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Improved convenience or a cyber security threat? Public acceptance of mobility-as-a-service in Great Britain

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ABSTRACT

This study examines public perceptions of **Mobility-as-a-Service (MaaS)**—an emerging transport model that integrates multiple services such as public transit, ridesharing, and cycling into a single, user-friendly digital platform, offering travellers a comprehensive multimodal transportation solution. While MaaS is gaining traction, it remains a relatively new concept, and public understanding and acceptance are still developing. To explore this, we conducted four online focus groups in January 2024 with 24 participants from both urban and rural areas across Great Britain, including London, Greater Manchester, rural Exeter, and rural Norwich. Using the **Technology Acceptance Model** as a framework, we investigated factors influencing willingness to adopt MaaS, including practical concerns and digital trust.

Our findings indicate that adoption is influenced by location, technological familiarity, cost, and socio-demographic factors such as age. Participants in rural areas questioned the feasibility of MaaS in their local contexts. While concerns about data privacy and cyber security were not initially raised, once prompted, they emerged as important factors shaping trust and adoption. Based on these findings, we recommend that MaaS providers prioritise data security, transparency, and effective communication to support broader adoption. Incorporating security features into the core service design is also essential for building user trust and encouraging wider acceptance.

1. Introduction

The transport sector stands as one of the largest contributors to greenhouse gas emissions, accounting for 26 % of the UK's total emissions in 2021 [1]. However, in recent years, the rapid advancement of information and communication technology (ICT) and digitalisation has introduced transformative opportunities within the transport sector, reshaping people's transport behaviour [2]. In this dynamic landscape, innovative business models have emerged, including Mobility-as-a-Service (MaaS). MaaS is a flexible, reliable, seamless, and integrated transport service, offering travellers a comprehensive multimodal transportation solution through a single platform [3–5]. By providing unified and integrated platforms that consolidate various modes of transport, MaaS simplifies access to different options. Therefore, MaaS has been proposed as an approach to decarbonising the transport sector [6].

However, the extent of its sustainability impact, whether significant or marginal, remains unclear [7]. A notable feature of MaaS is its

inclusion of car-based services, which are a critical component of a comprehensive transport system [6]. In the MaaS ecosystem, not only are public transport options (such as buses, trains, and trams) available, but private shared transport options are available [4]. Approximately 20 % of routes offered in MaaS trials implemented in cities such as Brussels and Edinburgh utilise carpooling options [8]. Moreover, the MaaS ecosystem provides opportunities for users to access electric vehicles, electric bikes, and scooters [9].

However, the MaaS ecosystem is still in its early stages of development, having been piloted in Sweden, Finland, Austria, Australia, UK, Germany France, US, Singapore and Canada [3,6,10–13]. Several cities and regions within the UK have experimented with the MaaS concept, including the, Southern region, West Midlands, Scotland, and Greater Manchester [10,12,14]. Notably, Birmingham and Scotland served as hubs for the Whim Trial developed and designed by Helsinki-based MaaS Global. While some scholars have explored public preferences for MaaS, willingness to adopt, and factors influencing adoption [2,14–18], there has been limited exploration of how trust-related

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concerns—particularly regarding data privacy and cyber security—influence public acceptance of MaaS, especially across different geographic contexts such as rural and urban areas. This paper addresses this gap by applying the Technology Acceptance Model (TAM) to examine public perceptions of MaaS and assess the role of cyber security risks in shaping acceptance.

Based on four focus groups conducted in urban and rural areas of the UK, the study identifies key factors influencing individuals' willingness to adopt MaaS, with a particular emphasis on digital trust and perceived security. Cyber security risks within the MaaS ecosystem stem from a range of sources, including malicious actors both internal and external to the system. These risks impact not only the digital infrastructure but also, socio-physical assets, such as individuals and physical infrastructure.

Decisions made by people and organisations play a critical role in generating and mitigating cyber security risks within this complex environment. Although previous research has examined privacy and security concerns, it has predominantly focused on system security and policymakers' perspectives [19–22]. This paper addresses the gap by exploring individual perspectives on how data privacy and security influence MaaS adoption. Additionally, it proposes potential solutions to enhance the development and adoption of MaaS systems. A key contribution of this paper lies in its consideration of cyber security alongside urban and rural contexts within the MaaS ecosystem. By addressing these often-overlooked dimensions, this study provides a more empirical understanding of the factors shaping MaaS adoption in urban and rural locations.

2. Theoretical background: Technology acceptance model

The Technology Acceptance Model (TAM) is a well-established framework for identifying the factors that influence an individual's acceptance of a particular technology [17]. Initially developed to understand user acceptance of information technology within organisations [19], TAM emphasises attitudinal factors as key drivers of adoption behaviour. Central to the model are two constructs proposed by Davis et al. [20]: perceived usefulness—the degree to which a user believes a technology will enhance their performance—and perceived ease of use—the extent to which they believe using the technology will be effortless. These constructs have consistently been shown to be the most influential drivers of adoption intentions and behaviour [17,21]. In the context of Mobility-as-a-Service (MaaS), which entails an integrated mobile application offering algorithm-based travel management, TAM is particularly applicable. MaaS qualifies as a new digital technology [22] where information technology plays a central role, making TAM an appropriate framework for examining user attitudes and adoption behaviour. By situating the study within TAM, this paper evaluates users' willingness to adopt MaaS by focusing on perceived ease of use and perceived usefulness, both of which are critical to understanding user preferences and behaviours [19,23] (Fig. 1).

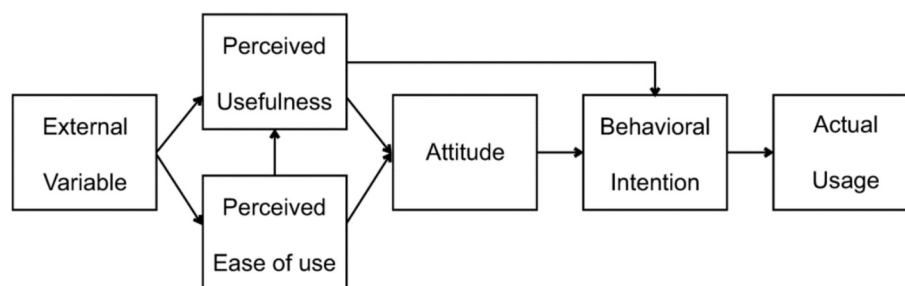


Fig. 1. Technology acceptance model.
Source: Davis et al. [20]

2.1. Broad applicability of TAM to digital technologies

The strength of TAM lies in its broad applicability to diverse technologies and contexts. It has been extensively validated across domains such as e-commerce [24], online learning [25], and internet banking [26]. This wide-ranging application demonstrates TAM's versatility in evaluating user behaviour in relation to digital systems. Applying TAM to MaaS not only builds on this legacy but also ensures that the analysis is grounded in a robust and widely accepted theoretical model.

In this paper, TAM provided a structured framework to systematically examine how perceptions of cyber security concerns influence user attitudes towards MaaS adoption. With data privacy and cyber security emerging as significant factors in the adoption of MaaS, TAM's focus on user perceptions allowed us to understand how these issues interact with broader attitudes towards usefulness and ease of use. This makes TAM particularly well-suited for analysing the interplay of technical and behavioural factors affecting MaaS adoption. TAM also facilitates categorising of attitudinal factors influencing MaaS adoption into three main classes: (i) mobile application, (ii) new mobility service, and (iii) mobility integration [17,27]. These dimensions reflect user perceptions of application functionality, the attractiveness of emerging mobility services, and the seamless integration of MaaS within existing transportation systems. By situating these factors within the TAM framework and incorporating empirical insights, this study provides a comprehensive understanding of user adoption.

3. Methodology

3.1. Focus groups: Rationale and recruitment

Focus groups serve as a significant research tool for eliciting detailed qualitative insights on emerging societal issues. For instance, they can shed light on consumer perspectives regarding innovative technologies within a social context [28,29]. According to Caporale et al. [30], the focus group methodology reveals participant opinions shaped by life experiences, expectations, and subject matter expertise.

Online focus groups gained prominence during the COVID-19 pandemic and continue to be a preferred approach for data collection because of their logistical efficiency and ability to facilitate diversity among participants [28]. Despite their limitations, such as potentially excluding those without digital access or literacy [31] and the challenge of reading body language compared to in-person settings [32], online focus groups were chosen for this study to ensure a broader geographical reach, reduce travel-related constraints, and enhance participant convenience.

To address the limitations of the online format, we designed each session to enhance engagement and maintain focus throughout the 120-min duration. Interactive elements, such as PowerPoint presentations, were incorporated to keep participants engaged. Additionally, we used Microsoft Teams as the virtual platform, allowing for easy screen sharing and supporting more dynamic discussions. Although non-verbal cues

were more limited in the online setting, the format allowed participants to join from familiar and comfortable environments, which may have encouraged more open and candid sharing.

In January 2024, we conducted four semi-structured online focus groups with a total of 24 participants residing in Great Britain. These focus groups were differentiated by key variables including traveller type and location, specifically urban versus rural settings, aiming to understand differences in perspectives among leisure travellers and commuters. Additionally, each group encompassed a variety of travel modes such as bus, train, car, and active transportation (see Table 1). We partnered with the Ipsos Transport & Infrastructure research team¹, a professional research organisation, to facilitate data collection through focus groups. Ipsos also managed the recruitment of participants for all four online focus groups. Attendance was as expected, with an average of six participants per session. To acknowledge their time and contributions, all participants were offered compensation for their participation.

3.2. Focus group materials

The research team developed the focus group topic guide to shape discussions while allowing flexibility for the moderator to explore noteworthy and emerging topics. This approach ensured that important themes were consistently addressed across all four focus groups. Each

Table 1
Focus group and recruitment sampling strategy.

Focus Group	Focus Group Category	Location	Demographic Feature
FG1	Commuters in urban city of London, reflecting diverse transportation mode.	London	Age range: 22–66 years Gender distribution: three male and three female Mixed ethnicity and socio-economic status.
FG2	Commuters based in rural Southwest of England, with diverse transportation modes.	Rural/semi-rural of Exeter	Age range: 23–63 years Gender distribution: three male and three female Mixed ethnicity and socio-economic status.
FG3	Leisure travellers based in an urban area of Northwest of England, with diverse transportation modes. 50 % of urban participants made multistage journeys.	Greater Manchester	Age range: 20–65 years Gender distribution: three male and three female Mixed ethnicity and socio-economic status.
FG4	Leisure travellers based in rural and semi-rural areas of East England, with diverse transportation modes. 50 % of rural participants made multistage journeys.	Rural /semi-rural of Norwich	Age range 26–72 Gender distribution: three male and three female Mixed ethnicity and socio-economic status.

Note. “Commuters” refer to individuals who travel daily for work, while “leisure travellers” denote those primarily traveling for entertainment, occasionally blending in work-related activities, particularly prevalent among those who predominantly work from home or engage in remote work.

session began with a brief introduction by the moderator, outlining the focus group’s purpose and project objectives, and participants provided their consent to be recorded. Each focus group session lasted approximately 120 min and adhered to a consistent structure centred around four core themes:

- Current modes of transportation,
- Public perceptions of MaaS,
- Privacy, safety, and trust,
- Cyber security (including hypothetical scenarios related to online security, phishing, and cyber threats)

More details on the format and structure of the focus groups can be found in the Appendix 1. MaaS, being a relatively new concept, was introduced to participants using a PowerPoint presentation (see Appendix 2), designed to educate and engage them. MaaS was defined as:

“A digital platform that integrates various forms of transport services into a single accessible platform. Through this platform, users can choose and pay for different types of transportation services, such as buses, bikes, or taxis, with the goal of making it easier to choose more sustainable transport options compared to using private cars”.

The concept of MaaS was introduced using slides and scenarios that describe both traditional commuting, such as a mix of walking and public transport and an enhanced commute through the MaaS platform, offering an integrated, technology-enabled experience. The presentation highlighted the benefits of MaaS, how it works, and its potential applications, providing participants with a clear understanding before discussing their views. To further explore participants’ perceptions and acceptance of MaaS, particularly regarding cyber security, two hypothetical scenarios were developed. These scenarios aimed to delve into specific concerns regarding online security, phishing, related to MaaS adoption.

3.3. Data analysis

Data were analysed using a thematic coding method. All focus group materials were transcribed, processed, and coded in NVivo 12, enabling the identification of nodes and sub-nodes. A bottom-up coding approach was selected to allow emergent themes to reflect participants’ unfiltered perspectives and experiences without imposing preconceived categories or biases. This approach provided richer insights into participants’ perceptions and contextual nuances, helping us understand how their experiences aligned with or diverged from the constructs of the TAM.

After the initial coding phase, similar or related codes were grouped into broader themes. Themes were iteratively refined to ensure they accurately reflected the underlying data. This process involved: i) Revisiting the raw data to ensure no significant insights were overlooked. ii) Naming and defining themes to clearly represent participants’ viewpoints. Once the themes were established, TAM constructs were introduced as a theoretical lens to interpret and organise the emergent themes. Themes were mapped to TAM constructs by identifying sub-dimensions such as simplicity and accessibility (for perceived ease of use) and efficiency and value-added benefits (for perceived usefulness). This systematic mapping ensured that participants’ perceptions were contextualised within a well-established theoretical framework.

While this method allowed for the emergence of novel insights, it inherently involved varying degrees of subjectivity when aligning the established codes with the conceptual framework. Although formal inter-coder reliability checks were not performed, potential bias was minimised through additional rounds of validation conducted by the lead author. These iterative reviews ensured that themes accurately reflected the raw data and were robustly aligned with TAM constructs. By combining an inductive, bottom-up coding approach with the deductive application of TAM and lead-author validation, this process facilitated the emergence of participant-driven insights while integrating findings within a theoretically sound framework.

4. Results

4.1. Current transport behaviours

In the initial phase of the focus group, participants discussed their current transportation methods, revealed distinct patterns between urban and rural attendees. Urban participants primarily relied on buses and the tube for commuting, while rural attendees utilised a mix of buses, walking, and private cars to meet their transportation needs. When it came to journey planning, most participants expressed a preference for using available applications, indicating a level of comfort with technology.

The preference for specific transport applications, such as City Mapper for urban attendees and Stagecoach or Trainline for rural participants, suggested that participants perceived these tools as easy to use and navigate. CityMapper, known for its comprehensive transit information and live timing updates, emerged as a favoured choice among urban attendees, particularly those based in or working in London. Similarly, rural participants favoured Stagecoach and Trainline applications for their journey planning needs. This comfort with using transportation applications contributed to overall satisfaction with the user experience.

Despite their preference for specific applications, participants occasionally relied on alternative platforms like Google Maps and the TfL website for journey planning. However, suburban and rural residents highlighted limitations in accessing services like City Mapper, indicating external factors that influenced the adoption of transportation applications. This underscored the importance of availability and accessibility in driving the adoption of transport-related technologies, with a notable emphasis on the use of travel planning tools, particularly for navigating unfamiliar routes.

4.2. Initial perceptions of MaaS

The following section presents the views and opinions of participants after they were introduced to the concepts of MaaS. This includes their initial perceptions of MaaS, their concerns, and their intention to use the service.

4.2.1. Perceived opportunities and benefits

This section outlines observations related to participants' perceptions of the perceived usefulness and ease of use of MaaS, aligned with the TAM (Table 2). The results indicated that user intention to use MaaS is largely driven by positive perceptions of its usefulness and ease of use, with convenience, time efficiency, cost savings, and sustainability emerging as significant factors encouraging adoption as a preferred mode of transportation.

Participants expressed enthusiasm for MaaS, appreciating its ability to effectively meet their transportation needs. They valued the customisable features that cater to individual preferences and highlighted the convenience of having all transportation services consolidated into a single app. This consolidation eliminates the need to navigate multiple platforms, which they described as inefficient, emphasising the importance of convenience and seamlessness in improving their experience.

In discussing the benefits of MaaS, participants noted the potential for improved time efficiency and cost savings (Table 2). The filtering feature of MaaS, which tailors services to user preferences, was seen as enhancing time efficiency by streamlining journey planning. Additionally, while some participants mentioned potential cost savings, there was uncertainty about whether significant cost reductions could be achieved. However, they believed that centralising information and

Table 2
Public perception regarding perceived benefits of MaaS.

Perceived Benefits	TAM variables	Illustrative Quotations
Convenience and seamlessness	Perceived ease of use	"Just using one app instead of having to open a Trainline, a First Bus app, all the rest of it, would be really, really convenient". "The main benefit is pure seamlessness. Right now, if I go to King's Cross, I use Trainline, then my debit card for the tube, then a separate app if I need a scooter to get to a meeting. With MaaS, that could all be integrated."
Time efficiency	Perceived ease of use	"I understand that the MaaS app would be a little bit more time-efficient because it's all filtered to the sort of service you'd like, but you're having to pay for that".
Cost savings	Perceived usefulness	"They've got more chance of saving people money if all the information's in one area, within the one body of people putting the information onto the app, there's no reason why it can't be just run on a daily basis at a cheaper cost".
Sustainability	Perceived usefulness	"There's the obvious sustainability benefits as well. So, you're talking about mobility rather than the journey itself. Do you know what I mean? You're talking about Mobility as a Service of getting from A to B, rather than booking a car or a train for example. [...] It's the obviously carbon benefits as well if it's directing you to the more sustainable mode of transport".

consolidating services on a single platform could help reduce costs and improve overall efficiency. These insights align with existing literature [32], which suggested that integrating all transport services into one platform can save time, reduce costs, and enhance overall travel experiences.

Another benefit highlighted by participants was MaaS's potential contribution to sustainability. They noted that its focus on providing efficient point-to-point transportation could promote more sustainable travel choices and reduce carbon emissions. This view aligns with existing literature [33,34], which suggests that MaaS can encourage sustainable travel behaviours and improve the transport system, although the extent of its impact remains uncertain [7].

4.2.2. Perceived disadvantages and risks

While MaaS holds promise for numerous advantages, participants expressed several concerns corresponding to elements of the TAM model, particularly regarding perceived usefulness, ease of use, and external factors impacting acceptance (Table 3).

A major reservation about MaaS was its viability and feasibility in rural areas. Participants from regions like Norwich and Exeter highlighted logistical challenges, such as difficulties in synchronising bus and train schedules, limited transportation options, and the need for coordination among different transportation companies. These concerns suggested that MaaS might be more suitable for urban areas such as Norwich, Ipswich, Cambridge, and London, where infrastructure could better support its implementation.

Participants voiced accessibility concerns related to the exclusion of certain demographics, such as the elderly, low-income groups, or individuals without digital devices or debit cards. For instance, older individuals or those without smartphones might face significant challenges in accessing MaaS services. There were also apprehensions about over-reliance on smartphones and digital platforms—participants questioned what would happen if the app malfunctioned or if a phone

Table 3
Public perception regarding the perceived reservations about MaaS.

Perceived Reservations	TAM variables	Illustrative Quotations
MaaS viability and feasibility, particularly in rural areas	Perceived ease of use	<i>"It's ideal for urban concentrations, bigger cities like Norwich, Ipswich, Cambridge, and London in particular. But I can't see this being much help to the rural population. And if it's something that's rolled out nationwide, how can you expect city dwellers to pay out more than those in rural areas".</i>
Exclusion of demographics without digital devices and lacking access to debit cards	Perceived fairness which is external factor	<i>"A lot of older people might not even have a smartphone, so that's a concern right away... It may be suitable for certain groups of people, certain ages, certain individuals, but I don't think it fits into a one-size-fits-all category."</i>
Reliability of digital devices and smart phones	Perceived ease of use	<i>"What if the app goes down or your phone battery dies? Is there a backup method where you can purchase a paper ticket using your debit card or cash directly on the mode of transport? Some people might prefer to use cash, and others don't even have debit cards".</i>
Fear of change or attachment to familiar routes	Perceived ease of use	<i>"I'm finding it quite complicated. One of the things about going to work the same route every day is that you just don't have to think about it. You can check your phone, read the paper, or do some work. With this, I'd be constantly switching around and thinking,</i>
Struggling to grasp the MaaS concept	Perceived usefulness	<i>"I don't like the name of it at all. It does remind me of mobility as in, like, restricted mobility or the Motability which is, I think, my grandad used to have one, like a disabled badge, and it just reminds me of that I think. I wouldn't think of mobility app and think, 'Oh, that's what it is".</i>
High cost of the service	Perceived usefulness	<i>"I think first of all, if there's a cost, I think it could alienate people who haven't got the money to pay for a service</i>
Data Privacy	Perceived risks which is external factor	<i>It's a positive, but it's the data I'm concerned about.</i>

battery died. Suggested solutions included alternative payment methods, such as paper tickets, and maintaining in-person assistance to ensure accessibility for all.

Some participants felt that MaaS could complicate their commute. For instance, a London-based participant preferred their familiar routine, valuing comfort and predictability over potential time savings. This highlights a general reluctance to shift from established habits to unfamiliar systems. Some participants also found it challenging to understand the concept of MaaS, given that it is still in the early stages of development. This uncertainty about its practicality led some to associate the term "Mobility-as-a-Service" with restricted mobility or disability services, which could hinder its adoption.

Cost concerns were frequently raised, with participants anticipating higher ticket prices due to the added features of MaaS. Affordability was a key factor influencing adoption, particularly for those with limited financial resources. One participant noted that introducing costs could exclude individuals who are unable to pay, highlighting the impact of socio-economic factors on MaaS acceptance. Data privacy also emerged as a significant concern, with participants expressing doubts about the security of their personal information—reflecting the perceived risks outlined in the TAM. Despite these concerns, some participants remained positive about MaaS, acknowledging its potential benefits while emphasising ongoing barriers related to viability, fairness, accessibility, and cost.

4.3. Intentions to use MaaS

Participants were asked to share their opinions about their willingness to use MaaS in the future after discussing its perceived benefits and reservations. The majority expressed neutrality towards adopting MaaS, indicating they were neither strongly positive nor negative about its uptake. However, a few participants expressed enthusiasm and positivity towards using MaaS. Additionally, several participants stated that while they were willing to use MaaS, they did not foresee using it on a day-to-day basis due to their familiarity with their current commuting routes. Nonetheless, they were open to using MaaS for seeking alternative routes when needed, suggesting its utility in such situations. Furthermore, some participants indicated that they would consider

using MaaS primarily for longer journeys, such as traveling to another city or navigating unfamiliar routes, rather than for daily commutes to work. They felt that the service is particularly well-suited for trips where they were less familiar with the routes. The findings suggest that participants were more likely to adopt MaaS when it demonstrably improves specific journeys [19]. This aligns with the TAM framework, which argues that an individual's intention to use technology is driven not only by their attitudes but also by their perceptions of its ease of use and overall usefulness [19].

However, some participants were unwilling to use MaaS due to concerns about sharing personal information. For them, the lack of clear personal benefit outweighed the potential convenience. While acknowledging its potential usefulness, they remained cautious about data privacy. Some noted they would only consider using MaaS if it were operated by well-known, trusted companies such as Uber or Google. This highlighted a key challenge: new services may struggle to gain user trust, which can act as a barrier to MaaS adoption.

4.4. Influence of data privacy on public perceptions of MaaS

After exploring consumer perceptions of MaaS, we asked participants about data privacy and safety concerns associated with such services. These concerns were not raised spontaneously but were mentioned explicitly after the topic was introduced by the researchers. The following key themes subsequently emerged: i) awareness of cyber security risks, ii) emphasis on using reputable applications, iii) discomfort and anxiety about sharing excessive personal information and the associated security risks, iv) concerns about marketing and targeted advertisements, and v) recognition of the positive potential of location tracking for enhancing public safety.

The majority of participants demonstrated awareness of cyber security and were familiar with key concerns related to using digital services like MaaS. They viewed MaaS as potentially offering practical tools to improve transportation efficiency and public safety. For example, the benefits of location tracking were recognised in terms of enabling better timetable adjustments and demand-responsive service improvements—indicating strong perceived usefulness. However, concerns about excessive data sharing and privacy risks tempered this optimism.

Table 4
Perceptions regarding personal information required for MaaS registration.

Perceptions of scenario 1	TAM variables	Illustrative Quotations
Concerns about data security and privacy	Negative impact on intention of use	"I'd be slightly concerned why they would need certain information and what they would be doing with that information."
Hassle of providing excessive personal information again during the registration process raises scepticism about its necessity.	Negative impact perceived ease of use and on intention of use	"I wouldn't expect it to be asking me those kinds of questions, because that's not really what I use it for. I wouldn't mind it asking me, but it's not what I would expect it to ask me, my household income and stuff like that". "I wouldn't have an issue with the questions. I think it's more about whether I'm bothered to fill out that much information. In terms of the questions being that personal and worrying, our network providers already have all that information anyway. They know all our accounts, what we do, where we go, who we see. They own that data. I know they already have it, so I'm not really worried about that". "If my card's involved, I need the two-factor authentication. As soon as it gets to the point of my card being involved, I need extra security."
Lack of two-factor authentication for banking details is off-putting	Perceived usefulness and intention to use	"I think they just need to be clear on why they're taking customer data and what it's going to be used for and not asking for an excessive amount of information about people".
Willing to share information if there is clear reasoning and transparency	Perceived usefulness	"With regards to the storage of data, as long as they are GDPR compliant then it doesn't bother me. At the same time,have enough data online through various apps and through anything, if anyone wanted to find it, they could find it".
Willing to provide requested information if MaaS complies with data regulations	Intention to use	"If a lot of people my age, if it was popular and loads of people were using it, I'd probably turn a blind eye to it. However, if I was at the forefront of it and I'd been using it before others perhaps had, I would say I would certainly be more sceptical".
Trust and familiarity increase willingness to share more information	Perceived ease of use	

Participants who were confident using online services, such as internet banking, generally found MaaS easy to use. In contrast, those with stronger concerns about data privacy and security perceived it as more complex, leading to lower perceived ease of use. Some acknowledged that data collection is a common feature of most digital platforms and avoiding it entirely would mean disconnecting from online life. Still, many emphasised the importance of using reputable applications to safeguard personal information and avoid phishing scams.

4.5. Perspectives of MaaS across cyber security scenarios

We developed two hypothetical scenarios of cyber security threats to explore perceptions and acceptance of MaaS in the context of these risks. The subsequent section examines public perception of MaaS in different scenarios from the perspective of the TAM framework.

4.5.1. MaaS registration process and personal information requirements

In the first scenario, the MaaS application required detailed personal information—such as date of birth, occupation, and travel patterns—during registration. Most participants found this off-putting, expressing discomfort, distrust, and concerns about data privacy and security (Table 4). They questioned the necessity of collecting such extensive information, highlighting risks such as data misuse, profit-driven motives, and vulnerability to hacking. Some suggested using simpler identifiers, like email addresses or phone numbers, to streamline registration and build trust. Concerns about the lack of two-factor authentication and other robust security features, particularly for transactions involving banking details, further reduced participants' willingness to use the app. A few stated they would uninstall the application if such requirements remained in place. One participant also mentioned that they would contact the developer, emphasising the value of user feedback in improving perceived usefulness and ease of use. Participants stressed the importance of trust and familiarity, noting they would be more willing to share information once the platform became widely used and endorsed by others. This aligns with the Technology Acceptance Model (TAM), which identifies trust and perceived ease of use as key drivers of adoption [33].

While some participants did not feel personally threatened by

sharing information, they were discouraged by the inconvenience of providing unnecessary details, suggesting that perceived complexity—rather than the sensitivity of the data—was the primary concern (Table 4). However, others expressed a willingness to share personal information if a clear rationale was provided and the data contributed to meaningful service improvements. This highlights a trade-off: users are more likely to share information when it leads to tangible benefits, provided their privacy is safeguarded.

Overall, this scenario highlights the importance of transparency, trust-building, and clear communication in MaaS design. Participants' responses suggest that the behavioural intention to use such applications depends heavily on whether privacy concerns are addressed effectively.

4.5.2. Perceptions in the context of phishing attacks

In the second scenario, which focused on online security and phishing attacks, participants raised concerns about the potential compromise of personal information and unauthorised transactions. Despite these risks, most felt confident in their ability to recognise phishing scams, crediting their awareness to prior experiences or workplace training. Many described proactive measures, such as verifying suspicious messages with providers, reporting scams through official channels (e.g., dialling "SCAM"), and avoiding email links in favour of navigating directly to trusted websites.

However, some participants acknowledged that not all users share this level of confidence. Concerns were expressed for more vulnerable groups—particularly older individuals or those less familiar with digital platforms—who may be more susceptible to phishing attempts. A few participants also admitted to limited digital literacy themselves, highlighting the need for stronger security features and targeted user education to ensure the safe and inclusive adoption of MaaS. Views also varied regarding accountability in the event of a phishing-related financial loss. While some accepted personal responsibility, others criticised perceived security shortcomings in MaaS platforms and stated they would delete suspicious emails or even unsubscribe from the service altogether (See Table 5). This divergence in attitudes underscores the critical role of trust and visible security measures in shaping public perception and willingness to adopt MaaS.

Table 5
Perceptions of MaaS in context of phishing attacks.

Perceptions in the context of phishing attacks	TAM variables	Illustrative quotations
Confidence in ability to recognise phishing scams	Perceived ease of use in implementing security measures	<i>"Well, I'd mainly go onto the app just to, sort of, see it. I understand that it might be identical and everything because that's what phishing emails are all about, but rather than going up to the app itself, if it does have a website, that's something that I'd need to do just to make sure that I can verify that information was correct. I'd just do that, to be honest".</i>
Not blaming MaaS provider	Trust and security (External factor),	<i>"I'd obviously feel really, really annoyed about it. I wouldn't hold anything against the MaaS provider. I'd just feel foolish myself, for clicking on it in the first place. So, yes, I wouldn't hold it against the provider anyway".</i>
Contacting MaaS provider to verify authenticity	Ease of use in implementing security measures	<i>"I wouldn't trust it straight away, if it's asking of personal information or my bank details, for instance. I would expect there to be, from the legitimate company, some sort of live chat where it's instant and you get an answer immediately. I would obviously contact them first and find out that it is in fact a scam".</i>
Readiness to handle the financial consequences	Behavioural intention	<i>"If it was a credit card, I'd ring the card provider and normally I think credit cards are good, aren't they, at refunding you when something like this happens. Or if it was a debit card, I'd ring the bank".</i>
Concern for vulnerable populations	Fairness (External factor)	<i>"It wouldn't be fair to people, especially the elderly, who might perceive this as a genuine request and then unwittingly hand over their bank details or other sensitive information".</i>
Unsubscribe from MaaS services due to perceived security shortcomings	Trust and security (External factor)	<i>"I would delete the email and cancel my subscription, and wait for them to come back to me and ask them why"</i>
Perceive phishing attempts as a significant threat due to their lack of awareness	Security and intention to use (External factor)	<i>"it's scary, isn't it, to think? Obviously, I'm not very tech-minded and up to date to things, so yes, it is a real, sort of, threat to me, just thinking obviously, 'I could be a target, quite easily a target as well. So yes, it would really bother me".</i>

4.6. Views on costs for ensuring secure operation of MaaS

We asked participants to share their perceptions of different payment options—or propose alternatives—for covering the costs of securing the MaaS platform from cyber security risks. Most expressed a strong preference for MaaS applications to be free of charge, with payment limited to the transport services used. This indicated that users see value in MaaS as a facilitator of mobility, rather than as a service worth paying for in itself.

The idea of paying separately for the platform or its security features was largely unappealing, with many viewing it as a barrier to adoption—especially among younger users with limited financial resources. The availability of free alternatives further reinforced this reluctance, as participants felt they would simply switch to other options if MaaS introduced additional costs.

Although participants strongly emphasised the need for robust cyber security, they expected it to be included as a basic feature—not something users should have to fund. The suggestion that users pay for additional protection led some to question the platform's overall trustworthiness. This highlights how expectations around security and pricing are closely tied to perceptions of trust and ease of use. To address these concerns, participants proposed alternative funding mechanisms, such as advertising, public funding through local authorities, or contributions from businesses benefiting from MaaS. These suggestions reflect an expectation that operators should explore broader, less user-dependent revenue models.

4.7. Perceptions of MaaS post-introduction of cyber security risks

Following the introduction of cyber security risks, participants were asked again to reflect on their views of MaaS. For many, their overall perceptions remained unchanged. However, when potential additional charges for ensuring data security were raised, several participants expressed stronger reservations about adoption. The idea of paying extra for privacy and protection reduced their willingness to engage with the service, suggesting that such charges may undermine trust in the platform. Some participants reiterated concerns that MaaS could function as a data-harvesting tool, especially if personal information was monetised or insufficiently protected. This reinforced earlier scepticism about the purpose and transparency of the platform. Despite these concerns, a number of participants remained open to using MaaS—particularly if it were free, operated by a trusted provider, and offered a streamlined user experience. Conversely, a smaller group highlighted the potential for MaaS to enhance cyber security by consolidating transport services into a single application. This, they argued, could reduce risks associated with managing multiple accounts and passwords. These contrasting perspectives reflect differing levels of digital confidence.

5. Discussion

This paper offers valuable insights into users' perceptions of MaaS through the lens of TAM, indicating that participants generally view MaaS as a promising concept—offering convenience, efficiency, cost savings, and sustainability benefits — which fosters a willingness and intention to adopt the service—aligns with existing literature [6,13,34]. While participants recognise these potential benefits, they also express concerns about data privacy. This concern subtly affects users' perceptions of MaaS's usefulness and becomes more prominent once introduced, suggesting that data privacy and security, though often a "silent factor," significantly influence adoption behaviours. This observation aligns with Heering et al. [35], who noted that data privacy concerns might not initially have a significant impact on MaaS adoption but could influence user trust over time.

This section highlights key themes emerging from the findings, including the interplay of privacy concerns, the roles of trust and affordability, and the impact of regional and socio-economic disparities.

5.1. Privacy concerns and the privacy paradox

According to TAM, perceived usefulness and perceived ease of use are pivotal to technology adoption; this study suggests that revealing potential extra fees for data security may challenge these perceptions, creating friction that dampens the adoption of MaaS. Interestingly, some participants proposed that MaaS operators offset cyber security costs by monetising anonymised data, introducing a paradoxical tension

between privacy concerns and financial incentives. This perspective reflects “privacy paradox” [36,37], where users express concerns about privacy but show a willingness to compromise if tangible benefits—like cost-free access to a service—are provided. Such a paradox challenges the notion of privacy as an absolute barrier to adoption, suggesting instead that privacy is a negotiable commodity when users perceive sufficient value in return. This reinforces the argument that MaaS providers must understand users’ privacy expectations and structure service offerings accordingly to maintain a balance between data protection and service affordability.

The concept of the privacy paradox emerges powerfully here, indicating that users’ decisions are not always aligned with their stated concerns. While users claim to value privacy, they may forego it when it conflicts with perceived benefits like affordability and convenience [36,37]. This contradiction underscores the complexity of human decision-making, revealing that MaaS adoption is not solely driven by privacy and security concerns but by a broader cost-benefit analysis that includes perceived value and ease of use.

5.2. The role of trust, cost, and perceived value

This study highlighted the critical role of **cost and affordability** as barriers to MaaS adoption, consistent with prior research [13] identifying financial factors as central to user decision-making. While participants recognised the platform’s potential benefits, many questioned its added value if it introduced separate charges for access or security. This raised concerns around inclusivity and equity, particularly for lower-income users—underscoring the socio-economic dimension of perceived usefulness within the TAM framework [19].

Trust in **reputable providers** was another decisive factor in adoption. Consistent with Huang [36], participants felt more confident using services from familiar operators, especially where data privacy was concerned. However, the idea of paying extra for cyber security was widely rejected. Users expected **security to be embedded** in the service—not treated as an add-on—suggesting that charging for basic protection may undermine both trust and perceived value. These findings point to a **critical interplay between trust, cost, and perceived benefit**. While trust facilitates initial interest, introducing additional costs—especially for essential features—can lower both perceived ease of use and usefulness. For MaaS to gain wider acceptance, providers may need to absorb or subsidise security costs to maintain user confidence and ensure equitable access.

5.3. Impact of demographic and socio-economic variation in MaaS adoption

This study highlights the significant influence of demographic and socio-economic factors on MaaS adoption, revealing disparities shaped by geography, income levels, and digital literacy. Regional variations were particularly pronounced, challenging existing studies that suggest geography has minimal impact on adoption [2]. Participants from rural areas (e.g., outskirts of Norwich, Exeter) expressed reservations about MaaS feasibility, reflecting an urban-centric focus in MaaS trials [42]. Barriers specific to rural regions included low population density, inadequate digital infrastructure, limited investment, low digital literacy, and weak connectivity [38,39]. These challenges highlight the need for tailored MaaS approaches that address the unique needs of rural populations.

Socio-economic disparities also emerged as critical adoption barriers. Lower-income groups were found to face specific challenges, including affordability issues and limited access to digital devices, consistent with prior literature [2,40,41]. Participants expressed concern that rural residents, in particular, might face higher financial burdens, potentially reinforcing existing transport inequities. These inequities often arise in areas where investments disproportionately benefit higher-income individuals who already have greater access to

transport and mobility options, rather than those with limited means or access [42,43]. These findings underscore the need for pricing models that ensure inclusivity and accessibility for underrepresented groups.

Demographics further shaped adoption patterns. Younger, tech-savvy individuals demonstrated greater openness to MaaS, consistent with literature noting higher adoption rates among this demographic [44]. Familiarity with digital services, such as banking apps, was a key enabler, underscoring the role of user experience in driving adoption. Conversely, older individuals or those lacking digital access potentially will face greater barriers, aligned with studies that highlight lower adoption rates among these groups [39,45,46]. These findings illustrate the interplay of demographic and socio-economic factors with regional characteristics, suggesting that a one-size-fits-all approach to MaaS may be ineffective. Instead, providers must develop tailored strategies that address geographic, economic, and demographic disparities to ensure widespread adoption. For example, trials that include multiple access points, such as those implemented in Helsinki [47], offer promising solutions for addressing digital access and inclusivity challenges.

5.4. Consideration of cyber security in MaaS adoption

Despite a general sense of neutrality, participants expressed a spectrum of attitudes towards MaaS, with concerns around privacy, trust, and affordability emerging as key barriers to adoption. The study confirmed that adoption is influenced not just by functionality, but also by personal circumstances, regional infrastructure, digital literacy, and perceived fairness.

Familiarity with commuting routines, trust in service providers, and cost sensitivity were especially influential highlighting the need for MaaS models that are simple, transparent, and inclusive. For providers, this means ensuring strong data protection practices, affordability, and clear communication to meet diverse user expectations.

Low awareness of MaaS among some participants—especially those who misidentified it as a service for people with mobility issues—points to the importance of targeted public engagement and education. In addition, affordability and limited access to digital devices were highlighted as barriers for lower-income groups, echoing existing research [2,4,42,43,46].

6. Conclusions and recommendations

In conclusion, this paper presented our findings on public perceptions towards MaaS in both urban and rural settings, with a focus on diverse cyber security risks. Our research, viewed through the lens of the TAM, suggests that various factors, including residents’ location, familiarity with commuting routes, individual characteristics, costs, technological proficiency, and socio-demographic factors like age, are pivotal in shaping willingness to adopt MaaS.

Moreover, our study highlighted the critical importance of data security, transparency, and effective communication in cultivating trust and confidence among potential MaaS users. This perception underscored the significance of safeguarding personal information in MaaS services, influencing users’ perception of its usefulness. However, the shift of attention to data privacy and security once it is brought up indicated that it is a silent factor affecting the adoption of MaaS compared to other factors. Participants emphasised the necessity of implementing robust security measures and proactive strategies to address cyber threats effectively, thereby ensuring the success and sustainability of MaaS services. We propose the following strategies to improve the data security of MaaS applications, with practical suggestions from the focus groups shaping recommendations 1–5:

1. Implementing multi-factor authentication for secure login.
2. Incorporating established payment providers (e.g., PayPal or Apple Pay alternatives) to enhance transaction security.

3. Providing clear and transparent explanations of why specific information is requested during registration.
4. Ensuring all communications occur within the application itself, reducing reliance on external emails.
5. Offering written guidelines on scam prevention to inform users about potential risks.

Additionally, based on our analysis, we recommend that local government or public providers, such as Transport for London, lead a digital literacy campaign to support MaaS users with diverse levels of digital familiarity, fostering inclusivity and safe adoption across all demographics. These security risk mitigation strategies, suggested by participants and aligned with TAM principles, aim to increase trust and acceptance of the application among users. By implementing these recommendations, MaaS providers can boost confidence among users and foster wider adoption of their services.

Furthermore, for the nationwide implementation of MaaS, we recommend that policymakers provide the necessary digital infrastructure and increase digital connectivity in rural areas. This can be successfully achieved through collaboration among various stakeholders, including transport providers, local authorities, and telecommunication companies. Additionally, we recommend implementing technological education campaigns to improve technological literacy and accessibility among the older generation and rural areas, as they are essential for promoting widespread and equitable adoption of MaaS. Digital literacy can foster trust in MaaS platforms, thereby increasing public adaptation and effectiveness. Literature indicates trust and familiarity with digital platforms significantly impact users' willingness to share information and engage with the service [48,49].

In order to increase the adoption of MaaS and better cater to user needs, services should also be tailored to specific journey types, such as long-distance or non-routine trips. This customisation can help address the diverse preferences of users.

CRedit authorship contribution statement

Pegah Mirzania: Conceptualisation, Methodology, Data curation, Visualisation, Writing – original draft, Writing – review & editing, Conceptual Framework, Data Analysis. **Nazmiye Balta-Ozkan:** Investigation, Conceptualisation, Project administration, Funding acquisition, Writing – review & editing. **Lorraine Whitmarsh:** Writing – review & editing, Validation.

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.

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Appendix 1. Focus group structure and discussion guide

Theme	Key Research Questions
Type of current Transport	<ul style="list-style-type: none"> - What is your current type of transport? - How do you currently plan your journeys? - Is this different for familiar/unfamiliar journeys?
Public perception towards MaaS	<ul style="list-style-type: none"> - Do you find journey planning easy or difficult right now? Why? - What are your initial thoughts and first impressions about MaaS? - How likely would you be to uptake/ adopt such a service? Why? - What, if any, concerns or reservations might you have about using MaaS?
Privacy safety and trust (Cyber security)	<ul style="list-style-type: none"> - What are the benefits and disadvantages of using MaaS in your opinion? - What potential online dangers or security issues might be associated with MaaS? - Have you or someone you know ever had issues with data security and privacy when using other online platforms or apps?
Hypothetical scenario related subscriptions and user concerns about the registration process of MaaS	<ul style="list-style-type: none"> - Do you think MaaS companies should take to safeguard your personal data and make sure it's secure online? - How would you initially feel when you notice that the MaaS website/app doesn't have enough steps to verify the accuracy of your personal information? - What alternative approaches could the MaaS provider take to ensure the accuracy of personal information without overwhelming users with too many steps?
Hypothetical scenario related online security and phishing attacks	<ul style="list-style-type: none"> - Considering this registration experience, how might it influence your overall perception of the MaaS platform? - How would this experience impact your trust in the MaaS provider? - How would you initially react upon receiving an email that looks like it's from your MaaS provider, asking for personal information? - How would you feel and what steps would you take upon receiving official confirmation from both the news and the MaaS provider that this email was indeed a scam?
Hypothetical scenario related to a cyber-attack on the trusted MaaS provider	<ul style="list-style-type: none"> - In the scenario where criminals make unauthorised transactions using your compromised information, how would you handle the financial repercussions? - How much does a cyber-attack on a service provider influence your trust in their security measures? - What actions would you expect from the company to regain your trust after such an incident? - To what extent do you feel reassured or not if a company claims that your personal information hasn't been compromised, even after a significant cyber breach? - Would you continue using the services of a company that suffered a cyber-attack, knowing your personal data is safe but their financial and intellectual property was compromised?
Costing and Governance of MaaS	<ul style="list-style-type: none"> - What are your thoughts on who provides the service? - What price, if any, would you expect to pay for a MaaS service? - How would you expect the pricing to be structured? - What about making payments for the service?

Appendix 2. PowerPoints shown to participants

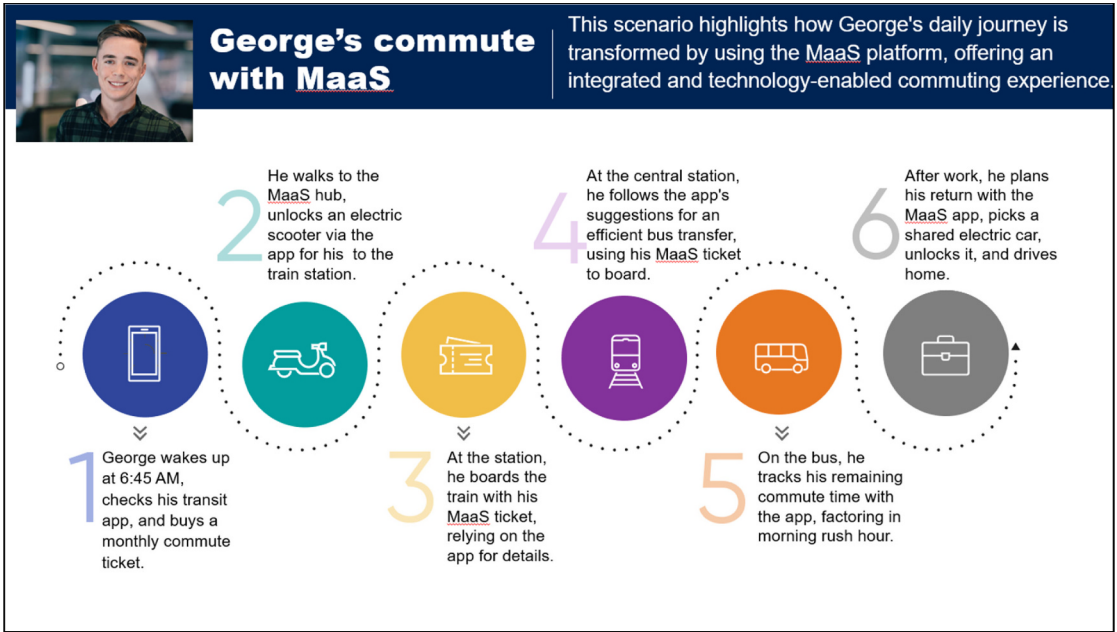
Mobility as a Service



- A digital platform that integrates various forms of transport services into a single accessible platform.
- You use an app to choose and pay for different types of transportation services, like buses, bikes, or taxis. The goal is to make getting around easier and more sustainable than using your own car.

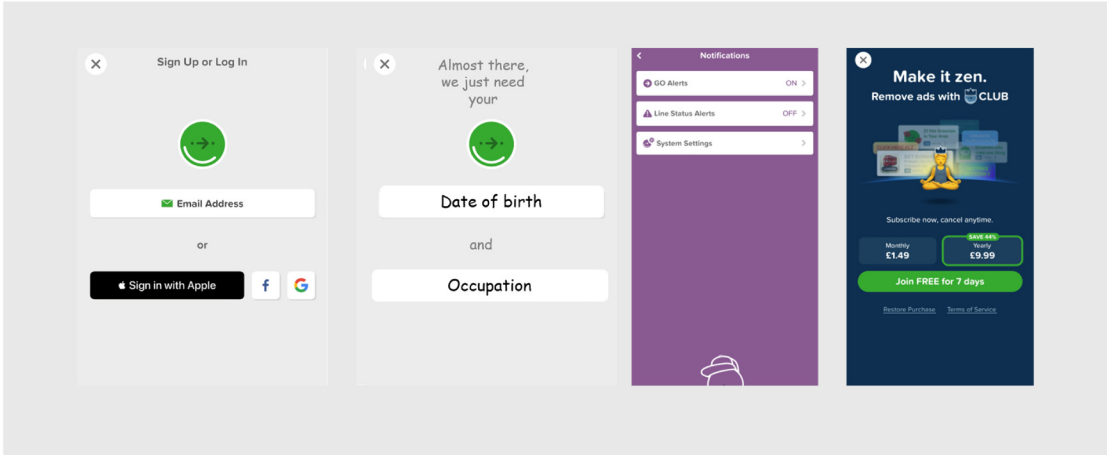
Definition of Mass.





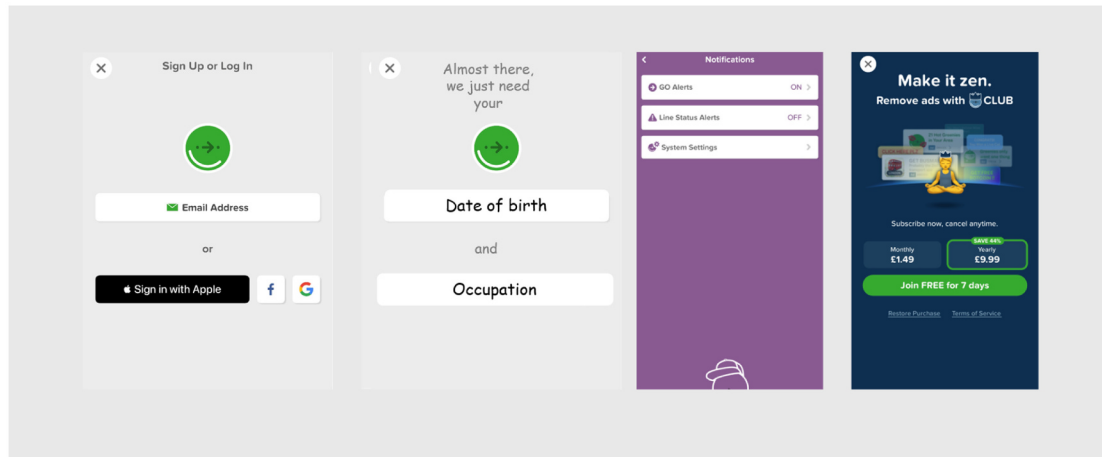
Travel routine with MaaS.

Imagine you have decided to get a MaaS subscription, but during the online registration, you notice that the website/app lacks sufficient steps to ensure the accuracy of your personal information. Additionally, you observe that the platform requests an extensive amount of personal information about you and your travel patterns.



Scenario 1:

Imagine you have decided to get a MaaS subscription, but during the online registration, you notice that the website/app lacks sufficient steps to ensure the accuracy of your personal information. Additionally, you observe that the platform requests an extensive amount of personal information about you and your travel patterns.



Scenario 2:

You come across breaking news reporting a cyber-attack on your trusted MaaS provider. The news reveals that the company's financial records and confidential information have been accessed and leaked by cyber criminals. However, the company has assured all its customers, including you, that your personal information hasn't been compromised. They've pledged to identify and take legal action against those responsible for the attack.



Scenario 3:

Data availability

Data underlying this study can be accessed through the Cranfield University Online Research Data (CORD) Repository at <https://doi.org/10.57996/cran.ceres-2690>.

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