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# Driving and navigation habits of Austrian drivers

Fanni Vörös [a,*], Georg Gartner [b], Béla Kovács [a]

[a] ELTE Eötvös Loránd University, Inst. of Cartography and Geoinformatics, Budapest, Hungary, vorosfanni@map.elte.hu, climbela@map.elte.hu
[b] Technical University Vienna, Research Division Cartography, Department of Geodesy and Geoinformation, Vienna, Austria, georg.gartner@tuwien.ac.at, ORCID https://orcid.org/0000-0003-2002-5339

* Corresponding author

**Abstract**: A proper navigation experience is essential while driving. A navigation device has not only to provide the driver with the right amount of information to find the ideal route (shortest, most spectacular, fastest), but also has to make driving safer. Since the driver looks at the user interface of navigation devices only for a few seconds, it is essential that the appropriate amount of information is in the right place. There are many options for drivers to navigate with: mobile phone app, PDA (Personal Digital Assistant)/PNA (Portable Navigation Assistant) or a built-in GPS Navigation System. The presented research examined the driving and navigation habits of 116 Austrian drivers by considering the differences between the devices they use.

**Keywords:** Car navigation, Location-based services, User experience

## 1. Introduction

While navigating in an environment, people are capable of learning the environment's spatial configuration – mainly when they use maps (Münzer *et al.*, 2006). Using maps for wayfinding requires elaborate cognitive processing of spatial information. This processing presumably involves mental rotation to align the current view of the map with the environment. During wayfinding, people make decisions about (route) planning to find correlations between the starting and ending point of a route. While moving, they pay attention by referring to objects of the environment and comparing them with the mental visualisation for confirmation (Gartner and Hiller, 2009).

Lately, people often used (paper) maps for navigation; nowadays, mostly navigation assistance systems are favoured. Systems are available for pedestrian navigation, bike navigation and other scenarios. The primary concern of the authors' research is the use of navigation assistance systems in cars, which can include mobile phone apps, PDAs (Personal Digital Assistant)/PNAs (Portable Navigation Assistant), or a in-built GPS Navigation System (Baus, Kray and Krüger, 2001; Wasinger, Stahl and Klüger, 2003; Krüger, Aslan and Zimmer, 2004; Baus, Cheverst and Kray, 2005). Navigation assistance systems indicate the proper direction from the user's current position and perspective – the requirement for cognitive spatial processing is minimised for the user. Particularly during 'car usage', these systems are adequate to make driving safer (Münzer *et al.*, 2006). For the safest possible driving, the driver only looks at the display for a few moments. To achieve this security, it is very important to select both the "external" and "internal" features of the assistant. The former means, for example, placement, physical appearance (functions), while the latter means the database itself. If the device is not suitable, either the driver will spend a long time handling it or will not use it at all.

Several navigation assistance systems on the market are "free" (users do not buy the navigation function itself, but a device that they use for something else, but it also includes the navigation function – e.g. Google Maps). In contrast, it is also possible to purchase a "stand-alone" navigation device (PDA/PNA, other mobile phone applications). From these, the most significant investment (temporal, monetary) for the everyday users is the in-built car GPS. It is exactly because of this investment why it is necessary to examine these devices and whether the users are satisfied with the navigation device'.

In the survey, the authors wanted to get information from the drivers to understand and interpret their driving and navigation habits, to understand what characteristics should be implemented into a new generation navigation device. They were asked about the following:

- How Austrian chauffeurs drive in different life (and driving) situations;
- What they use for navigation during driving (in different situations);
- How (professionally) they use the cars' in-built navigation system and interface.

## 2. Literature overview

Only a few studies are available on this specific issue of examining how the in-built car navigation systems are used. NNG, a Hungarian-founded company, which developed the iGO Navigation Engine, prepared a questionnaire with 153 questions in 2011 (Varga, 2011). TomTom navigation users were asked by Al Mahmud, Mubin and Shahid (2009). However, due to the complexity of the topic, the literature available from the components (spatial orientation, map reading skills, navigation

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interface issues and user experiences) goes back for several decades.

### 2.1 Spatial knowledge

Ortag (2005) investigated the differences in the spatial acquisition of knowledge with verbal orders and mobile maps during driving. Münzer *et al.*, 2006 compared three electronic navigation systems with paper maps and found that although navigation system users have poor survey knowledge, they have good route knowledge. Gartner and Hiller (2009) examined different display-sized maps and evinced that the size has an effect on spatial acquisition of knowledge during navigation. The 'Wizard of Oz' prototyping (which is a design methodology used to improve user experience (UX)) was used in the research, e.g. no GPS was used. Ishikawa *et al.* (2008) have already included map-based GPS navigation systems in their research (in addition to paper maps and direct travel experience) to compare spatial knowledge acquisition with it.

### 2.2 Location-based services

Location-based services (LBS) are computer (especially mobile) applications that give information depending on the location and context of the user (and device) (Raper *et al.*, 2007, Brimicombe and Chao, 2009). According to Raper *et al.* (2007b), the largest groups of LBS applications (including driver assistance, passenger information and vehicle management) are the mobile (car or pedestrian) navigation systems. These systems are created and designed to help people during wayfinding activities in different environments (Huang *et al.*, 2018).

#### 2.2.1 *Display problems*

This location-based information can be forwarded to the users as an overview map or as turn-by-turn instructions. The problem with overview maps is the visualisation – it is difficult on a limited-sized screen (Gartner, 2003). Giannopoulos *et al.* (2014) state that only good wayfinding instructions reduce uncertainty; otherwise, the cognitive load will increase. Fabrikant and Goldsberry (2005) highlight that bottom-up and top-down mechanisms drive human visual attention. According to Boucheix and Lowe (2010), unexperienced users process animation displays based on perceptual salience and not thematic relevance. In previous research, users could detect a maximum of four moving objects simultaneously (Ware, 2013). These 'Geographic Information Displays' (GID) can be examined from a) GIScience, b) cartographic, and c) cognitive science perspective (Thrash *et al.*, 2019).

a) From this perspective, the main challenge is the 'context' (information for a person, place or object characterisation) – modelling, inference, management and adaptation (Dey, 2001). According to Griffin *et al.* (2017), if people get more information about the environment (e.g. spatial and task contexts often alter during navigation), their behaviour will change – technical systems should solve this challenge.

b) Graphic elements (represented by the display) should change according to a lot of visual variables to help the user's understanding (Bertin *et al.*, 1983, Roth, 2016). The more sophisticated the visualisations are, the better the performance of navigation-related tasks is. New features were developed to this end – e.g. to-be-walked routes at multiple scales in contemporaneous representation. This reduced the demand to zoom in and out in order to orient (Delikostidis, Van Elzakker and Kraak, 2016). It was also shown that the extent of a visualisation task's performance depends on expertise (Scaife and Rogers, 1996; Hegarty *et al.*, 2009; Maggi *et al.*, 2016) and emotional context (Gardony *et al.*, 2011).

c) GIDs should support the user's mental representation of the diversity of spatial relations that can be applied during navigation (Thrash *et al.*, 2019). For navigation, a translation of spatial information from a reference frame to another is needed (Thorndyke and Hayes-Roth, 1982). GIDs can facilitate this transition by assuring a track-up map that improves navigation efficiency (Münzer, Zimmer and Baus, 2012). Since GIDs give instructions along the way, these decrease the decision-making process of the user (Bakdash, Linkenauger and Itt, 2008; Chung, Pagnini and Langer, 2016), or rather deprive visual attention of the environment – space is experienced less directly by users (Gardony *et al.*, 2013; Gardony, Brunyé and Taylor, 2015).

### 2.3 User experience

The phrase "user experience" is associated with an extensive meaning (Forlizzi and Battarbee, 2004). According to Alben (1996), "experience" means the aspects of the way how people use interactive products: the feeling of possessing, feeling while they are using it, the understanding how it works, how well it serves their purposes and how well it fits into the entire context in which they are using it. UX is a consequence of a user's internal state (expectations, needs, motivation, mood, etc.), the characteristics of the designed system (includes all products, services, and infrastructures that are involved in the interaction when using the examined product) and the context (or the environment) within which the interaction occurs (Hassenzahl and Tractinsky, 2006; Roto, 2006). UX is subjective: the system perception is affected by the user's state, which affects the experience and the user's state. In-vehicle GPS navigation systems have the potential of affecting the interaction of users with their environment in profound and complex ways. The use of GPS units changes how people interpret, learn, navigate, and experience spaces and places according to empirical and theoretical analyses. Navigation using GPS is based on abstract representations of spaces and places (Leshed *et al.*, 2008).

## 3. The questionnaire

In order to answer the questions mentioned in the introduction, a questionnaire was created. This helped us to examine how Austrian drivers drive, how they navigate in certain life situations, and how practically they use the in-built GPS during driving their car. Due to the Covid


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pandemic, an online questionnaire was an obvious choice so that many people could complete the questionnaire safely. In other life situations, the questionnaire would have been completed in person – either by personally supervising the drivers while driving or analysing their behaviour based on camera recordings (e.g., eye movement tracking). Google Form was used, which is a familiar interface for most people, and it is easy to manage from both the creator's and the user's perspective. Altogether, 50 questions were formulated on three topics (Figure 1), which can be found on https://mercator.elte.hu/~vorosfanni/navigation.html.

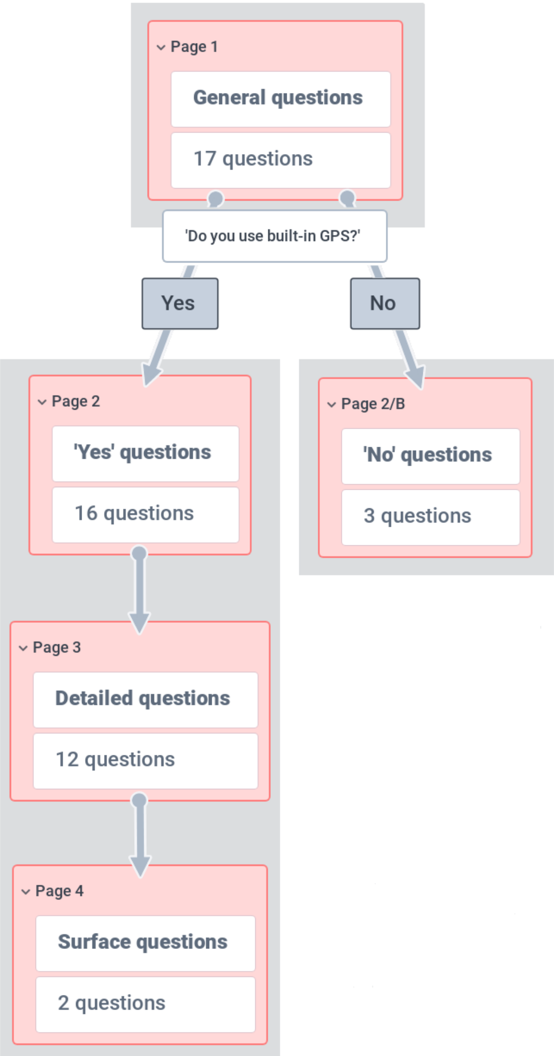


Figure 1. Structure of the online questionnaire. Three topics marked in grey.

On page 1, 17 questions were asked – these are general questions about the participant. The only limitation to fill it in was to be a driver. General vehicle usage questions and opinions on autonomous cars were also asked. The last two points asked if they have an in-built GPS and if they use it. At this point, the questionnaire was divided into two parts. First, if the respondent has GPS but does not use it or does not have GPS, three additional questions had to be answered before submitting their answers (page 2/B). Second, those who have and use GPS are directed to another page (pages 2–4). On page 2, general in-built navigation system usage habits were asked – similar but more detailed questions were found on page 3. Everyone who has got this far has already answered 45 questions. There were two more complex questions on the last page, so – since we did not want someone to leave the questionnaire early – they had to be filled out voluntarily. Most people completed all the pages. This paper gives a comprehensive picture of the results without presenting the questions and answers.

## 4. Results

### 4.1 General questions

The questionnaire was available from October to November 2020. During this time, 116 participants completed it. The following statements were made based on the responses of these respondents. The male-to-female ratio of the respondents was three to two. Half of them live in the capital city (Vienna), a quarter in villages, others in provincial capitals or towns. Younger people (age group 18–45) are dominant with 70%. One third has his/her own car, one third bought second-hand car, other third uses someone else's car (e.g. parents'). The average age of the participant's cars is 8.3 years, which is three years younger than the EU's average (ACEA Report, 2019). 94% drive less than 20,000 kilometres a year. Several questions asked how often drivers meet certain driving situations and how drivers behave in them. The given driving situations are listed in Table 1.

| Situations | Driving environment |
|---|---|
| 1 | Everyday routes within the city (e.g. workplace) |
| 2 | Everyday routes between cities (e.g. commuting to work) |
| 3 | Other routes within the city |
| 4 | Other routes between cities |
| 5 | Weekend trips |
| 6 | Domestic holidays |
| 7 | Holidays abroad |
| 8 | Other abroad trips |

Table 1. Numbers indicating the driving situations.

Driving frequency according to Table 1 is shown in Figure 2. "Never" travel has the smallest percentage in cases 4 to 6 – this means that these drivers go very often on holidays (both weekend trips and domestic). In contrast, they go abroad significantly less often.

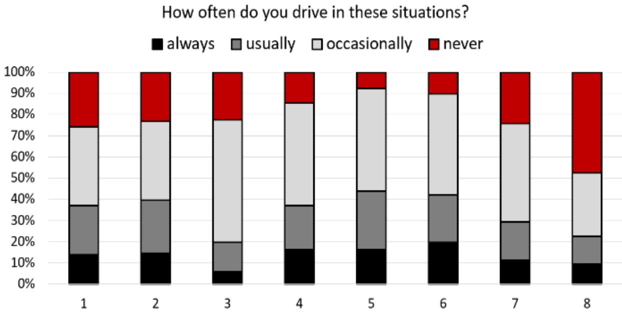



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Figure 2. Frequency of driving in various situations.

Based on the last two questions of page 1, it turned out that nearly half of the respondents have in-built GPS, and 88% of this group uses it (Figure 3).

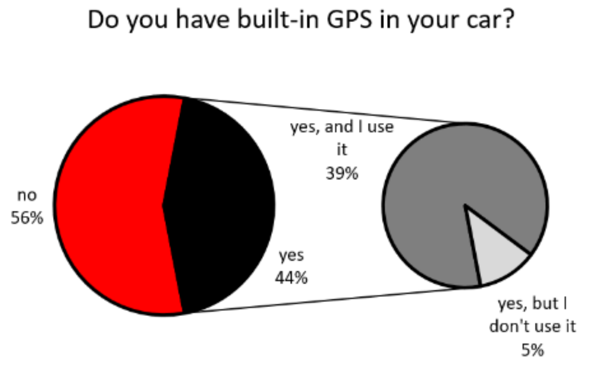


Figure 3. The proportion of drivers using a in-built GPS.

### 4.2 'No' questions

For those who do not use it or do not have an in-built navigation system, three other questions were asked about

- Why they do not use in-built GPS;
- In what circumstances they would use an in-built navigation system;
- What other device they use if they do not have in-built navigation.

When the driver bought the car, the GPS was not included in most cases – either because he/she bought a used car or did not have the opportunity to ask for it in the store. In less than half of the cases, it was a significant reason that it would have been expensive to install.

Not surprisingly, the most common device is the chauffeur's mobile phone, but some people have other external navigation systems (TomTom, Garmin, etc.).

What is more surprising, 20% said he/she would use an in-built GPS under no circumstances. The others all made the usage dependent on price.

### 4.3 'Yes' questions

44% of the respondents use in-built GPS during driving. It was interesting to examine whether there is any correlation between driving situations and GPS use. In Figure 4, the first column for each driving situation shows the frequency of travels of all participants, while the second column shows the frequency of travels of in-built GPS users. Those respondents who use in-built GPS travel abroad more often or go on longer journeys. This is most evident in the case of abroad trips (Figure 4, 7–8 columns).

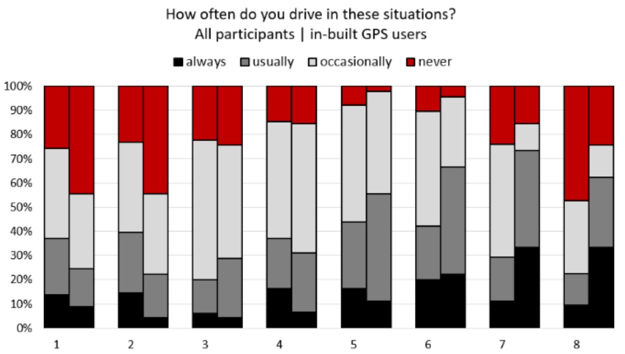


Figure 4. Frequency of driving in different situations. The first column includes all participants, the second column includes in-built GPS users.

Based on this, the frequency of the use of in-built GPS is also illustrated (Figure 5). The radar chart shows that respondents do not need navigation for everyday-known routes; however, the farther the (unknown) road is, the more help they need. This is also supported by Figure 6: people do not plan their route for everyday activities – the slight increase in abroad trips is due to the fact that a smaller percentage of people travel abroad (Figure 4); that is, these "non-existent" trips are not even planned. It is obvious that the less common the road is, the more people tend to plan ahead.

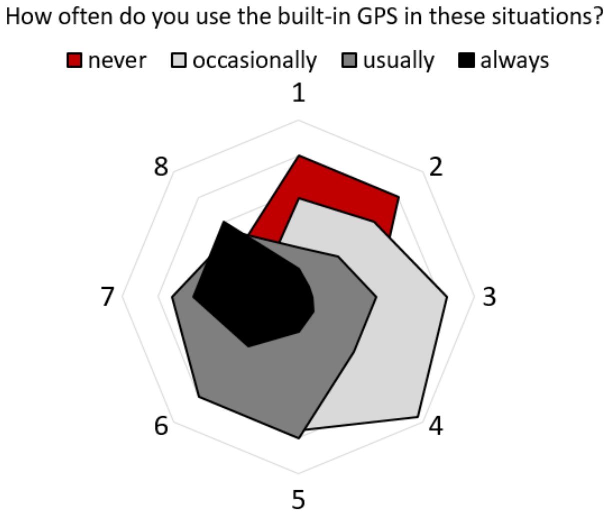


Figure 5. Frequency of in-built GPS usage in different situations.

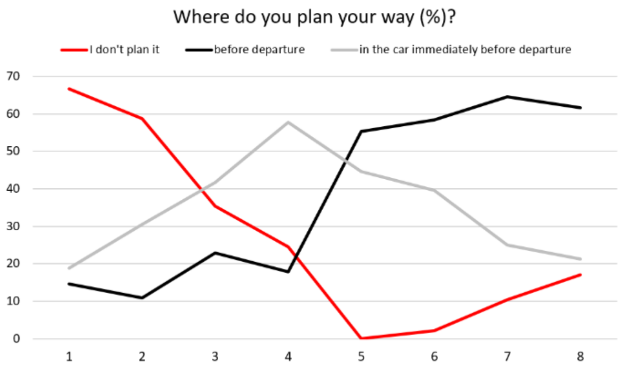


Figure 6. Road planning habits in different situations.


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The other issues were already explicitly related to their in-built navigation device. Five possible placement modes for the in-built GPS interface have been provided (Figure 7). The first option favours left-handers in particular, as it is easier for them to handle the surface on the left. The 2nd place is behind the wheel on the dashboard. The 3rd option is at the top of the central console. GPS in the central console itself, in its "usual place" is the 4th possible place, while the 5th is when the surface is projected onto the glass. The test wanted to know where the surface is now and where the drivers would like to see it, where it would be most comfortable for them.

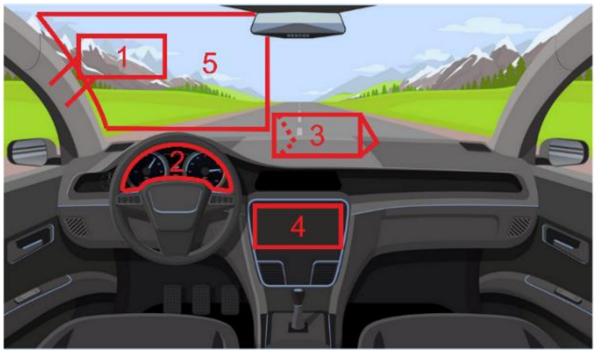


Figure 7. Possibilities for in-built navigation placement (www.vectorstock.com).

Currently, "usual-placed" GPSs are clearly dominating the market. With relative superiority, this turned out to be the most favoured placement (Table 2).

| Placement | Currently | Recommended |
|---|---|---|
| 1 (folding left) | 0% | 2% |
| 2 (dashboard) | 2% | 16% |
| 3 (foldable) | 20% | 22% |
| 4 ("usual place") | 76% | 49% |
| 5 (projected onto the windscreen) | 2% | 11% |

Table 2. Responses to the current and potential placement.

In Figure 8, other applications the drivers use besides their in-built navigation can be seen. The driving environments are on axis x, the applications, maps are shown on axis y. The colouring expresses what percentage of the respondents has chosen the application in each case. As expected, most people use Google Maps as an additional application for navigation. This is followed by TomTom GO and Apple Maps. They are used mainly for foreign trips, but a paper map is also displayed.

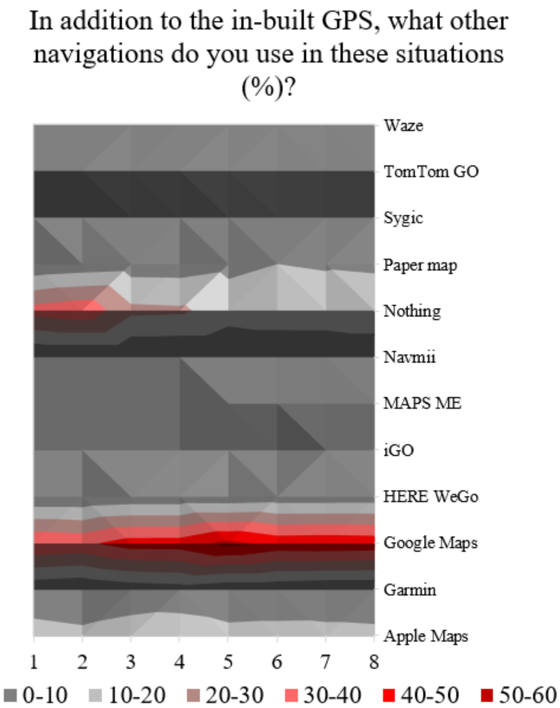


Figure 8. Other applications used besides the in-built GPS.

Figure 9 reveals that the participants do not really care about keeping their in-built GPS up to date: only 20% takes extra steps to keep their GPS database daily. 77% of those who update their GPS in some way do it annually or more often.

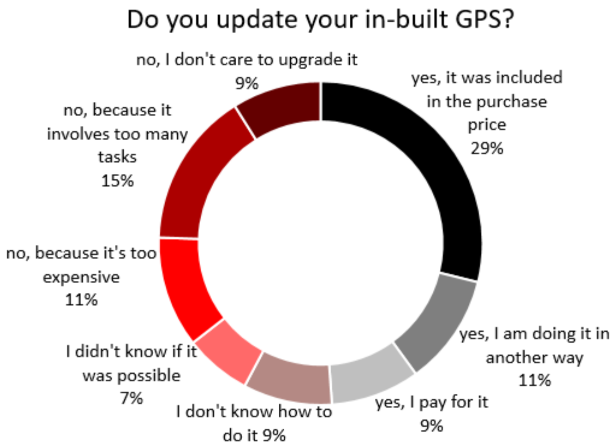


Figure 9. Update habits.

Here are some observations according to the responses how people use the features of the in-built GPS :

- 84% use the "night mode" feature, only 7% feel bothered; the rest is unaware that they could set it up themselves;
- The GPS speaks German for almost all participants, and the drivers (if they can control the system with voice control) also instruct the device in German;
- The drivers check the offered alternative routes almost every time and plan accordingly;


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- Approx. 60% use intermediate waypoint entry: 60% of these think ahead and do not complete the original instruction on the way;
- The navigation system allows to save frequently visited addresses without having to re-enter them all the time: only 7% do not use this possibility;
- Some people save to "favourites": usually family/friends or work addresses – but the majority (66%) has less than five addresses;
- An important issue for safe driving is whether drivers use the device while driving. 60% do it, but only a third of them when the vehicle is rolling – the rest stops or treats the surface while waiting at a red light (usually because of giving in a new address).

## 5. Conclusions and future work

Although only a few selected topics have been presented, some conclusions can already be drawn based on 116 responses:

a) Examining the different driving situations, there is no one in which they drive outstandingly much – most, on the other hand, insist on weekend getaways but avoid trips abroad. Presumably, these are all due to the current constraints created by the Covid pandemic. There is a correlation between the frequency of the driving situation (the distance of the road) and the frequency of GPS use – the less common a road is, the more drivers are inclined to seek electrical assistance, and proportionately more drivers with in-built GPS go abroad than their counterparts without such device;

b) In all cases (those with and without in-built GPS), Google Maps is a prominent navigation tool. (Since most people have criticised the high price of in-built navigation, its paramount significance is understandable). A smaller number also uses Apple Maps, HERE WeGo, a paper map and TomTom GO. Their frequency is essentially the same in all life situations. The paper map is the only one that is used multiple times for longer trips;

c) Almost half of the participants have in-built car GPS. Most users are aware of the more advanced features of GPS and use it. One thing that they do not put either time or money into is the upgrade.

A future study will compare the results of the questionnaire with other countries that are economically and socially different from Austria (e.g. Hungary, Romania, Serbia). There are other issues too that will be worth examining:

- Are the participants satisfied with their navigation interface (placement, content, features)? If not, what would they want – based on questions not mentioned in this article. If not, they will get suggestion for an "ideal" in-built GPS;
- Are there significant differences in countries in terms of navigation habits and needs?

## 6. Acknowledgement

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