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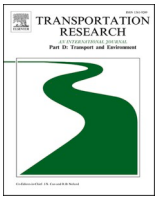

Supporting inclusive debate on Advanced Air Mobility: An evaluation

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ABSTRACT

Advanced Air Mobility (AAM) is being progressed, yet evidence suggests low levels of public salience and minimal debate. Efforts to engage the public have been framed around achieving acceptance made with little clarity of the potential impacts and benefits. This paper analyses an approach which sought to overcome low interest and to make technical information accessible to a general audience. The research used virtual reality (VR) to represent AAM technologies in public spaces proximal to where participants lived. During a second phase of research, additional supporting materials (an animation, a short game, and a recorded presentation) were developed to respond to gaps in understanding. The research was undertaken at five sites in England (N = 603). The representativeness of the sample is analysed, and the value of the VR, additional materials, and siting of the research are reviewed. Drawing upon detailed responses to open questions, the extent of meaningful involvement is explored showing how the additional supporting materials increased the depth of understanding amongst participants.

1. Introduction

Advanced Air Mobility (AAM) refers to the potential future integration of autonomous and electrically powered aircraft alongside traditional crewed aircraft. These new platforms typically comprise of drones for the movement of goods (logistics drones) and electric vertical take-off and landing (eVTOL) aircraft, or 'air-taxis' which would provide for short journeys for up to ten people (UK Research an Innovation, 2021). The term AAM stems from the concept of Urban Air Mobility (UAM) which envisages the adoption of these aircraft in urban areas and AAM extends the concept to wider contexts (Andritsos et al., 2022.), although both AAM and UAM are referred to by government agencies.

Many governments envisage the greater use of lower airspace for the purposes of mobility. Examples of current research and innovation include NASA's Advanced Air Mobility Mission, which aims to "transform communities by bringing the movement of people and goods off the ground, on demand, and into the sky" (NASA, (National Aeronautics and Space Administration) 2024). EASA

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(European Union Aviation Safety Agency) expect Urban Air Mobility to become a reality in the next few years and that the "EU, and EASA in particular, have an important role to play in enabling this breakthrough and so helping European industry be a first mover at global level" (European Union Aviation Safety Agency, 2024). In the UK, the Future Flight Challenge seeks to "assure the UK's position in the third aviation revolution" and the programme aims to "speed up the acceptance of these innovative air vehicles into service…by encouraging different businesses to share their knowledge and resources to work together" (Civil Aviation Authority, 2024). Parallels can be readily drawn with the push for self-driving vehicles which have increasing support from Governments (Olin and Mladenović, 2022) with links being made to the potential for economic growth and the drive to be a global leader (Mladenović et al., 2020). The public are often seen as a barrier to technological progress which therefore needs to be overcome (Stilgoe and Cohen, 2021), with the call for greater scrutiny of new transport technologies at an early stage before they become embedded in everyday lives (Stilgoe, 2020).

This is a key point in time to reflect on what AAM could mean for communities, calling for a broader level of public participation which reaches beyond those with a vested interest in its progression. However, involving a more general audience in the debate is challenging, firstly due to future flight technologies such as logistics drones and eVTOL having low public salience, secondly because of limitations in how this potential transport future has so far been communicated. Smith et al. (2022a) found low engagement with drone technology and that conflation of multiple drone applications presented some ambiguity with respect to their potential future role in logistics. Furthermore, there is an absence of detail on parameters around use, such as where they might fly, how high and how often. In the UK, trials using drones in logistics have largely focused on the delivery of medical items which attracts little controversy. These trials have mostly taken place away from populated areas with low numbers of flights. The effect has been to supress debate around wider use (Smith et al., 2022b) with media coverage of trials presenting optimistic and sometimes inaccurate representations of the purpose and outcomes (Oakey and Smith, 2024).

This paper reports on research undertaken in England during 2022 and 2023 which aimed to understand wider public perspectives in relation to the future use of logistics drones and eVTOL. The research used virtual reality (VR) to represent logistics drones and eVTOL in places proximal to where participants live to help them grasp the nature of the technologies, imagine future use scenarios, and understand potential impacts in a local context (see Dickinson et al., 2024). It also addressed concerns with previous research that conflated different types of drones (Smith et al., 2022a) through audio-visual representation that clearly differentiated logistics drones from smaller survey and hobby drones. The research sought to avoid deficit models of engagement which assume that greater support for adopting new technologies rests on increasing public knowledge, and that the public will interpret these facts in a uniform way (Simis et al., 2016). With respect to automated vehicles, Cohen et al., (2020 p2) argue that there is a need for transport innovators to "work with and incorporate the social complexities of the real world". To explore 'social complexities', there is a need to increase the reach of engagement whilst providing unbiased clarity regarding the technology under consideration.

The first phase of our research uncovered several widely held misconceptions regarding the use of drones for deliveries, these included assumptions that there would be faster deliveries, reduced traffic congestion and emissions savings. Achieving faster deliveries is dependent on the availability of a direct flightpath and weather conditions. With respect to medical logistics, comparisons against other land-based transport modes have exaggerated the potential time savings (Oakey and Smith 2024). Modelled scenarios show time and emissions savings may be achieved for drone deliveries to remote or island communities. However, this is at greater financial cost and the need to transport medical items more quickly is poorly evidenced (Grote et al 2024). Faster delivery of retail items has been demonstrated, for example, an average delivery time of three minutes has been reported for drone delivery services in Dublin, Ireland (Healy 2024). As logistics drones can carry relatively small payloads, the impact on congestion is negligible, with the potential for drones to generate new transport demand (Zenz and Powles, no date). Multiple trips would be needed for a logistics drone to replace a van, and this limits environmental benefits. Emissions savings are smaller when compared to electric vehicles (Filcak et al., 2021), whilst opportunities for increased consolidation using road transport may provide more significant emissions savings (Grote et al., 2023), and opportunities for the use of cycle couriers has been overlooked (Oakey et al., 2023). Public awareness of eVTOL in the UK is low (Marshall et al., 2022) and initial sampling using the VR led to basic operational and technical questions from participants. In response, additional supporting materials were introduced in a second phase of data collection with the aim of supporting participants in more evidence-based reflection. With respect to logistics drones, the VR experience was augmented with a digital game that enabled participants to reflect on ground risk and energy use, alongside a short animation which provided an overview of key issues. A separate recorded presentation was also created to introduce eVTOL.

This paper analyses the approach which has sought to overcome the challenges of low interest and of making technical information accessible to a general audience. The evaluation is undertaken in two parts: firstly, the representativeness of the survey sample is analysed relative to the local population, and the value of the VR, and siting of the research is reviewed; and secondly, drawing upon detailed participant responses to open questions, the extent to which the research activity enabled meaningful engagement and helped address misconceptions is evaluated. A key contribution of the research is the development of an approach which makes deliberation of a potential transport future relevant and more directly accessible to a wider audience.

2. Literature review

2.1. Barriers to participation in transportation planning and research

Ideals relating to transport justice rest on inclusive participation. However, achieving a level of participation which is representative of the communities which are ultimately affected is challenging. Bickerstaff and Walker (2001) identified low levels of engagement in the development of Local Transport Plans in England. A subsequent review by Elvy (2014) acknowledged that measures were included to increase representation but noted that there were still no specific initiatives for some groups, such as those on low

incomes and lone parents. Bertram (2023) identified low levels of youth participation in the planning of nationally significant transport infrastructure in England and Wales whilst highlighting the benefits that input from this group could bring to policy making and planning.

Low levels of engagement are attributed to a range of barriers and disincentives. Van den Berg et al (2022) suggest a divide between 'engaged' and 'passive' citizens with the former more willing to commit to participatory processes concerning urban planning. These more engaged citizens were typically middle aged and had the confidence and experience to support their active participation. Participation which is limited to the 'usual suspects' is often viewed negatively (Bickerstaff and Walker, 2001); however, May (2007) suggests that the contribution that this group makes should be valued, noting the commitment of time and energy required in negotiating "bureaucratic culture rules" (p70). This reinforces the idea that the type of competence required to participate in formal participation processes is a limiting factor for enabling greater diversity. Evidence also highlights a lack of trust in the ability of participation processes to influence outcomes, with unclear or limited linkages to policy development (Bickerstaff et al., 2002, Elvy, 2014).

Reflecting on the success of block parties in generating feedback on an urban street transformation initiative, Christiansen (2015) describes how public meetings can attract lower and less representative attendance compared to more informal activities. The block parties provided accessible participation in terms of both location and timing. The welcoming of children within this setting was also significant, creating a relaxed atmosphere which supported the participation of parents. Linovski and Baker (2023) describe how community-led engagement can support increased representativeness of under-represented groups and how providing 'pop-up' events for the completion of surveys in pre-selected locations also supported this aim. Wagner (2013) highlights the importance of creating engaging experiences that are "collaborative rather than confrontational" (p40) with success measurable in terms of the extent to which individuals felt that collaboration is encouraged and that their opinions were heard and valued. Serious games can also help to create a more engaging experience. Serious games can immerse players in a problem and have affective outcomes including learning, leading to deeper involvement and participation (Krath et al., 2021). There are many examples of serious games with an urban planning focus (see Ferri et al., 2018 for examples), these include games which focus on the use of transport (Freese et al., 2020). Creating engaging and accessible participation processes may also help to address low levels of interest which reflects the extent to which an issue is disconnected from current everyday lives, including geographically or temporally (Batel and Devine-Wright, 2014) as with AAM. The personal costs of participation (primarily time) can seem to outweigh the benefits (Bickerstaff and Walker, 2001) and incentives can act to compensate whilst attracting greater participation (LaRose and Tsai, 2014). The impact of incentives during face-to-face surveys can be difficult to generalise, as their effects sit within the context of the wider survey protocol with engagement tools, interviewer techniques and siting also having a significant role. A limited number of studies have explored the propensity for incentives to change the demographic composition of the survey sample. Blohm and Koch (2013) found an increase in cooperation rate with marginal changes to the sample composition as participation became more attractive to younger people and those living in urban areas.

2.2. Communication

Enabling broader deliberation on the future use of new transport technology hinges on how it is communicated, what type of information is made available, and the value given to different understandings. For the National Academies and of Sciences, Engineering, and Medicine (2017) the first step in a programme of science and technology communication is the alignment of the goal with the approach to be taken. They identify five types of goal, ranging from a desire to "simply share the findings and excitement of science" to a need "to engage with diverse groups so that their perspectives about science related to important social issues can be considered in seeking solutions to societal problems that affect everyone." (p2). This latter goal emphasises the role of society in defining expectations and improving decision-making whilst moving away from the deficit model by acknowledging and placing value on the role of personal and social contexts in shaping attitudes and beliefs. Blastland et al., (2020) emphasise the need to "inform, but not persuade" with the focus on designing "communications that do not lead people to a particular decision but help them to understand what is known about a topic and to make up their own minds on the basis of that evidence." (p363). However, communication during an engagement process does not take place in a vacuum, therefore there is a need to recognise the effects of wider discourse and the potential for misinformation to prevail.

Social representations theory explains the process through which people build representations of reality that become widely shared in society (Halfacree 1993). Social representations arise through direct experience, from the media (Olausson, 2011), and during interactions with others (Moscovici, 1981) and help people understand new ideas or objects in the world around them (Hogg and Abrams, 1988). Elite groups have scope for more influence; therefore, government ambitions and industry operators' have considerable power to shape national and local media (Van Dijk, 1997) and hence emerging representations of future flight technologies (Smith et al., 2022). In developing a social representation, people make sense of something unfamiliar (in this case the AAM) by using familiar concepts. In the case of logistics drones in the UK, people readily grasp the ideas being circulated such as helping the National Health Service or reducing congestion and embrace these as positive tropes regardless of whether these are practical. These discourses have become associated with logistics drones and provide a familiar reference point for any new encounters. People persist in drawing on familiar reference points which have considerable inertia and can remain despite evidence to the contrary. However, through successive small changes, new ideas can be built into social representations even when there is little exposure to the phenomenon (Moscovici, 1981). Direct experience is a powerful way to help people question inconsistencies in their social representations and in the absence of involvement in AAM trials, the VR experience reported in this study goes some way towards addressing this issue by presenting realistic scenarios within context. This follows similar approaches adopted by Stolz and Laudien (2022) and Thomas and

Granberg (2023) which use VR to show drone and eVTOL movement and sound in an urban context.

3. Methodology

The study comprised of two phases which took place in 2022 and 2023. Phase 1 deployed the logistics drone VR at five sites and eVTOL VR at one site, both were followed by a questionnaire. During phase 2, additional steps were added including the use of a digital game and a short animation to support the drone VR and a recorded presentation to support the eVTOL VR. The the incentive value was increased to reflect the additional time required to take part (Table 1). Table 2 summarises the field work protocol of the two phases.

3.1. Logistics drones VR design

The VR was designed to give participants an immersive audio-visual experience akin to drones flying live above them in their actual location or as near as physically practical. Details of the logistics drone VR design and development have been reported in detail elsewhere (Dickinson et al., 2024). In brief, the logistics drone VR shows a fixed-wing hybrid drone and a multi-rotor drone (Fig. 1), both capable of vertical take-off and landing to provide different examples of common logistics drones. The drones fly past at a speed of 40 mph/18 m/s at three heights (30 m/100ft (multi-rotor), 76 m/250ft (fixed wing) and 122 m/400ft (multi-rotor)). Six drone flights are visualised, one after another in around three minutes (including the introductory text) to give participants a time compact experience of the two drones flying at varied altitudes and typical cruising speed. This does not reflect anticipated frequency of flights and participants were made aware of this in the written participant information, by the researchers just before VR use and through introductory text in the VR headset as follows:

> 'You will see delivery drones fly past 6 times at varied altitudes. There are two types of drones illustrated. The flight frequency is for illustration only and does not reflect foreseeable real-world use'.

It was also recognised that there was a need to make more detailed images of the drones used in the VR available to provide clarity on their size. As such, for Phase 2, a poster was created and printed at A1. This was displayed on the inside of the gazebo and on the library wall (Fig. 1).

3.2. Digital game design

Concurrent with the Phase 1 VR work, the digital game was designed and piloted at two public outreach events where participants

Table 1
Study phase 1 and phase 2 details.

	Phase 1					Phase 2	
	District town centre	**Large town centre**	**City Centre 1**	**Country Park**	**Local suburban centre**	**District town centre**	**City Centre 2**
Place	Boscombe (a large suburban centre in southern England)	Bournemouth (town centre in southern England)	Southampton (a large city centre in southern England)	Lepe (countryside recreation area in a national park in southern England)	Southbourne (suburban area in southern England)	Boscombe (a large suburban centre in southern England)	Coventry (a small city centre in the midlands of England)
Day	Monday and Tuesday. Term-time	Tuesday and Wednesday. School holidays	Saturday and Sunday. Term-time	Friday (school holidays) SundayMonday (term-time)	Saturday, Monday, and Tuesday. Term-time	Friday and Saturday term-time (drones) Monday term-time (eVTOL)	Thursday term-time (eVTOL) Friday and Saturday term-time (drones)
Month/Year	July 2022	August 2022	September 2022	June 2023	June 2023	November 2023	November 2023
Indoors/ outdoors	outdoors	outdoors	outdoors	outdoors	outdoors	indoors	indoors
Setting	Pedestrian shopping area	Pedestrian shopping area	Pedestrian shopping area	Country Park	High street	Indoor shopping area	Public library
Gazebo or room	Gazebo	Gazebo	Gazebo	Gazebo	Gazebo	Gazebo	Room
AAM covered	Logistics drones	Logistics drones	Logistics drones	Logistics drones	Logistics drones & eVTOL	Logistics drones & eVTOL	Logistics drones & eVTOL
Additional supporting materials						Yes	Yes

Table 2
Research protocols:

Phase 1	Phase 2
Participant: 1. recruited on a next-to-pass basis 2. reviews an information sheet, including health and safety precautions related to VR headset use, before consenting to take part 3. uses VR headset to view the logistics drones 4. completes a questionnaire on a tablet or hard copy 5. receives £5 shopping voucher	Participant: 1. recruited on a next-to-pass basis 2. reviews an information sheet, including health and safety precautions related to VR headset use, before consenting to take part 3. watches animation/recorded presentation 4. uses VR headset to view the logistics drones/eVTOL 5. plays digital game (drones only) 6. completes questionnaire on a tablet or hard copy 7. receives £10 shopping voucher

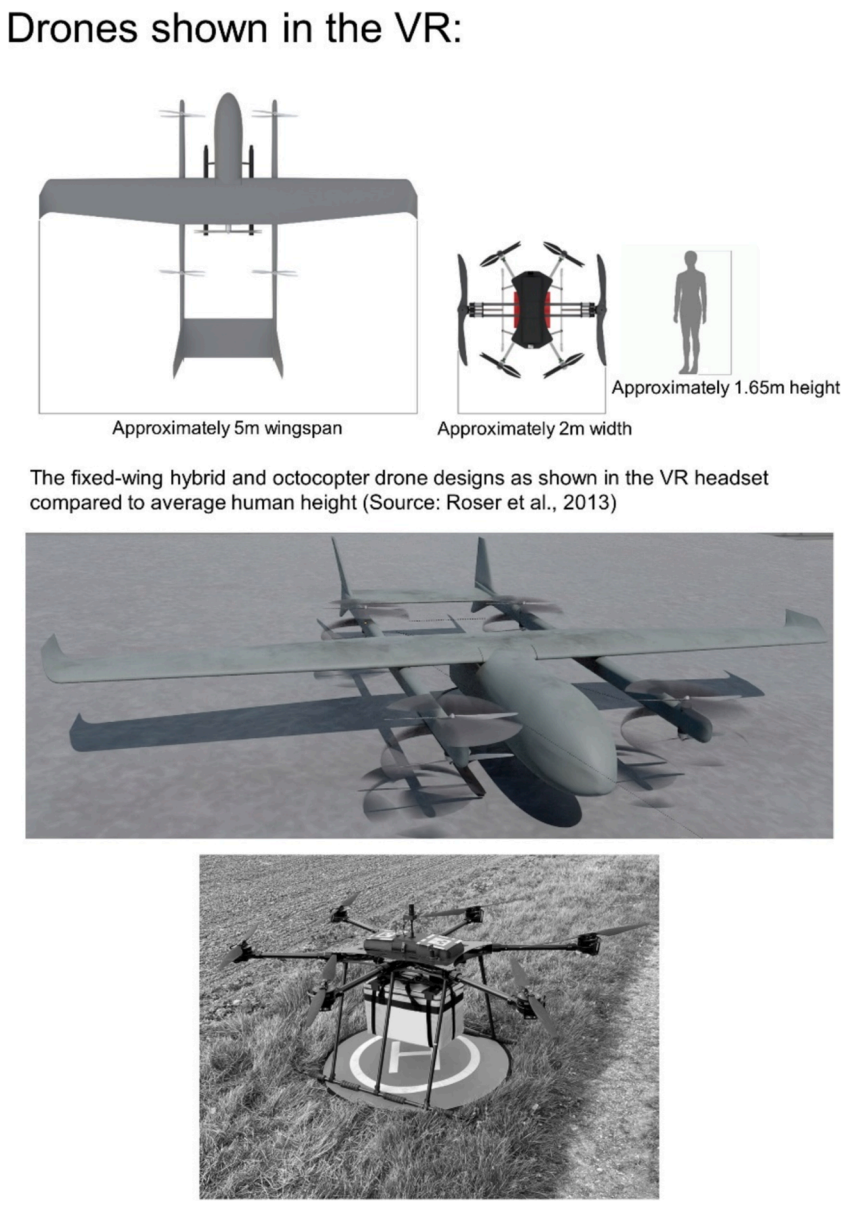


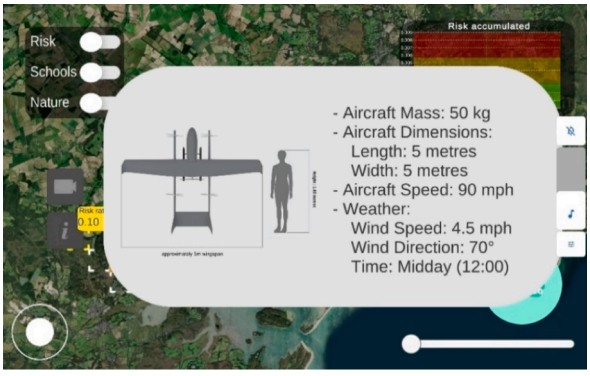
Fig. 1. A1 Poster displayed in the gazebo/on the library wall where participants used the tablet computers. (Note image is of a hexacopter but description states octocopter. This error was picked up after fieldwork).

completed a similar questionnaire to that used with the logistics drone VR work (Snow et al., 2023). It was concluded that there were benefits of participants utilising both the VR and digital game as they offered different affordances.

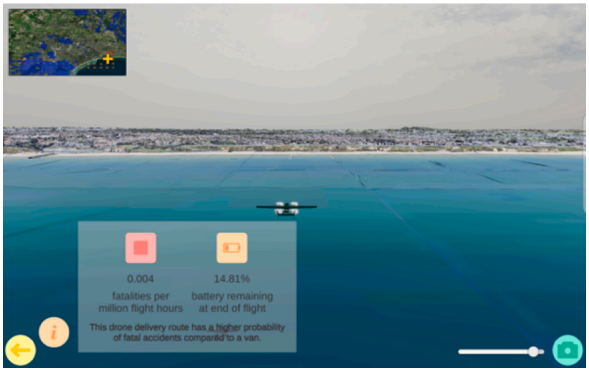
The game was designed for use on a tablet computer. The player's mission is to deliver a package between two fixed points using a drone. To undertake this, players must plot a route whilst considering the drone's battery life (energy consumption) and ground risk (the risk of the drone failing during flight and striking a person on the ground). The game utilises satellite imagery to allow players to explore drone flight paths in their own area, with versions of the game created for the two areas within which the Phase 2 sites are located.

The game utilises a spatial temporal ground risk model developed by Pilko and Tait (2022) which uses the 2021 Census of England and Wales, traffic and time-use data to provide a national model of exposed population across a 24-hour period to estimate the

Screenshot of Bournemouth version of digital game.



Screenshot showing drone information visible when the player selects the information button



Screenshot of drone overflight with feedback information

Fig. 2. Screenshots of digital game.

probability of a human fatality resulting from a drone crash. An energy modelling formula is used to calculate the expected energy expenditure over a given distance with set operating parameters, including the type of drone featured in the game (Snow et al 2023). The game shows risk for each grid square and accumulated risk for the selected route as a graph in the corner of the screen. A battery icon is used to show energy use as the route is plotted (Fig. 2). Once a route is successfully plotted, participants see a bird's eye view of their drone flight alongside feedback relating to the accumulated risk and energy use (Fig. 2). The game introduces participants to drone route planning and two issues:

I. That logistics drones can be routed to avoid places, for example where there is high ground risk; and
II. That there are energy/battery capacity limitations on the distance that can be flown.

3.3. Logistics drones animation

To address gaps in knowledge and the misconceptions evident from Phase 1, a short animation was created and integrated into the Phase 2 protocol. The animation was developed around four key communication objectives:

1. What is it about and why should I take an interest?
2. What are the implications for society?
3. How could this affect me?
4. What are the risks?

The animation is available online (What do you know about drones?), screenshots are shown as Fig. 3. The animation was shown to participants on the tablet computer alongside a short video explaining how to play the digital game.

The revised protocol was piloted on a university campus in September 2023 involving a mixture of staff and students. Due to the longer time commitment to take part (between 20 and 30 min) the incentive was increased to £10. Phase 1 VR work was undertaken outdoors so that the drones could be viewed in the position they fly by. The variability of the UK weather presented planning challenges, so for Phase 2 the activity was moved to indoor locations near to the place shown in the VR.

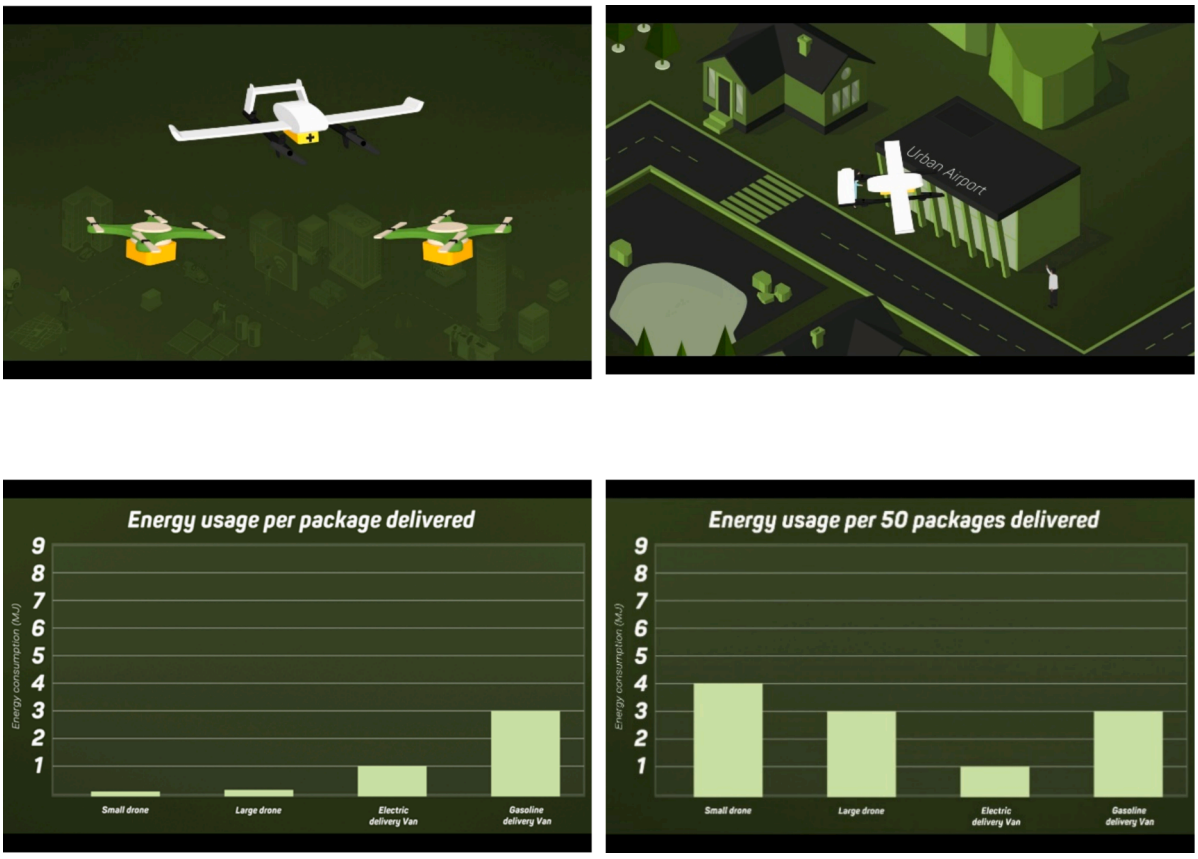


Fig. 3. Screenshots from the animation.

3.4. eVTOL VR design

The eVTOL design was adapted from a review of various likely designs drawing most on the DaVinci_H2 configuration of wings set for horizontal and vertical movement (Kim, 2021) (Figs. 4 and 5). All source designs were either used with permission or from sources that allowed for academic use. The VR experience shows the eVTOL take off from a vertiport, fly over each site twice at 150 m (see Fig. 6) and return to land at the vertiport. The take-off/landing area was chosen as being an area likely to host such services, i.e., near commercial areas yet open enough to allow safe eVTOL activity (see Fig. 6). The audio development was as per the logistics drones and has been reported elsewhere (Dickinson et al 2024). As for logistics drones, the included introductory text was as follows:

> 'You will see an electric air taxi or eVTOL take off from a vertiport. It will then fly past this location four times at varied altitudes. The air taxi then lands at a vertiport.'

The eVTOL VR and questionnaire were piloted in a local suburban centre during Phase 1. The data from the pilot indicated that participants had little or no exposure to eVTOLs in the UK, unsurprising since trials are only in the planning phase and there has been little media reporting on the topic. Learning from the logistics drone experience, the team felt it was vital to provide some upfront materials to contextualise eVTOLs and to this end, an explainer presentation was developed for phase 2 (Introduction to eVTOL). The recorded presentation was produced by the researchers, it included commentary that was both audio recorded and written on the screen. The content was carefully created with respect to a defined rationale with content drawing on eVTOL literature and information produced by developers of the technology, whilst responding to gaps in knowledge identified from the suburban centre sample. The slides are included as Appendix A. The final research protocol was similar as for the logistics drone VR experience (see Table 2) but excluded the digital game as this was not available for the eVTOL.

Within the pilot, the team also explored whether participants could engage with both the eVTOL and logistics drones or whether these should be kept separate. A test of logistics drones only on day 1, eVTOL only on day 2 and both technologies on day 3 found that there were some impacts on participant views of logistics drones when the two technologies were both shown to participants. As a result, the eVTOL research was conducted on a separate day to the logistics drones in phase 2 work.

3.5. Data collection

The data for both phases was managed by a minimum of four researchers. Similar questionnaires were developed for the logistics drone and eVTOL experience. The study was inductive and used predominantly open questions and one checklist. This was to avoid prompting responses on specific issues and to allow for the capture wider range of reflections. The checklist sought to link overflight frequency with place context, allowing participants to reflect on how this may present varying levels of impact. Some new questions were added for phase 2 according to project needs and some questions removed having served a purpose in early parts of the project. The phase 2 questionnaires are in Appendix B and C. The analysis in this paper focuses on questions 1, 5, and 6 which were consistent through both research phases.

A convenience sample was used by recruiting participants on a next-to-pass basis. Social media was also used to reach local people

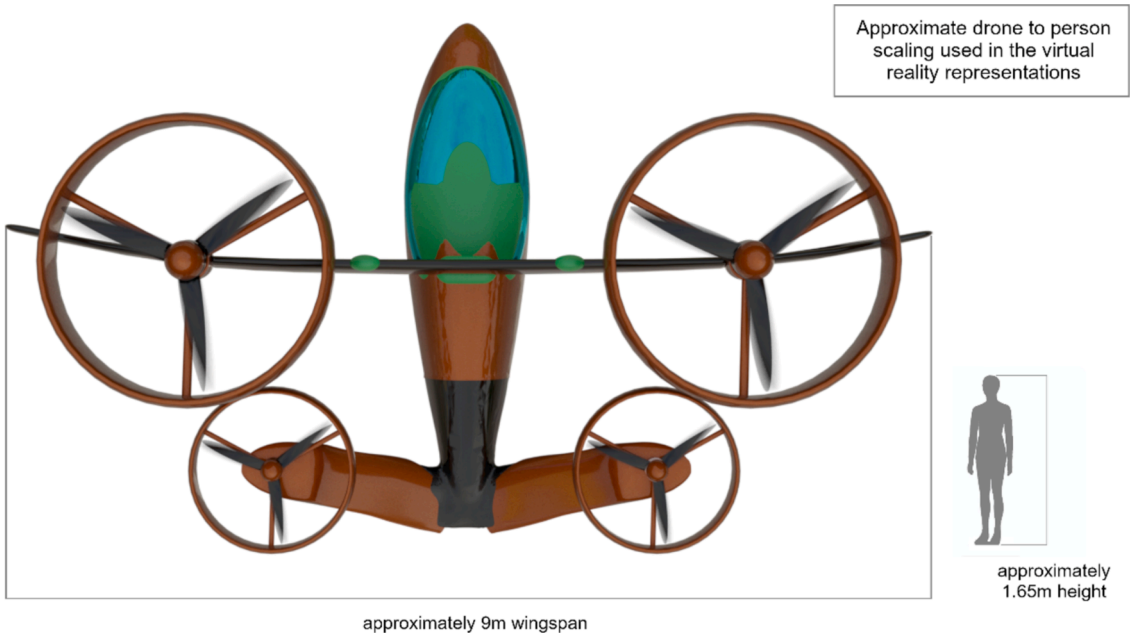


Fig. 4. The eVTOL design compared to average human height (Roser et al., 2013).

Fig. 5. eVTOL design.

Fig. 6. eVTOL vertiport and eVTOL flight over Coventry city centre.

prior to the activity with participants also sharing social media posts about the activity after taking part. During phase 2, the city council also alerted their staff to the research activity via their intranet. In terms of locations, the country park was chosen to capture views in a countryside setting and is in a location close to where logistics drones trials have been undertaken. Suburban, district, town and city centres provided for a range of urban place types. In 'city centre 2′ there was an opportunity to do work in the early evening. Note that all the eVTOL surveys were on weekdays and this has impacted sample composition which is reported in the results section.

3.6. Data analysis

Frequencies for gender, age, and ethnicity were compared to national census data for England and each study location. Postcode data were used to code participant home locations into rural and urban categories using the 2011 Rural-Urban Classification for Output Areas in England (Government Statistical Service, 2017), according to whether they were local to the area based on proximity from study site and according to the English indices of deprivation 2019 (GOV.UK, 2019). The open questions were reviewed thematically and then content analysed to identify key categories (Weber, 1990) based on an emergent coding system. Three researchers reviewed the answers, compared notes and developed a category list. This category list was then applied by two researchers to the data, the coding compared, disagreements discussed and adjudicated by the third researcher. Coded categories were entered into SPSS (IBM

Corp, 2023) as binary data (presence/absence). In addition, the nature of the open responses was reviewed to explore the depth of understanding in relation to the video and game. The checklist generated ordinal data that were not normally distributed therefore non-parametric tests were used to compare differences in responses before and after the revised protocol (Mann-Whitney *U* test). Four logistics drone comparisons were made between the five places prior to use of the animation and digital game, and the two places where these were used. The eVTOL analysis compared data from the pilot (prior to the recorded presentation) and the two places where the video was shown. A limitation here was the small data set related to the eVTOL VR in Southbourne (n = 19) and the relatively small eVTOL data set overall (n = 97).

4. Results

4.1. Reaching people who wouldn't normally take part

The study sought to achieve a representative sample by increasing accessibility through location choice and scheduling, supported by an interactive research format and the use of incentives. The district town centre (2022) work was a pilot, and a postcode question was added to the survey after the first day. We subsequently recognised that a wider range of people were being reached and a question on ethnicity was added for all sites. Following the work in town and city centres during 2022, we were keen to explore a rural location and a different suburban location (see Table 1 for all study location details). It was challenging to find a rural location with enough footfall to make data collection viable and a national park was chosen to achieve this. The suburban centre location was selected as it has a small shopping area, but enough footfall for viable data collection and is in a higher decile area according to the indices of deprivation (GOV.UK 2019) (Table 7).

A good gender balance was achieved in all places except for logistics drones in the suburban local centre where the sample size was small, and more women took part (Table 3). In previous work we have reported success at reaching younger age groups (Dickinson et al., 2024) with 3 % more 18 to 24 year olds in the total logistics drone sample compared to the national population (Table 3) This difference was greatest in the samples from the 'large town centre' and 'city centre 1′ with 18 to 24 year olds comprising of 26 % of the sample in both locations. The eVTOL work all took place on weekdays when younger age groups are more likely to be in work, here the proportion of 18–24 year olds was 3 % less than the national population. 'City centre 2′ included an early evening slot, however this was held in a library with a lower footfall of younger people compared to the shopping areas of the 'large town centre' and 'city centre 1′. The choice of place was critical and different places had different affordances for reaching people. The country park and suburban

Table 3
Gender and age composition.

Phase 1						Phase 2			
	District town centre (n = 95) %	Large town centre (n = 71) %	City Centre 1 (n = 75) %	Country Park (n = 97) %	Local suburban centre (n = 33) %	District town centre (n = 62) %	City Centre 2 (n = 73) %	All sites (n = 506) %	Census for England %
	Town/ suburb	Town	City	Countryside	Suburb	Town	City		
Logistics drones									
Gender									
Male	48	52	55	49	30	50	48	49	49
Female	52	48	45	51	70	50	52	51	51
Age									
18–24	12	26	26	8	13	7	11	14	11
25–34	26	20	34	10	7	23	18	20	17
35–44	17	17	14	29	10	24	19	20	16
45–54	14	17	7	18	13	7	19	14	17
55–64	17	14	11	16	27	18	22	17	16
65–74	7	3	8	14	17	15	8	10	12
75–84	3	3	1	4	10	8	3	4	8
85+	4	0	0	1	3	0	0	1	3
eVTOL					(n = 19)	(n = 35)	(n = 43)	(n = 97)	
Gender									
Male					47	55	49	51	49
Female					52	46	51	50	51
Age									
18–24					0	3	16	8	11
25–34					16	14	14	14	17
35–44					21	26	12	19	16
45–54					11	14	28	20	17
55–64					11	11	21	16	16
65–74					32	20	9	18	12
75–84					11	11	0	6	8
85+					0	0	0	0	3

local centre reached an older age demographic, while the town and city centre locations were better at reaching younger people. Participants at the country park were drawn from a wider area compared to the urban sites (Table 6). Non-white ethnic groups comprised of a higher proportion of the sample compared to the local populations. Although 'Black, Black British, Black Welsh, Caribbean or African' groups had lower proportion than the local population in 'city centre 2', where these groups constituted 9 % of the local population. There was much less ethnic diversity at the country park and in the suburban centre. The 97 % of the country park sample was white, 10 % of which were of non-British backgrounds. Of the white groups, the district town centre was better for reaching the white population from a non-British background (Table 4). Education levels and employment status also varied by place with the district town centre reaching more people with disabilities, those with no formal qualifications and unemployed (Table 5).

Despite efforts to reach diverse audiences, some groups were underrepresented. No participants under 18 took part due to research ethics considerations and people aged 75 or over were underrepresented. Several people were assisted with the questionnaire due to disability or poor literacy skills. The VR was not accessible to some who experienced visual disturbances and/or had medical conditions that prohibited use. The research team made efforts to involve everyone and helped entertain children and watched over pets to enable some to participate. The incentive was important for encouraging participation.

4.2. Impact of additional materials

Analysis of where delivery drones or eVTOL should fly (question 2) comparing phase 1 and phase 2 using Mann Whitney *U* test showed no differences between the two groups for both logistics drones and eVTOL (all not significant, $p > 0.05$). Therefore, the additional materials did not alter levels of aversion to flights over any setting. However, comparison of open question responses for phase 1 and 2 showed the foci of concern changed in terms of better understanding, additional detail, change in focus and desire for more consultation.

4.2.1. Better understanding

The additional materials in phase 2 improved participants understanding of some aspects of logistics drones and eVTOLs, but not all. The materials reduced the proportion of participants who assumed that there would be less traffic and/or congestion in both the logistics drone and eVTOL surveys. A small proportion of logistics drone participants (5 %) further recognised that drones would not reduce traffic congestion due to limitations in payload (Tables 8 and 9). For example, a phase 1 response on logistics drones stated: "Seems like a good idea to take traffic off the roads" (Initial comments Phase 1: Male, aged 55–65, large town centre), whereas in phase 2 a participant stated: "Drones are not going to reduce congestion on the roads because they cannot take larger deliveries" (Initial comments Phase 2: Female, aged 55–64, city centre 2). For logistics drones, there was also a reduction in the numbers of responders

Table 4
Ethnic group.

	Phase 1								Phase 2					
	Large town centre (n = 71) %		City Centre 1 (n = 75) %		Country Park (n = 97) %		Local Suburban Centre (n = 33) %		District Town Centre (n = 62) %		City Centre 2 (n = 73) %		All sites* (n = 411) %	
Logistics drones	S	C	S	C	S	C	S	C	S	C	S	C	S	C[1]
White	*66*	*91*	*51*	*81*	*97*	*97*	*89*	*94*	*72*	*87*	*59*	*66*	*72*	*82*
White: English/ Welsh/ Scottish/Northern Irish/ British	49	82	35	68	86	93	79	85	55	58	45	55	58	74
White: Irish	2	1	4	1	1	1	4	1	0	1	3	2	2	<1
White: Gypsy or Irish Traveller	0	<1	0	<1	0	<1	0	<1	0	<1	0	<1	0	<1
White: Roma	0	<1	0	<1	0	<1	0	<1	0	1	0	<1	0	<10
White: Any other White background	15	8	12	12	10	3	7	8	17	27	11	8	12	6
Asian, Asian British or Asian Welsh	25	3	36	11	0	1	0	2	17	4	36	19	20	9
Black, Black British, Black Welsh, Caribbean or African	2	1	3	3	0	0	0	1	2	2	4	9	2	4
Mixed or Multiple ethnic groups	2	3	7	3	2	1	4	3	5	5	0	3	3	3
Other ethnic group	4	2	3	2	1	0	7	1	5	3	1	4	3	2
eVTOL							(n = 19)		(n = 35)		(n = 43)		(n = 97)	
White							74	94	78	87	61	66	69	82
White: English/ Welsh/ Scottish/Northern Irish/ British							63	85	66	58	54	55	60	74
White: Irish							5	1	3	1	5	2	4	<1
White: Gypsy or Irish Traveller							0	<1	0	<1	0	<1	0	<1
White: Roma							0	<1	0	1	0	<1	0	<1
White: Any other White background							5	8	9	27	2	8	5	6
Asian, Asian British or Asian Welsh							21	2	13	4	21	19	18	9
Black, Black British, Black Welsh, Caribbean or African							0	1	6	2	14	9	9	4
Mixed or Multiple ethnic groups							0	3	3	5	0	3	1	3
Other ethnic group							5	1	0	3	5	4	3	2

Data on ethnicity not available for District Town Centre Phase 1. S = Sample, C = Census data for location, [1]Census data for England.

Table 5
Employment and education.

	Phase 1					Phase 2		
	District town centre (n = 95) %	Large town centre (n = 71) %	City Centre 1 (n = 75) %	Country Park (n = 97) %	Local suburban centre (n = 33) %	District town centre (n = 62) %	City Centre 2 (n = 73) %	All sites (n = 506)
Logistic drones								
Employment status								
Employed full-time	22	47	49	41	32	40	41	39
Employed part-time	12	10	9	18	16	8	26	14
Self-employed full-time	11	10	5	8	7	5	6	8
Self-employed part-time	3	6	8	4	0	7	4	5
Looking after home/family	6	1	1	3	3	3	0	3
Unemployed	14	7	4	0	0	5	6	6
Permanently sick/disabled	8	0	0	4	0	7	1	3
Full-time student	6	13	13	5	10	7	6	8
Retired	16	7	8	20	36	21	10	15
Other	3	3	7	2	0	0	4	3
Highest level of education								
No formal qualifications	13	0	4	3	7	5	3	5
O-Level/ CSE/ GCSE	27	14	7	11	16	15	12	15
A-Level or equivalent	18	18	18	20	13	18	8	17
Higher National Diploma or equivalent	7	11	11	18	10	7	7	10
University degree or equivalent	18	27	37	30	32	34	37	30
Post-graduate qualification	10	23	24	17	23	18	26	19
Other	7	7	0	2	0	5	7	4
eVTOL					(n = 19)	(n = 35)	(n = 43)	(n = 97)
Employment status								
Employed full-time					26	23	51	36
Employed part-time					11	11	16	13
Self-employed full-time					5	6	2	4
Self-employed part-time					11	9	5	7
Looking after home/family					0	6	2	3
Unemployed					5	9	12	9
Permanently sick/disabled					0	6	7	5
Full-time student					5	9	5	6
Retired					42	23	7	20
Other					0	3	0	1
Highest level of education								
No formal qualifications					11	9	2	6
O-Level/ CSE/ GCSE					11	14	26	19
A-Level or equivalent					16	3	14	10
Higher National Diploma or equivalent					21	20	16	19
University degree or equivalent					26	20	21	22
Post-graduate qualification					16	29	19	22
Other					0	6	2	3

who assumed that there would be delivery advantages in phase 2 (Table 8).

There was a statistically significant reduction (8 % compared to 2 % in phase 2) in the number of comments relating to privacy regarding logistics drones in phase 2 (Table 8). Further analysis showed that a third of privacy concerns raised in phase 1 mentioned the possibility of the drone taking photos, filming, or having a camera, whereas there were no mentions of this aspect in phase 2. A further 25 % of phase 1 privacy comments referred to the potential for spying and surveillance (Fig. 7). For example:

> "…there are privacy concerns if camera[s] are mounted".
> Initial comments Phase 1: Male participant, aged 55–64, country park.

The remaining comments raised concerns about privacy more generally. This was not explicitly covered in the animation, but it explains future operation, stating how drones are largely automated and remotely piloted. The animated drones have a simple form (see Fig. 3) which does not include any visible camera equipment. The drones displayed on the poster and within the digital game were

Table 6
Urban/rural area and local resident classification (Government Statistical Service, 2017).

	Phase 1					Phase 2			
	District town centre (n = 95) %	Large town centre (n = 71) %	City Centre 1 (n = 75) %	Country Park (n = 97) %	Local suburban centre (n = 33) %	District town centre (n = 62) %	City Centre 2 (n = 73) %	All sites (n = 506)	England %
Logistic drones									
Urban rural classification[1]									
Rural hamlets and isolated dwellings	0	4	2	5	0	0	0	2	3.1
Rural: Village	0	0	2	1	0	0	2	1	5.2
Rural town and fringe	0	2	2	7	0	2	0	2	8.0
Urban city and town	87	75	93	83	100	97	95	89	43.2
Urban major conurbation	14	20	2	4	0	2	3	6	35.5
Distance of participants' homes from survey site									
Local > 3 miles*	69	41	45	10	79	85	86	54	
Local > 5 miles*	79	51	65	16	93	93	89	63	
Local > 10 miles*	81	55	76	39	97	95	96	72	
Local > 20 miles*	83	58	82	69	100	97	99	82	
eVTOL					(n = 19)	(n = 35)	(n = 43)	(n = 97)	
Urban rural classification									
Rural village					0	0	5	2	5
Urban city and town					100	100	95	98	43
Distance of participants' homes from survey site									
Local > 3 miles*					84	94	70	81	
Local > 5 miles*					90	100	81	90	
Local > 10 miles					95	100	88	94	
Local > 20 miles					95	100	95	97	

*Differences between sites statistically significant.

also very different from more familiar hobby drones from which privacy concerns may have originally arisen (Smith et al., 2022a). Additionally, the animation showed drone landing sites as opposed to direct deliveries to peoples' homes since the UK population is predominantly urban (Government Office for Science 2021) with limited scope for drones landing at peoples' homes in the near future. The drones shown in the VR were flying past some distance from the viewer at 40 mph and therefore features of the drones were difficult to see. 'Privacy and intrusion' were identified as a very significant area of concern by the Department for Transport's Technology Tracker, however there is conflation of a range of drone uses, and respondents are shown an image of a drone with a mounted camera (Marshall et al., 2022, p58).

In contrast to the above, responses to question one for logistics drones showed a statistically significant increase in comments that assumed an environmental benefit in Phase 2 (Table 9). This increase was unexpected given that this was an area where the animation sought to provide greater clarity. Further breakdown of the coding for this category showed how those in phase 2 made greater reference to efficiency, reductions in energy use and emissions (Fig. 8). A similar effect is evident within the responses to the same question in the eVTOL survey, where 6 % of participants in phase 2 assumed that the use of eVTOLs would reduce carbon emissions and/or pollution in general with no similar comments in Phase 1. Further, in response to the eVTOL question seeking feedback to regulators, there was a significantly higher proportion of comments relating to the need for environmental impact assessment in phase 1 (32 % compared to 9 % in phase 2, X^2 (1) = 6.727, $p = 0.009$).

This shift in emphasis relates closely to the content of the additional materials. The animation states how using drones to deliver items could help to reduce carbon emissions before caveating that these benefits may not be realised when there are larger payload requirements or potential changes in demand. Information is given about energy use, and the digital game also shows how the drone is powered by a battery. The eVTOL video states how eVTOL will not generate exhaust emissions but goes on to explain that compared to electric cars, over a lifecycle, they will likely generate higher carbon emissions. The increase in assumed environmental benefit can be attributed to the brevity of the introductions with the mention of energy and efficiency having greater resonance than more subtle information around changes to demand and emissions over a lifecycle. Van der Linden (2024) describes how attempts to address misinformation can have the undesirable effect of reinforcing existing beliefs. Social representations theory explains how beliefs can be persistent, even in the face of contrary evidence (Moscovici, 1981). The findings here reflect assumptions about the benefits of electric vehicle emissions, though these are dependent on the electricity source, do not acknowledge wider manufacturing impacts, opportunities for modal shift or reductions in transport use.

Table 7
Indices of deprivation classification (GOV.UK, 2019).

IDM by decile	District town centre (n = 95) %	Large town centre (n = 71) %	City Centre 1 (n = 75) %	Country Park (n = 97) %	Local suburban centre (n = 33) %	District town centre (n = 62) %	City Centre 2 (n = 73) %	All sites (n = 506)	England %
Logistics drones									
1	32	7	4	1	0	21	0	8	10
2	11	7	12	4	4	18	24	12	10
3	5	13	21	4	4	11	6	9	10
4	14	27	12	8	7	19	14	15	10
5	11	9	7	13	22	4	10	10	10
6	8	7	5	12	11	25	16	12	10
7	3	4	16	7	0	0	10	6	10
8	3	9	4	13	4	4	11	8	10
9	3	11	7	20	40	0	5	11	10
10	11	7	12	18	7	0	5	9	10
eVTOL					(n = 19)	(n = 35)	(n = 43)	(n = 97)	
1					0	23	17	16	10
2					17	17	10	13	10
3					11	10	17	13	10
4					0	23	17	16	10
5					39	3	2	10	10
6					11	10	12	11	10
7					0	0	10	4	10
8					0	10	5	6	10
9					17	0	5	6	10
10					6	3	7	6	10

Table 8
Initial comments on the use of drones for making deliveries.

Topic	Summary	Phase 1: %	Phase 2: %	All %
Noise negative	Concerns questions and thoughts about noise impacts	32	30	31
Delivery advantages	Speed and time saving; use case to islands; value for people less able to leave home; value for urgent deliveries; trustworthy delivery	28	22	26
Safety and accidents	Airspace conflict, drone malfunction, crashes, dangerous, items being dropped	14	20	16
Environmental benefits[a]	Reduced energy use and/or carbon footprint, more efficient, broad comments on less pollution and environmental benefits	11	20	14
Security	Concerns about malicious activity (e.g., theft, use by criminals), interference with the drone	6	7	6
Privacy[b]	Concerns about camera use and surveillance, including Government surveillance, and what happens to data (video data or other data held by operators)	8	2	6
Questions or concerns about technical capabilities	Who controls and trust concerns about operators, weather impacts, weight limits, better ways for delivery	11	14	12
Annoyance NOT noise focused	Annoying in general, visual intrusion, distraction, disturbance	11	7	10
Drone frequency	The number of drones needed, time of day and routes	8	7	8
Reduction in traffic/congestion	Assumed reduction in traffic and/or road congestion	8	6	8
Jobs negative	Loss of work for delivery drives and negative comments on the nature of work	7	7	7
Medical use case	References to medical use scenarios	6	10	7
Environmental concerns	Questions/comments about efficiency, impact on wildlife/animals, bad for the environment generally	5	6	6
Altitude	Impacts related to altitude	5	2	5
Positive/neutral comments on noise	Noise compared to cars (positive or neutral), generally noise neutral, will be okay if noise is addressed and need for more clarity on noise	3	0	2
Environmental question or caveat	Raise a question about environmental benefits or caveat use based on not harming the environment	1	4	2
Drone use in rural or remote areas	References to rural or remote area use cases	2	4	2
Jobs positive	Creation of new jobs and better jobs than current delivery driving	1	2	1
Limited impact on congestion	Recognition that drones will not reduce traffic congestion and are limited in what they can carry	0	4	1

[a] Environmental benefit is statistically significant X^2 (1) = 6.331, $p = 0.012$.
[b] Privacy is statistically significant X^2 (1) = 6.53, $p = 0.011$.

Table 9
Initial comments on the use of eVTOL.

Topic	Summary	Phase 1: (n = 19) %	Phase 2: (n = 78) %	All %
Cost	Expensive technology and price dependent to use	16	14	14
Noise negative	Concerns questions and thoughts about noise impacts	21	10	12
Safety and accidents	Safety concerns about malfunction and crashes, concerns no pilot	16	10	11
Faster travel/ save time	Improvements in travel times and saving travel time	11	10	10
Questions necessity/usefulness	Questions whether the technology will be needed or be useful	21	6	9
Efficient	Comments stating that the technology will be efficient	5	8	7
Emergency/medical use	References to medical and emergency use scenarios	5	8	7
Futuristic/sci-fi	Comments stating how the technology was futuristic or something from science fiction	0	9	7
Crowded skies & plans for restrictions on use	Concerns that skies will become crowded and comments on restricting why eVTOLs might fly	11	5	6
Limited use cases	Suggest use cases are limited	0	8	6
Conflation with delivery drones	Mentions value in delivering items as per delivery drones	5	6	6
Will reduce carbon emissions/ pollution	Assumes eVTOLs will reduce carbon emissions and/or pollution in general	0	6	5
Inevitable	Inevitability that the technology will be implemented regardless of public feedback and potential impacts	0	5	4
Reduction in traffic/congestion	Assumed reduction in traffic and/or road congestion	11	3	4

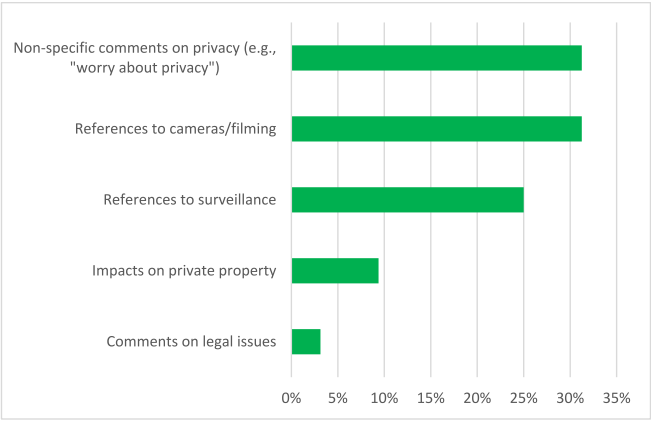


Fig. 7. Breakdown of comments about privacy (drones). (Phase 2 breakdown not shown as only two privacy related comments).

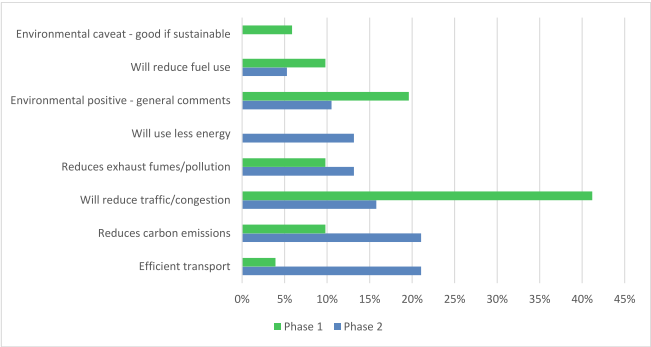


Fig. 8. Breakdown of comments regarding assumed environmental benefit (drones).

The eVTOL recorded presentation had more impact (Table 9) on initial comments for a range of issues however, the sample is relatively small (n = 97), particularly the group taking part prior to the recorded presentation (n = 19), therefore before and after comparisons need to be made with care to not overemphasise effects. The impact over a range of topics is expected given much fewer participants had heard of eVTOLS prior to the VR experience. The recorded presentation provided some use context so there were fewer queries about the necessity and usefulness of eVTOL, and reduced concerns (noise, safety, crowded skies).

4.2.2. *Additional detail and changes in focus*

Participants provided detailed comments in both phases, but the emphasis shifted in Phase 2. For example, for eVTOL participants' feedback to regulators focused more on operational parameters such as where and how high they would fly (11 % phase 1 compared to 19 % in phase 2). There was evidence of understanding that operational aspects could control issues like noise and safety with a drop in the number of comments in phase 2 (Table 9). Some comments made in Phase 2 linked safety with operational aspects drawing on information presented in the recorded presentation. For example:

"Concerned to learn that they may not be piloted".

Initial comments. Phase 2: Male, aged 35–44, district town centre.

> "…we don't build heliports in inner city areas for safety reasons – interesting and potentially useful tech however – just a little early for current cityscape".

Initial comments. Phase 2: Male, aged 55–64, city centre 2.

For logistics drones, there was an increase in comments relating to safety in phase 2 in response to question 1 and question 5 on feedback to regulators. The latter was statistically significant (11 % phase 1 and 18 % phase 2, X^2 (1) = 4.00, p = 0.045). Further breakdown of comments for question 1 (Fig. 9) shows that this increase was partly attributable to new comments relating to the risk of fatalities and links between increased risk and where the drones would fly.

> "Do not want to be a world, encased with these numerous, noisy machines that have the potential [to] fall fatally on you."
> Initial comments Phase 2: Female, aged 55–64, city centre 2.
> "I think it is a good idea but there are risks involved with it, especially in built up areas where there are a lot of people."
> Initial comments Phase 2: Male, aged 45–54, city centre 2.

Both the digital game and the animation make the link between risk and where the drones might fly, with areas with higher population densities or where there are more people outside presenting higher levels of risk.

4.2.3. *Desire for more consultation, information, trials and use cases*

In terms of additional information requested by participants, for logistics drones the focus was on operational parameters (17 % in both Phase 1 and 2). For eVTOL there was a general drop in additional information needs in phase 2 (Table 10).. There was, however, an increase in the need for research updates, more consultation and demonstrations (16 % in phase 1, and 19 % in phase 2). For example:

> "I'd like there to be more public consultation about this – today is the first time I've ever heard of eVTOLs".
> Additional information, eVTOLs. Phase 2: Female, aged 65–74, district town centre.
> "More face-to-face sessions"
> Additional information, eVTOLs. Phase 2: Female, aged 45–54, city centre 2.

Overall, it was positive to see a desire for more information in general, and about trials and use cases in both phases which made the research worthwhile.

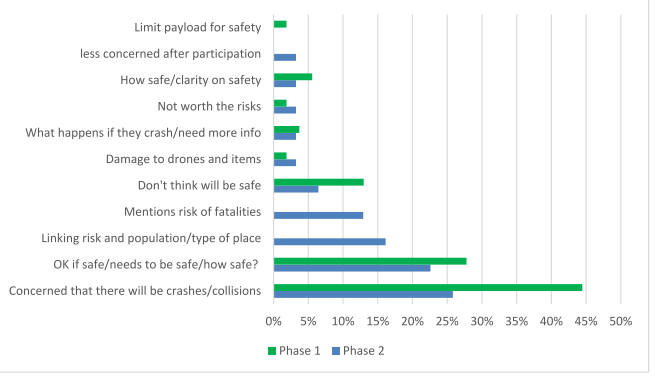


Fig. 9. Breakdown of comments about safety (drones).

Table 10
Additional information sought.

	Sought information		
	Phase 1 %	Phase 2 %	All %
Logistics drones	52	59	54
eVTOLs	74	60	63

4.2.4. *Value of additional materials*

Logistics drones and eVTOLs present different opportunities and issues. The inclusion of additional materials emerged from two separate, but linked projects and the materials evolved to address gaps in understanding and assumptions according to initial VR findings. Some specific assumptions were addressed, though assumptions around environmental benefits were inadvertently reinforced. The logistics drones and eVTOL additional materials also differed in content and design as there were opportunities to develop further materials for logistics drones. In addition, participants had far less awareness of eVTOLs prior to the VR experience compared to drones. It was therefore anticipated that the additional materials might have different impacts on the logistics drone and eVTOL findings. Fig. 10 summarises the impact of additional materials. Both videos sought to challenge emerging assumptions about the technologies reducing congestion and it was positive to see increased understanding of this, alongside some recognition that logistics drones may provide for limited delivery advantages. There can be commercial interests in allowing assumptions to persist, particularly when they lead to supportive views, enhance government support and funding. It is also disingenuous to allow assumptions to persist or even be reinforced. Previous analysis (Dickinson et al., 2024) has shown how medical use cases for logistics drones garner more support. Ultimately this has social justice implications as people are prepared to put up with disturbance, for example, from drone noise, for a perceived social benefit that may not be practical. In the meantime, less socially desirable use cases can emerge which differentially impact on some groups who have been misled.

The additional materials also focused participants' attention on operating parameters and safety, as people began to think more about how these might be managed. The focus on noise reduced, as participants were better able to understand how this might be addressed through operating parameters. There was also greater focus on environmental benefits as participants sought to clarify that there would be environmental benefits and, in some cases, expressed views that development should not proceed without this.

> "Would depend whether it is an environmentally friendly alternative to current deliveries. If so, I would be in favour, if not, then against".
> Initial comments – drones. Phase 1: Male, aged 35–44, country park.

Calls for more consultation increased in general with a desire to find out more from trials and use cases. Also, calls for drones and eVTOL to be used primarily to support medical and emergency use cases increased in phase 2, reflecting the influence of wider representations of drones in the media (Oakey and Smith, 2024), but also how AAM is not yet a reality. Participants were therefore able to step outside of the normative position which places value on individual choice when planning for transport (Mullen and Marsden 2016), instead they defined broader, society-centric expectations including caveating the requirement for any future deployment to be dependent on environmental benefits whether these had been assumed or questioned.

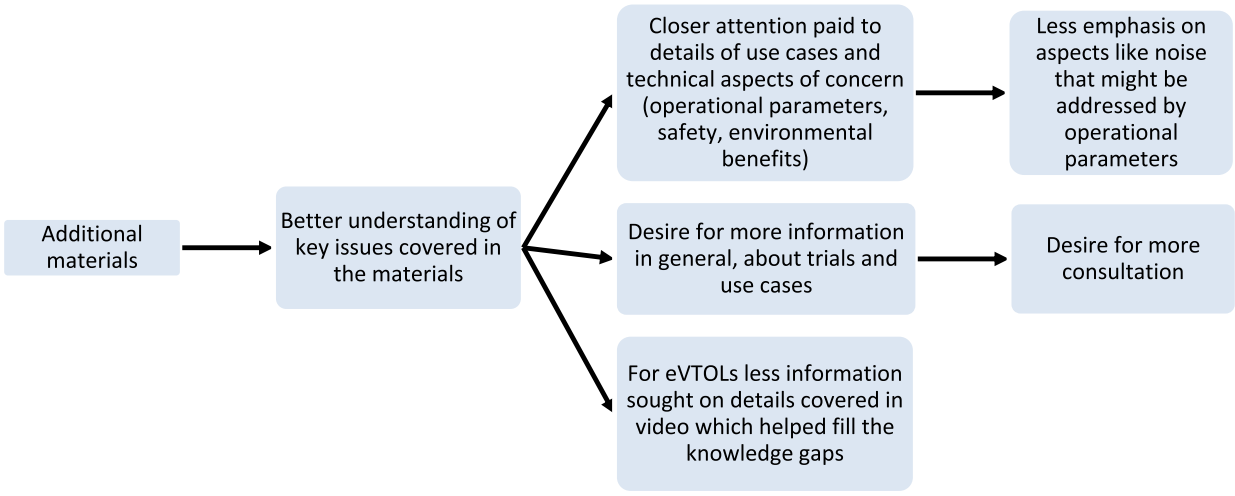


Fig. 10. How have additional materials changed things?

5. Conclusion

This paper has evaluated the effects of interventions to improve environmental and social justice in transportation systems in two respects. First, it analysed an approach that sought to reach a wider audience than typically achieved in transport consultations. Second, it explored how blended materials seeking to address emerging assumptions and misconceptions might improve participants' contribution to the debate around AAM provision if implemented in the future. When seeking to reach a wider audience, the location of activities is important knowing that different groups are present in different places and at different times. Advertising a transport consultation in a public building is likely to attract only the interested parties but approaches that take activities out into public spaces in different places and at different times will help reach more diverse groups. Some places offer quieter space for reflection than others, though places with good levels of footfall are vital. The format of the activity is also important, and it is useful to directly approach people and to offer incentives where feasible. A gazebo on the street gives people scope to size up the opportunity, observe others taking part and see others like themselves taking part, whereas a meeting in a Town Hall feels like it is for other people and may not be accessible to all (for example, people with young children). A range of tools and some novelty to the experience are also advantageous but generally not affordable or feasible, though the eVTOL recorded presentation demonstrates a cheap way of doing this.

The information presented is important. Ultimately this is in the context of wider narratives and care needs to be taken so materials do not reinforce misinformation. There is a need to help steer the narrative so that participants can reflect on available evidence. As eVTOL were new and few had heard of them, this was a chance to contribute to the wider narrative. The logistics drone narrative was more established, nevertheless materials helped people to question this.

The study reached a relatively large audience (n = 603 overall) with an immersive virtual reality experience. There were upfront costs associated with the materials and staff costs to deliver the activity. However, for AAM, VR is a cost-effective solution to involve people with this transport future that is largely yet to exist. The alternative is very costly trials with limited flying time in discrete locations that few people will get to see. The project materials are available for others to use and develop (e-drone VR).

Further research could usefully reflect on adapting materials for different needs and learning styles. Some people were unable to use the VR and an alternative video would have helped, though less immersive. There is scope for a longer-term study to analyse how an approach feeds into and shapes decision making. For example, can social justice be achieved in the implementation of AAM given decisions about use cases, infrastructure, flight paths and flight times are likely to differentially impact different groups? This study shows there is a desire to set environmental and social criteria for the introduction of AAM. The potential to achieve this is in question. Approaches that involve people can help to inform assessment criteria and policy but ultimately decisions can remain politically and economically motivated.

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CRediT authorship contribution statement

Angela Smith: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Janet E. Dickinson:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Taalia Nadeem:** Investigation, Formal analysis. **Ben Snow:** Software, Resources, Methodology. **Rama Permana:** Data curation. **Tom Cherrett:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Jason Drummond:** Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A:. eVTOL recorded presentation slides

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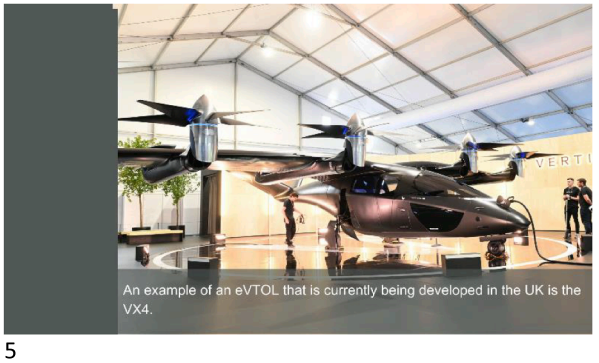

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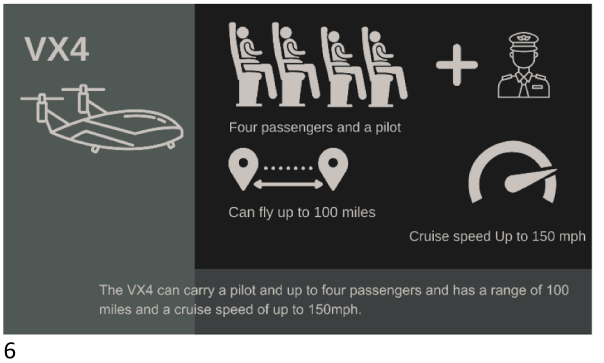

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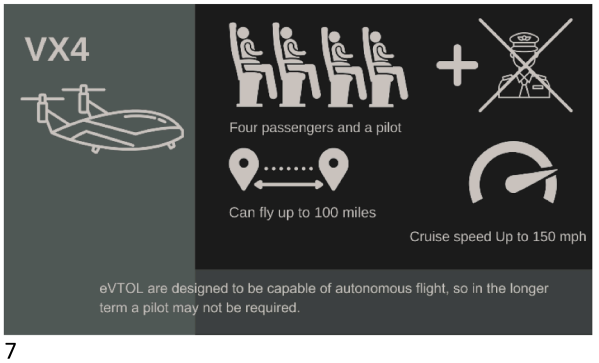

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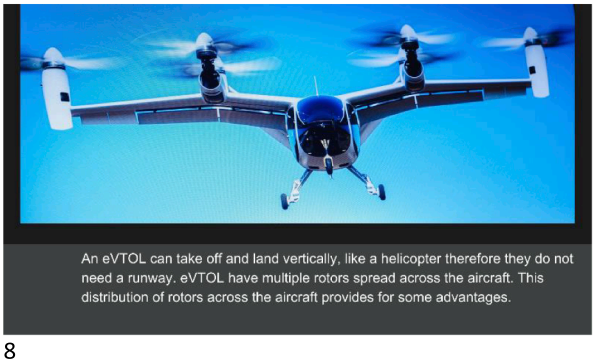

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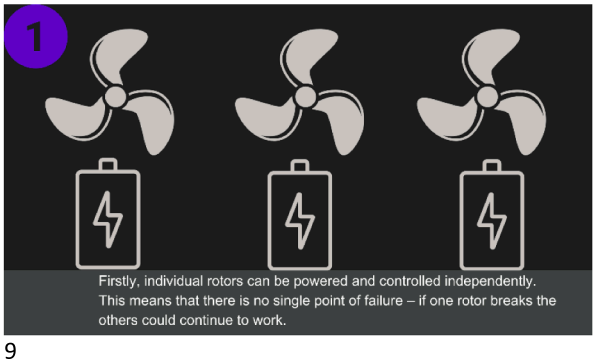

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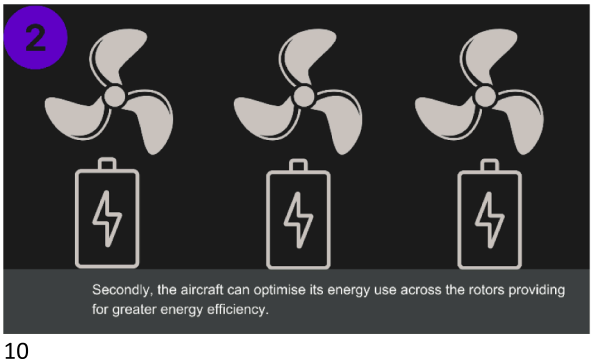

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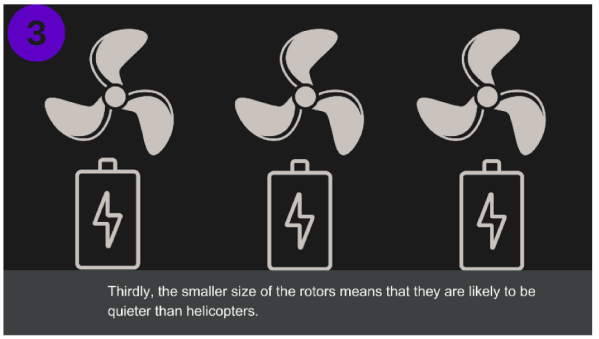

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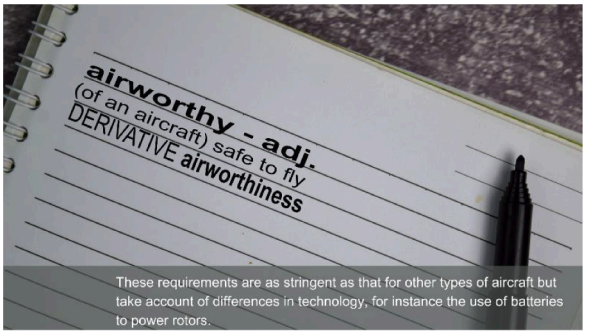

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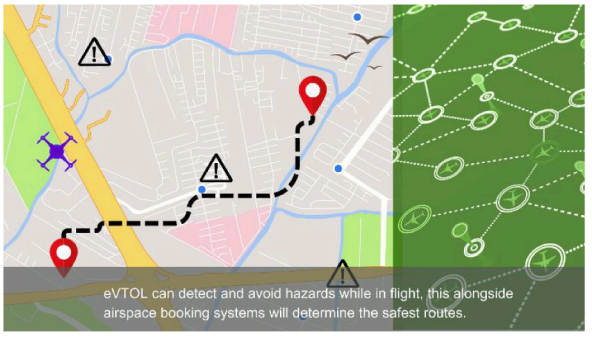

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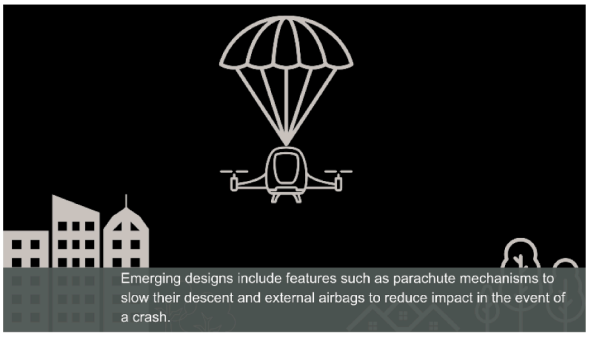

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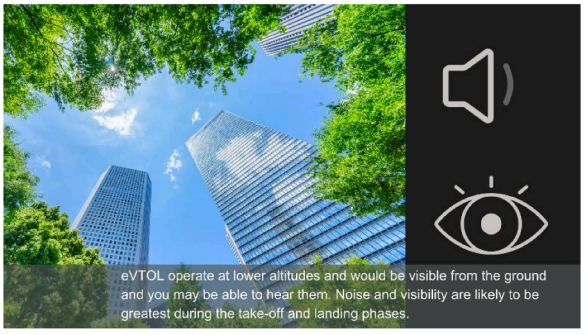

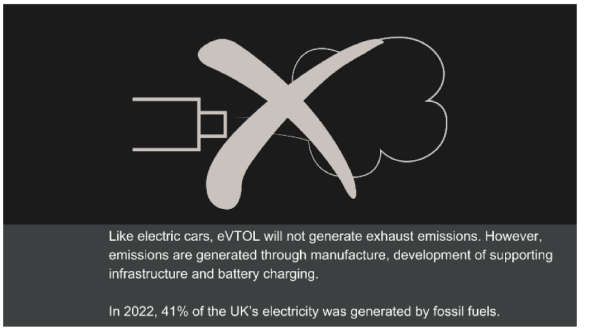

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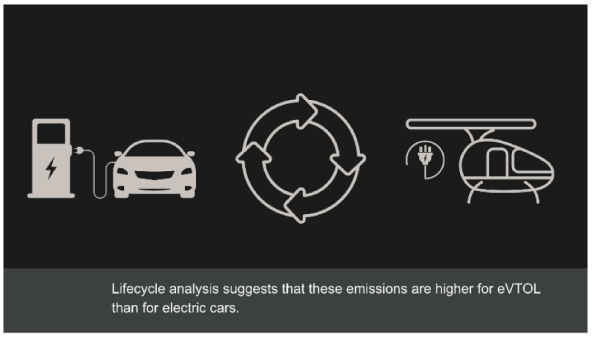

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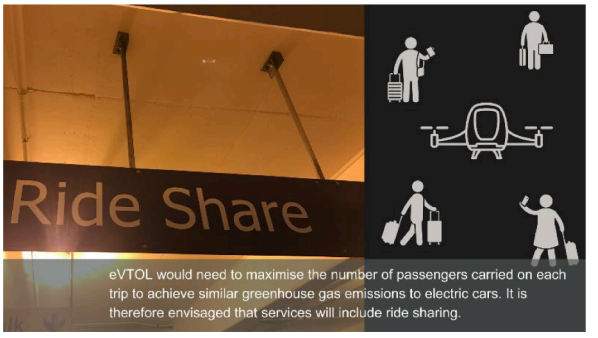

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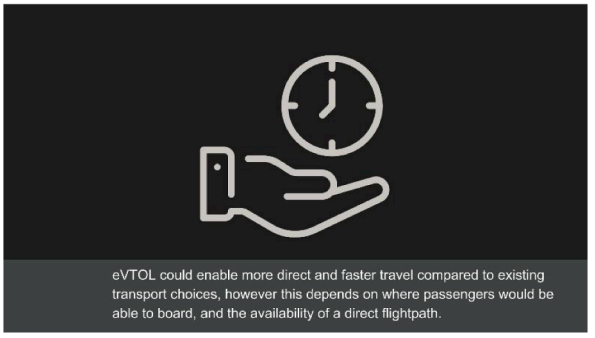

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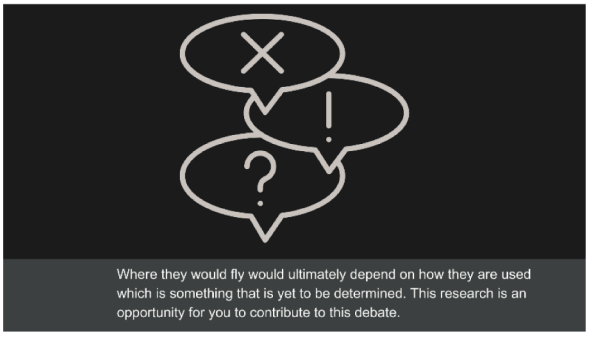

Appendix B:. Logistics drone questionnaire

Initial thoughts about delivery drones.

1) What are your initial comments on the use of drones for making deliveries?

Where should delivery drones fly?

Drones like those you have just seen in the Virtual Reality headset could be used in the future to make regular deliveries in the UK. Early-stage delivery services would operate along fixed flight paths using pre-determined landing sites.

2) Which settings do you think it would be appropriate for delivery drones to fly over?

Tick the frequency option you feel is most appropriate for each setting.

	No drones flying over	No more than four drone flights a day	A drone flying over every hour	A drone flying over every 30 min	A drone flying over every 15 min
Over an area of housing	☐	☐	☐	☐	☐
Over a town or city centre	☐	☐	☐	☐	☐
Over an industrial area	☐	☐	☐	☐	☐
Over an urban park	☐	☐	☐	☐	☐
Over an area of countryside used for recreation	☐	☐	☐	☐	☐
Over agricultural land	☐	☐	☐	☐	☐
Over my home	☐	☐	☐	☐	☐

Your thoughts on delivery drones:

The Government funded Future Flight Challenge is looking at how the use of drones for deliveries might become a reality in the UK over the next few years. We have provided an introduction to this idea and would like to get your views to help inform further research and future decision making.

3) How might delivery drones play a role in Coventry and the surrounding area? (Consider **who** might use delivery drones, the **items** that might be delivered and the **places** they might be delivered from and to).

4) What impacts might there be on Coventry and the surrounding area?

5) What feedback would you give to those responsible for developing regulation?

6) What additional information would you like to help you develop your viewpoint on this?

About you

7) How much, if anything would you say you know about drones? (Select one answer).

- Hadn't heard of them before now
- Hardly anything but I have heard of them
- A little
- A fair amount
- A lot
- Don't know

8) Have you ever personally used a drone? (Select as many as apply).

- Yes, used one personally
- Yes, used one for commercial or work-related reasons
- No

9) What is your gender?

10) What is your age group? (Select one answer)

- 18–24
- 25–34
- 35–44
- 45–54
- 55–64
- 65–74
- 75–84
- 85 and over

11) What is your ethnic group? (Select one answer)

1) White English/Welsh/Scottish/Northern Irish/British
2) White Irish
3) White Gypsy or Irish Traveller
4) White Any other White background, please describe
5) Mixed White and Black Caribbean
6) Mixed White and Black African
7) Mixed White and Asian
8) Any other Mixed/Multiple ethnic background
9) Asian or Asian British Indian
10) Asian or Asian British Pakistani
11) Asian or Asian British Bangladeshi
12) Chinese
13) Any other Asian background
14) Black African
15) Black Caribbean
16) Any other Black/African/Caribbean background
17) Arab
18) Other (please add details below)

12) What is your employment status? (Select as many as apply).

Employed full-time
Employed part-time
Self-employed full-time
Self-employed part-time
Looking after home/family
Unemployed
Permanently sick/disabled
Full-time student
Retired
Other

13) What is the highest level of education that you have completed? (Select one).

No formal qualifications
O-Level/ CSE/ GCSE
A-Level or equivalent
Higher National Diploma or equivalent
University degree or equivalent
Post-graduate qualification
Other

14) What is your home postcode?

Thank you! Please hand your completed survey to the researcher

Appendix C:. eVTOL questionnaire

Initial thoughts about eVTOLS?

1) What are your initial comments on the use of eVTOLs?

Where should eVTOLs fly?

eVTOLs like the one you have just seen in the Virtual Reality headset could be used in the future to transport people in the UK. Early-stage services would have a pilot, would operate in particular locations and use pre-determined landing sites.

2) Which settings do you think it would be appropriate for eVTOL to fly over?

Tick the frequency option you feel is most appropriate for each setting.

	No eVTOL flying over	No more than four eVTOL flights a day	An eVTOL flying over every hour	An eVTOL flying over every 30 min	An eVTOL flying over every 15 min
Over an area of housing	☐	☐	☐	☐	☐
Over a town or city centre	☐	☐	☐	☐	☐
Over an industrial area	☐	☐	☐	☐	☐
Over an urban park	☐	☐	☐	☐	☐
Over an area of countryside used for recreation	☐	☐	☐	☐	☐
Over agricultural land	☐	☐	☐	☐	☐
Over my home	☐	☐	☐	☐	☐

Your thoughts on eVTOL:

The Government funded Future Flight Challenge is looking at how the use of eVTOL might become a reality in the UK over the next few years. We have provided an introduction to this idea and would like to get your views to help inform further research and future decision making.

3) How might eVTOL play a role in Coventry and the surrounding area? (Consider **how** eVTOL might be used, **who** might use them and the **places** they might travel to and from).

4) What impacts might there be on the Coventry and the surrounding area?

5) What feedback would you give to those responsible for developing regulation?

6) What additional information would you like to help you develop your viewpoint on this?

About you

7) How much if anything would you say you know about eVTOL? (Select one answer).

Hadn't heard of them before now
Hardly anything but I have heard of them
A little
A fair amount
A lot
Don't know

8) What is your gender?

9) What is your age group? (Select one answer).

18–24
25–34
35–44
45–54
55–64
65–74
75–84
85 and over

10) What is your ethnic group? (Select one answer).

1) White English/Welsh/Scottish/Northern Irish/British
2) White Irish
3) White Gypsy or Irish Traveller
4) White Any other White background, please describe
5) Mixed White and Black Caribbean

(*continued on next page*)

(*continued*)

1) White English/Welsh/Scottish/Northern Irish/British
6) Mixed White and Black African
7) Mixed White and Asian
8) Any other Mixed/Multiple ethnic background
9) Asian or Asian British Indian
10) Asian or Asian British Pakistani
11) Asian or Asian British Bangladeshi
12) Chinese
13) Any other Asian background
14) Black African
15) Black Caribbean
16) Any other Black/African/Caribbean background
17) Arab
18) Other (please add details below)

11) What is your employment status? (Select as many as apply).

Employed full-time
Employed part-time
Self-employed full-time
Self-employed part-time
Looking after home/family
Unemployed
Permanently sick/disabled
Full-time student
Retired
Other

12) What is the highest level of education that you have completed? (Select one).

No formal qualifications
O-Level/ CSE/ GCSE
A-Level or equivalent
Higher National Diploma or equivalent
University degree or equivalent
Post-graduate qualification
Other

13) What is your home postcode?

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