future takes is therefore still to be determined. This represents an opportunity to realise calls for greater co-development of transport futures recognising that changes in transport provision can impact all sections of society.

Achieving purposeful public participation is challenging. Firstly, in the absence of defined plans for wider deployment, the use of drones in logistics is tangential to people's lives adding to prevailing issues around achieving participation in transport planning (Bickerstaff and Walker 2001). Secondly, the use of drones in logistics has low public salience, demonstration projects have been focused on the movement of medical items with trials taking place away from populated areas. These are uncontroversial, generating little interest and providing few relevant reference points (Smith et al., 2022a). Thirdly, there is need to ensure that accurate information is available to provide for legitimate debate. Experience from discourse around the use of autonomous vehicles shows how significant misconceptions can become embedded (Du et al., 2022) and how this can lead to the acceptance of something which has not been accurately represented (Cohen et al., 2020). Therefore, there is a need to both introduce the concept of logistics drones and to overcome a lack of interest.

Our initial response to these challenges has been through the use of Virtual Reality (VR) to introduce the sight and sound of logistics drones into a familiar location before asking participants to provide their reflections on this application of the technology. Building on the findings from the VR survey tool, two games have been developed; a digital game which enables participants to explore the risk and energy implications of drone logistics and a board game providing a format for group discussion. These approaches are discussed in the following sections with particular focus on how we are working to address assumptions and develop information to enable informed debate. The aim of this paper is therefore to demonstrate the value of game based and VR approaches to involve the public in debates about transport futures.

2. USE OF VR TO INTRODUCE LOGISTICS DRONES

2.1. The development of the VR survey tool

VR is beginning to be used in the transport field given its scope to represent transport options prior to implementation decisions. Studies have explored responses to transport infrastructure (see for example, Mertens et al., 2021), including work on cycling (Bialkova et al., 2018 and Bogacz et al., 2021), and travel routes and security (Agudelo-Velez et al., 2021). VR avoids the risks associated with experiments, for example, with cycling, and avoids problems with asking people to reflect on hypothetical scenarios (Farooq et al., 2018). VR is typically used to place people into another environment (for example in game spaces), however, in the E-Drone project the VR brings logistics drones to place where participants are situated. The approach is immersive and engaging, providing a realistic experience of logistics drones that would otherwise be very costly to provide with actual drones. It is also multisensory providing both an audio and visual experience that is helpful for representation of transport systems.

The VR experience created in the E-Drone project represented two different types of logistics drones chosen to represent those likely to fly in urban areas (a fixed wing and octocopter). These were shown flying on fixed routes at three heights (30m/100ft, 76m/250ft and 122m/400ft) reflecting the lowest feasible altitude, a mid-altitude and the 400ft threshold below regulated air space. The drones fly past at around 40mph/18m per second. Audio recordings of fixed wing and octocopter drones were used to represent noise which fades in and out as each drone approaches and passes and according to altitude. After initial tests, visualisations of a take-off and landing were removed as in the near future, logistics drones are only likely to take off and land at designated sites away from the public.

The VR experience lasts around 3 minutes and participants were made aware that the flight frequency was not representative of actual frequencies which are yet to be determined. The VR was designed so it can be transposed onto other places. The VR was utilised with an accompanying questionnaire in summer 2022 in three urban settings: Boscombe, a suburb of Bournemouth, Bournemouth town centre and Southampton city centre (Figures 1, 2 and 3).

Figure 1 View from VR headset in Bournemouth Town Centre (Showing a fixed wing drone)

Figure 2 View from VR headset in Southampton City Centre (Showing a fixed wing drone)

Figure 3 View from VR headset in Boscombe Town Centre (Showing a fixed wing drone)

A questionnaire was completed immediately after the VR experience and sought to avoid leading respondents. The design therefore utilized open questions to freely elicit views and a checklist to explore views on frequencies of overflights in different urban settings (housing, urban park, industry, city or town centre, my home) and included a section specific to medical logistics (see Smith et al., 2022b for more details of the survey design, see Dickinson et al., (2023) for analysis of the findings. An incentive was used to encourage passers-by to take part and 241 participants viewed the VR and completed the questionnaire. The town centre settings led to diverse participants reflecting the breadth of age groups from 18 to 85+, both genders, diverse ethnicities, people with disabilities and those with poor literacy.

2.2. Identification of assumptions and uncertainty

Prominent themes were identified from responses to the first open question "what are your initial comments on the use of drones for making deliveries?". These reflections took the form of statements or questions, sometimes with suggested caveats on use. These reflections indicated both where assumptions were being made and where participants expressed uncertainty about aspects of use.

The most prominent assumptions were:

1) That drones will provide for quicker deliveries. For example:

> "Great option to deliver small goods, would allow for quick shopping delivery"
>
> (Female participant aged 25-34)

Achieving faster delivery compared to ground transport is dependent on the ability to achieve a direct flight path. The extent to which this would be feasible is highly context dependent with the areas where drone overflights will be allowed yet to be determined. Key factors in deciding where drones will fly relate to levels of acceptable risk, the presence of obstacles and the need to avoid conflict with other airspace users.

2) Using drones to make deliveries will provide environmental benefits. Here participants stated that drones would contribute to reductions in road vehicles, energy use or emissions. For example:

> "Seems like a good idea to take traffic off of the roads"
>
> (Male participant aged 55-64)

Drones can provide for emissions reductions compared to conventional, fossil-fuel powered delivery methods although there are limitations to the scope of use scenarios (e.g., small payloads, shorter distances). Comparisons with electric trucks and vans yield smaller savings (Filcak et al., 2020). Existing ground logistics, carrying bulk items will still be required with scope for additional consolidation offering potentially greater opportunities for energy savings (Grote et al., 2022). Where new drone services have been developed it is not clear the extent to which these have replaced existing ground logistics or have generated new demand (Smith and Powles 2022). Use of drones in last-mile logistics may need to be

supported by additional warehousing provision which generates additional emissions (Stolaroff et al 2018).

3) That drones have a clear role to play in healthcare logistics. For example:

> "The use of drones to deliver medical and urgent supplies is good. I'm not sure the use of drones for food delivery will be safe."
>
> (Male participant aged 45-54)

Drone trials in the UK have focused on medical logistics, this in part builds on experiences in developing countries where medical drone services have been established. For example, drones have been delivering blood across rural Rwanda since 2016 (Zipline, undated), here drones overcome road infrastructure limitations whilst operating in less congested airspace compared to the UK. In the UK, the medical use case is yet to be demonstrated. For instance, a review of the use of drones to transport aseptic medicines concludes that there is no evidence of a need for more responsive or faster delivery enabled by drones (Smith et al., 2023). Modelling of the use of drones to support networks of pathology van rounds shows that some efficiencies could be gained but these are subject to overcoming cost constraints and the reducing the number of no-fly days by using more weather-resistant drones (Oakey et al 2022)

The most prominent areas of concern and uncertainty were around noise and the risk of accidents, although it should be noted that participants often commented on a range of potential issues:

> "I think it's a great idea, but I would imagine that noise pollution would be a primary concern in residential areas. In addition, health and safety would be a large part of why this type of technology would struggle, in my opinion. However, if the technology and mapping is accurate and safe enough, I see no reason why delivery via drone [couldn't] be a regular type of transport for packages, medical and even food…"
>
> (Male participant aged 18-24)

The impact of noise and the risk of accidents are both directly related to where drones might fly and how often. This in turn relates to the assumptions made around environmental benefits and achieving faster deliveries which depend upon reaching a consensus on what is acceptable. Assumptions around the medical use case are significant as there is a greater propensity to accept impacts when social value is claimed. The VR survey demonstrated that participants were significantly more likely to accept drone overflights and therefore any risk and noise implications for the transportation of medical items, demonstrating the effects of this framing (Dickinson et al., 2023).

3. DEVELOPING ADDITIONAL TOOLS FOR ENGAGEMENT

3.1. Navigating the Skies

The digital game is being developed to enable stakeholders to engage with the risk, energy, and time trade-off within drone delivery. The game focuses on a mission to deliver a package from point A to point B using a drone. Players plot a route whilst considering the

drone's battery life (energy consumption) and the risk of a drone crash. To achieve this, the game utilises satellite imagery to allow players to explore drone flight paths in their own area. The current version of the game focuses on the city of Southampton and its surroundings, however, the game can be transposed to other places. As the player plots their preferred route, they are provided with an indication of the risk relative to the temporal population density. The time in the game is fixed at 13.00 to represent a period where a greater proportion of the population will be active and exposed to risk. A graph shows how the risk accumulates for the route choice. A battery provides an indication of energy use with less direct routes resulting in faster depletion of energy. Both the risk and energy indicators have been derived from modelled data. Once the route has been plotted, the player presses 'Go', and the drone overflight is shown alongside an overall summary of the risk (**Figures 4** and **5** below).

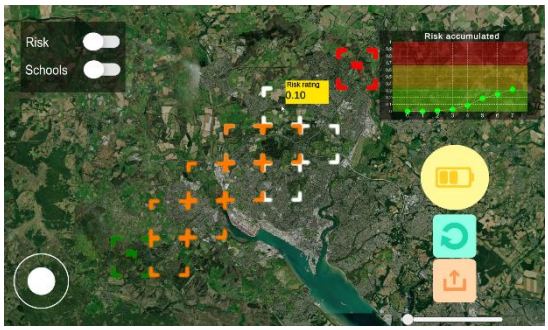

Figure 4 Screenshot from the digital game

Figure 5 Screenshot of drone flight

The game has been trialled using tablet computers at two public engagement events hosted by the University of Southampton. A post game survey (n- 41) provided feedback to inform further development, for example, a number of players stated a desire to be able to choose their routes with more precision by reducing the size of the selection squares. The survey used questions taken from the VR survey, including "What feedback would you give to those responsible for developing regulation?". Whilst game play was based around risk and energy, the responses to this question included a much wider range of issues for regulators to consider. Comments requesting the consideration of the potential impact of noise were more prominent than those relating to safety. Privacy was also a significant issue raised, indicating that participants were thinking about the wider implications of logistics drones. As with the VR survey, participants commented on more than one aspect of using drones in logistics, sometimes highlighting the link between issues:

> "Consider the future, what would a world of regular use of drones look like? In addition to weighing safety risks weigh impact on amenity and privacy. Consider whether the purpose of the flight outweighs the impact"
>
> (Female participant aged 55-64)

In the example above, the participant raises the balance between risk and need. The suggestion that the use of drones in logistics should be restricted was made by other participants within the VR survey and the trial of the digital game.

The use of this question within the VR survey and the Digital Game survey elicited a small but significant number of responses calling for greater consultation with local communities (12% and 18% respectively):

> "The agreement with the residents around the drone delivery routes. Keep transparency - if the purpose is for energy saving, we also want to know the risk, energy saving etc."
>
> (Female participant aged 35-44)

Asking participants to offer feedback to those responsible for developing regulation indicates that there is scope to contribute to decisions around where and how logistics drones might be used. The use of a location which is familiar to the participant seeks to make their contribution more relevant to them, acknowledging the existence of a national-local gap in personal assessment of local development issues (Batel and Devine-Wright 2015).

3.2. A Game of Drones

Both the VR survey and digital game elicit individual perspectives. Exploring ideas with others provides opportunity for debate. The use of a board game supports a shift from individual perspectives and encourages people to develop their understanding and viewpoints through discussion generated through game play (Gomes et al 2021). The board game can be played by 2 – 8 players with scope for players to play in small teams of two people). Khoury et al. (2018) found that traditional workshop provided for limited in scope for people to grasp the complexity of the issues and that games helped to address this challenge.

The board game uses a setting which is familiar to participants in recognition of the need to generate interest and relevance. Within the first version, a schematic map of the Bournemouth area was created as this was the initial location for use, however the game can be adapted for different settings. Hexagons are used to create a schematic map of the Bournemouth area (see **Figures 6** and **7**). The hexagons are coloured to indicate risk levels (green, orange, red) and a risk budget it provided using a sliding scale for each player or team as the game progresses. An energy budget in the form of energy cards with the requirement to 'pay' for each move taken with an energy card, with further energy implications applied during the game play. Players are tasked with flying their drone from a start and end point on the board as determined by the mission cards. There is some flexibility in the route taken with avoidance of higher risk hexagons enabling players to manage their accumulated risk, although longer routes will require more energy points. Mission update cards are issued to each player every round, these provide both negative and positive feedback with implications for energy scores (e.g., "good winds, gain 5 energy points"), hexagons with comment symbols require all players to answer the question out loud for the benefit of all players (e.g. "Delivery drones should only be allowed to take off and land in places such as [complete the sentence]"). See Nadeem (2022) for more details of game play.

Figure 6 The Bournemouth Game Board

Figure 7 A group playing the game in Bournemouth

The Bournemouth version of the game was played at a café in Bournemouth with three separate groups each comprising of four to six participants as part of the 2022 ESRC festival of Social Sciences. Each game lasted around one hour and comprised of two rounds each presenting a different mission scenario. This was followed by a debrief during which participants were able to ask questions and reflect on their experience.

Participants were observed to collectively unpick significant issues and develop new perspectives:

> "…the game's changed me. I came here thinking I probably was a little bit negative about drones… It's actually made me take the devil's advocate view and go, well, actually let's have a look at what's good about them."

(Participant 2, Group 3)

Players discussed the factors that might contribute to ground risk, with recognition that the use of drones could extend beyond the realm of existing transport infrastructure, and that the severity of a crash would be dependent on multiple factors, for instance the mass and profile of the drone. Participants also discussed the need for regulation and potential approaches that could be taken with reference to the role of the Civil Aviation Authority. Whilst such discussions provided an opportunity for deeper reflection it was evident that they continued to represent areas of uncertainty throughout the game. As within the VR and digital game, assumptions were made around the potential for drones to reduce congestion and the role of drones in supporting medical logistics. Reference to more familiar, and sometimes unpleasant experiences of hobby drones was made during play, noting that the VR and digital game provided for a visual introduction to how logistics drones might fly over an area rather than hover and as such there was less conflation with this drone use.

4. DISPELLING MYTHS

It was evident that misconceptions about logistics drones surfaced when people engaged with all three approaches and it is apparent that even stakeholders with more active interest in the future use of delivery drones can perpetuate these, for example, trials of

medical logistics drones have been assumed to provide for fully functioning services within parliamentary questions (HC Deb, September 2022). In capturing views on transport futures, researchers and practitioners have some responsibility to try to dispel myths. Here it became clear that the three approaches offered different affordances, with the VR providing a reference point to the size of delivery drones to avoid comparison with small hobby drones. Future work will therefore use a combination of approaches to address misconceptions.

A pre-bunking (Blastland et al 2020) approach can also be useful to address myths. This primes people with information before they fall back on and reinforce the myth. The project is adopting a three-step strategy to pre-bunking:

1. Identify myths in preliminary work
2. Compiling the information needed to provide clarity to participants
3. Establish an appropriate approach to present the information

Our approach is to use traditional text and images in a video format that will be shown prior to VR use or game play. In the study, reducing congestion emerged as a myth since gains here are likely to be minimal. Text and images make clear that last mile logistics drones have small payloads and therefore vans will still be required for the majority of deliveries.

5. DISCUSSION AND CONCLUSION

Most people do not get involved in debates until it is too late, and change has happened. Timing is therefore important, but it is difficult to engage people who are time-poor and find little salience in future transport issues. Game based approaches introduce an element of novelty and fun that can bring more diverse stakeholders to a dialogue and once engaged, people can get more involved (Medema et al., 2020). The digital game and VR take relatively little participant time and can quickly make logistics drones relevant to the place where people live giving rise to greater attention to the topic (Pope 2021). Games also provide a safe space to explore complex problems where there is no consensual view (Aubert et al., 2019). Here we have used games to illustrate conflicting goals (e.g., risk versus energy use) enabling players to understand the trade-offs. This can trigger emotions, especially related to risk (Marini et al., 2020), which further motivates participation in the debate and critical reflection on the issue (Rodela et al., 2018). Post activity debriefing combined with pre-bunking of myths will help inoculate against further misinformation facilitating more informed debate across society.

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