C-MOBILE

Accelerating C-ITS Mobility Innovation and deployment in Europe

D6.3: Impact assessment on users and key stakeholders

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Legal disclaimer

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Abbreviations

Abbreviation	Definition
ACC	Adaptive Cruise Control
API	Application Programming Interface
ALPR	Automatic License Plate Recognition
BAR	Barcelona
BIL	Bilbao
BOD	Bordeaux
BSD	Blind Spot Detection
CC	Communication Consortium
CPH	Copenhagen
CACC	Cooperative Adaptive Cruise Control
CBA	Cost-Benefit Analysis
CCC	Conventional Cruise Control
CTLV	Cooperative Traffic Light for VRUs
CTVi	Vitoria's Intermodal Centre for Transport and Logistics
CVRIA	Connected Vehicle Reference Implementation Architecture
D	Deliverable
DS	Deployment Site
DIRA	Direction Interdépartementale des Routes Altantique
EBL	Emergency Brake Light
EV	Emergency Vehicle
EVWD	Emergency Vehicle Warning
FCD	Floating Car Data
FESTA	European project, developed methodology for conducting FOTs
FI	Flexible Infrastructure
FOT	Field Operational Test
GLOSA	Green Light Optimal Speed Advisory
GP	Green Priority
HGV	Heavy Goods Vehicle
HMI	Human Machine Interface
ITS	Intelligent Transport Systems
IVS	In-Vehicle Signage
KPI	Key Performance Indicator
M	Mean
MAI	Motorcycle Approaching Indicator
MPA	Motorway Parking Availability
MTTA	Mode and Trip Time Advice
N	sample size
OBU	On Board Unit
PI	Performance Indicator
PoC	Proof of Concept
PRM	People with Reduced Mobility
PS	Pilot Site
PTZ	Pan Tilt Zoom
PVD	Probe Vehicle Data
RFID	Radio Frequency Identification
RHW	Road Hazard Warning
RSU	Road Side Unit
RWW	Road Works Warning

SD	Standard Deviation
SUS	System Usability Scale
SPaT	Signal Phase and Timing
SSVW	Slow and Stationary Vehicle Warning
SVW	Signal Violation Warning
TAM	Technology Acceptance Model
TJAW	Traffic Jam Ahead Warning
TMC	Traffic Management Centre
UPA	Urban Parking Availability
VRU	Vulnerable Road User
WP	Work Package
WSP	Warning System for Pedestrian

Executive Summary

In the past years, there has been tremendous progress in the field of intelligent transport systems; several successful cooperative mobility initiatives have proven potential benefits of cooperative systems in increasing both energy efficiency and safety for specific transport modes. However, the large variety of cooperative applications have been designed for different goals, stakeholders or specific settings / environments and have been developed on a silo-based approach and deployed independently from each other, serving however, at higher level, similar goals and functionalities for the end-user. Scalability, IT-security, decentralization and operator openness are some of the most important properties that a technical and commercial successful solution must provide.

C-MobILE aims to stimulate / push existing and new pilot sites towards large-scale, real-life C-ITS deployments interoperable across Europe. Well-defined operational procedures will lead to decentralized and dynamic coupling of systems, services and stakeholders across national and organizational borders in an open, but secure C-ITS ecosystem, based on different access technologies, the usage of which is transparent for service providers and seamless and continuous for the end-users across different transport modes, environments and countries.

The main scope of this document is to present the subjective evaluation results gained from surveying users who actually experienced the services deployed in the C-MobILE project. The assessment focuses on the performance of the systems at service and at app level. In order to examine the quality of the implementations, common criteria such as (perceived) usefulness, (perceived) performance, reliability, and usability are taken into account.

1. Introduction

1.1. C-MobILE at a glance

The C-MobILE (Accelerating C-ITS Mobility Innovation and depLoyment in Europe) vision is a fully safe & efficient road transport without casualties and serious injuries on European roads, in particular in complex urban areas and for Vulnerable Road Users. We envision a congestion-free, sustainable and economically viable mobility, minimizing the environmental impact of road transport. C-MobILE will set the basis for large scale deployment in Europe, elevating research pilot sites to deployment locations of sustainable services that are supported by local authorities, using a common approach that ensures interoperability and seamless availability of services towards acceptable end user cost and positive business case for parties in the supply chain.

1.2. Objective

C-MobILE aims to stimulate / push existing and new pilot sites towards large-scale, real-life C-ITS deployments interoperable across Europe. Well-defined operational procedures will lead to decentralized and dynamic coupling of systems, services and stakeholders across national and organizational borders in an open, but secure C-ITS ecosystem, based on different access technologies, the usage of which is transparent for service providers and seamless and continuous for the end-users across different transport modes, environments and countries.

The main scope of this document is to present the results of the impact assessment on users and key stakeholders in the C-MobILE project. It is meant to provide insights in the acceptance, perceived usefulness, and usability of the C-ITS services deployed within C-MobILE.

1.3. Intended audience

The audience of this deliverable are deployment site leaders, service providers and public authorities involved in the implementation of the C-MobILE services in each of the deployment sites. Beyond that, the deliverable is written for all stakeholders interested in learning about the impact of C-ITS from the user perspective.

1.4. Expected impacts

C-MobILE will demonstrate the way for C-ITS deployment in Europe, serving as the reference for all stakeholders and new cities/ regions, interested in investing in C-ITS. Furthermore, C-MobILE results will significantly reduce fragmentation of C-ITS developments across the EU, accelerate deployment and market uptake of C-ITS, make C-ITS benefits concrete and interpretable for relevant decision makers and investors, and stimulate the competitiveness of related EU industries.

- Expected Impact 1: Improved level of performance for the entire surface transport system, including more efficient and sustainable traffic management, improved safety and contribution to overall socio-economic development.
- Expected Impact 2: Testing and demonstration of fully integrated C-ITS concepts in real-life, complex environments.
- Expected Impact 3: Greater collaboration (and partnerships) between multiple stakeholders to deploy applications and facilitate the interoperable interactions across all elements of the road transport system, including the use of data from multiple sources.
- Expected Impact 4: A comprehensive Cost-Benefit Analysis (CBA) demonstrating the value added and economic viability of C-ITS services and solutions for users and other stakeholders.
- Expected Impact 5: Validated results and proven impact on user acceptance, safety, resilience and security with respect to transport demand and the environment.
- Expected Impact 6: Development of validated guidelines for the large-scale deployment of operational and sustainable C-ITS services in Europe.

With regard to these expected impacts, WP6 (validation and impact assessment) was dedicated to the evaluation of C-ITS services:

- Task 6.1 addressed the overall impact assessment methodology.
  - Results are reported in Deliverable 6.1. Hypotheses and performance indicators were derived applying the FESTA methodology.
- Task 6.2 addressed the technical validation of the services.
  - Results are reported in Deliverable 6.2. Since this document contains classified information this report is not publicly available.

- Task 6.3 addressed the impact assessment on users and key stakeholders.
  - Results are reported in this deliverable (D6.3). The main focus is on subjective evaluation, i.e. the acceptance of C-ITS services and the usability of the deployed apps, both measured via questionnaires.
- Task 6.4 addressed the impact of C-ITS on the transport system.
  - Results are reported in Deliverable 6.4. An impact assessment methodology was defined which enables service evaluation from naturalistic driving, allowing to derive objective performance indicators from an event-based logging of user trajectories.
- Task 6.5 addressed a comprehensive Cost-Benefit Analysis of C-ITS services.
  - Results are reported in Deliverable 6.5. An ex-post CBA analysed the impact of the services for each deployment site and compared these with the costs stemming from service provisioning. The CBA findings will be used for the development of business plans for the large-scale deployment.

1.5. Document structure

This deliverable presents the results of the impact assessment on users and key stakeholders. In order to facilitate the use of this document by all interested parties the concrete chapters and contents are listed below:

- Chapter 1 “Introduction” provides the rationale and context of this deliverable.
- Chapter 2 “Evaluation Methodology” presents the overall approach for investigating attitudes of users and stakeholders towards C-MobILE services.
- Chapter 3 “Impact assessment by service” provides details on the user questionnaires’ results for each service at every deployment site and a comprehensive overview condensed at service level.
- Chapter 4 “Usability of apps by provider” presents the results of user surveys on the usability of the deployed apps.
- Chapter 5 “Stakeholder questionnaire results” provides insights in the impacts expected by stakeholders such as traffic managers.
- Chapter 6 “Discussion and conclusions” finally reflects the outcome of this deliverable.

2. Evaluation Methodology

D6.3 covers the impact assessment on users and key stakeholders whereas impacts on the transport system are examined in D6.4. However, some objective performance indicators obtained in T6.4 do not only tell about safety or efficiency effects, but also about users' compliance with service advices. Thus—where applicable and useful data is available—objective measures of user compliance are considered besides purely subjective evaluation which doubtlessly has the leading part in this deliverable.

In order to investigate the attitudes towards the C-MobILE services, different user groups were surveyed. Whereas in some cases apps were distributed in Google Play Store to the general public, other deployment sites recruited users or equipped professional drivers.

Besides, deploying services at eight different cities or regions necessarily includes the covariation of local conditions, such as traffic demand or street topology, but also different technical preconditions. For instance, GLOSA in Barcelona was implemented in intersections with fixed timing whereas the same service from the same app provider was applied to dynamic signal phasing in North Brabant. Furthermore, several services—even when carrying the same name—were implemented differently among app providers, i.e. providing different information thru different user interfaces. Finally, services were either rolled out in Large-Scale Deployment or as Proof of Concept (PoC); the latter either being implemented in public road environments (small scale) or on closed test tracks.

Erratically varying all these factors seriously impedes the comparability of results between deployment sites and service providers. Along with rather small sample sizes this led to the decision to provide only descriptives and to abstain from inferential statistics.

2.1. Subjective evaluation approach

Subjective evaluation through questionnaires was performed to asses user acceptance of C-ITS services deployed in each deployment site. A detailed description of questionnaire development is available in D6.1. Acceptance models consisting from various constructs were presented and discussed. User acceptance investigations from other projects which had similar aims and objectives were reviewed. An acceptance model was adapted to understand how user acceptance is formed and to asses user acceptance. It was decided to use the Technology Acceptance Model (TAM) as a base to assess the impact of C-ITS services on user acceptance.

Three major stakeholders were identified; end-users (drivers, professional drivers and vulnerable road users (pedestrians, cyclists), public authorities (cities, municipalities, traffic managers, road operators), and private companies (private industry consisting of C-ITS technology, service, or solution providers). Experience from experts who were involved in past projects were considered in the questionnaire development. Specific questionnaires were developed for each stakeholder. These questionnaires were shared with deployment sites to be translated in local language. Questionnaires were implemented with the respective local language into a survey server (SoSci). Questionnaires were customized according to the needs and requirements for each deployment site.

For end-users there were two types of questionnaires: expectation and experience. The aim was that users complete the expectation questionnaires before they use new ITS services. In this questionnaire users were free to share their personal information, their user profile and mobility behaviour. Based on the service description users indicated their past experience, rated the usefulness and stated whether they would use a specific service once it is available.

It was envisioned to collect actual experience data multiple times to observe long time effects and to observe change in mobility behaviour. It was expected that ITS services will be released one by one. The aim was that end-users should share their experience after they had their first interactions with the service. The intention was to use these results to derive recommendations to optimise the interface which should be shared with service providers. Once all intended services are deployed and there is no HMI improvement required, end users should share their actual experience with specific services and the entire application. The aim was to conduct data collection at least twice, where the final data collection should be completed three months before the project ends.

Some deployment sites did not have a direct access to their potential end-users for the expectation questionnaire. These deployments sites tried to collect subjective data by sharing the questionnaire link on their social media account. Other deployment sites who had direct access to their potential end-users contacted their end-users via email or send a physical copy of the questionnaire. The average response per deployment site was 25 (min. 10 / max. 46).

At the same time before service deployment started, some deployment sites conducted user trainings. In user training, participants were requested to complete the expectation questionnaire before the training started. During the training, a presenter explained the features and functionalities of specific services and showed demos how the services will work once it is released. After the user training participants completed a second questionnaire which was adapted from the experience questionnaire.

Depending on the number of services which was planned for each deployment site the expectation questionnaire took in average 10-15 minutes. Some deployment site leaders reported that end users perceived the length of the questionnaire as too long. This issue was more present at deployment sites who planned to deploy more services. A short version of the original experience questionnaire was created and made available to deployments sites. Deployment sites were free to decide whether to distribute the short version of the experience questionnaire if they believe they can receive though this more data. Due to technical problems and the COVID-19 pandemic, service deployment in each deployment site was significantly delayed. Service usage and consequently subjective data collection was interrupted because of COVID-19 related restrictions. Another implication of this issue was that some deployment sites could not deploy specific services in large scale and conducted “proof of concept” studies in highly controlled environments. These questionnaires were removed from the original questionnaire. Data collection for the experience questionnaire towards was conducted only one time towards the end of the project.

2.2. User surveys

/ Expectation Questionnaire

The first questions of this questionnaire were about demographics; age, gender, educational level and occupation. These were followed by user profile and driving habits; driving license / since, modal split, frequency of mode usage, average mileage per year. This was followed by items related to specific services that end-users are going to use in their deployment site; past experience with a service, usefulness rating of a service and intention to use a service once it is deployed. The questionnaire was completed with an open question where end users may express their expectation from new ITS services in general.

/ Experience Questionnaire

In the initial questionnaire participants rated their experience on newly implemented ITS specific questionnaire, consisting of 13 closed questions for each service (5-point Likert Scale). Specific items which were not applicable for a service were removed. As described in D6.1, ten items are based on standardized questionnaires with their respective constructs; perceived usefulness, perceived ease of use, perceived safety & trust and behavioural intention. There were additional items where end users rated the amount of displayed information, the timing of displayed information and the quality of feedback mode of the service. Then, end users rated the entire app through the system usability scale (SUS). After completing the SUS end-users were asked to indicate whether they are willing to pay for the app they are using. End-users were able to provide insights about the HMI through open questions. End users were free to indicate if there is anything (e.g. feature) is missing on the app, what would be the first thing that they would do in order to improve the app and any other final comments about the application.

Due to the length of the questionnaire there was a general concern about the response rate. Therefore, it was decided to create a short version of the initial questionnaire. The number of service specific items was reduced to five; perceived usefulness, information amount, information timing, quality of feedback and behavioural intention. End-users had the option to express their opinion or to add comments at each service. Five SUS items which were distinctively different from each other were used in this version. The open questions at the end of the questionnaire were kept as in the initial questionnaire.

/ Stakeholder Questionnaire

Some deployments sites conducted additional workshops with fleet operators, local authorities and traffic management centres. Applicable services which are going to be deployed were presented. After the sessions, participants had the opportunity to share their impressions and thoughts via a questionnaire. Areas of interest were the aims of C-MobILE services to reduce the environmental impact of vehicles in urban areas, to have an effect on efficiency and to have an effect on safety. Participants indicated how important these aims are for their own institution/organisation.

3. Impact assessment by service

Questionnaires were distributed in various ways, namely e-mail, social media, in-app notifications, and QR-codes at test sites. Due to this variety no meaningful response rates could be calculated but it can be stated that the number of filled questionnaires differs from DS to DS, and so do user numbers. Since some users filling the questionnaire might not have experienced every service, subsample sizes are even lower.

Service implementations have strongly been hampered and delayed by the Covid-19 pandemic, and especially by the resulting mobility restrictions. In consequence, user surveys—in particular with regard to actual service experience—were delayed, too, and partially rather few users were available for the questionnaires, as illustrated in the following table.

Table 1: No. of users (downloads) and questionnaire responses for cellular services

DEPLOYMENT SITE	USERS (DOWNLOADS)	RESPONSES
Barcelona	900 (2024)	49
Bilbao	20 (recruited users)	20
Bordeaux	ca. 40 w/ logs (418)	21
Copenhagen	10 (recruited users)	6
Newcastle	37 (recruited users)	5
North Brabant	40 (recruited users)	29
Thessaloniki	ca. 1000 (taxis)	39
Vigo	80 (recruited users)	68

Very few respondents made use of the opportunity to answer open questions. Whenever such comments provide valuable insights—especially with regard to potential for service improvement—these are reported along with the numerical results.

3.1. Motorway Parking Availability (MPA)

Motorway parking availability provides motorway parking availability information and guidance for truck drivers to make informed choices about available parking places. Existing solutions provide information about the location of truck parks, capacity, available equipment, facilities on site, security equipment and information about dangerous goods parking.

3.1.1. MPA by CEIT

The MPA service in Bilbao DS has been deployed in the CTVi industrial vehicles' parking, located at the intermodal route of the Northern Peninsula (E-5, E-80). Two plate readers and RFID modules have been installed at the entrance and exit of the parking, to monitor its occupancy (its maximum capacity is 180 spots).

The implemented solution provides information about the (1) location of parking, (2) free spots in real time, (3) available equipment, (4) facilities on site, (5) security equipment and (6) information about dangerous goods (see Figure 1).

Figure 1: C-MobILE MPA app from Bilbao DS

3.1.1.1. Bilbao deployment (large-scale deployment)

This service has been implemented in the CTVi truck park, which has a capacity of 180 spots in Vitoria - Gasteiz. CTVi completes the intermodal network of the North of the Peninsula (E-5, E-80). This parking has already certain number of habitual users and others that use it on a rotation basis.

The target users for this service are truck drivers. Within the project some users of the CTVi parking were engaged. However, the companies receiving the app may already know the car park well, and know how they use it, so it may not have added value for them. And the companies that park on a rotation basis are, in many cases, unknown, so getting the app to them may be complicated, or impossible

The application is available since February of 2020 and it was downloaded by 19 different users in the last year. Currently there are 5 active users.

Subjective service evaluation

Due to the low number of users that used the application the CTVi parking manager was asked for the evaluation of this service. His impressions were quite good regarding the functioning of the license plate identification and authorisation management system that was installed. Digitising all entries, outs, companies, regular drivers and its permissions meant a radical improvement for them.

However, the app designed specifically for the truck drivers was not successful because even if the pandemic situation has slightly altered the usual frequencies and flows in the car park, the number of subscribing companies is still high, and occupancy per parking space is still at a maximum. Most of the companies receiving the app already know the car park well, and know how to use it, so it may not have added value for them. And companies that park on a rotation basis are, in many cases, unknown so for this case a platform such as Truck Parking Europe should be necessary for its diffusion.

Integration of results and conclusions

No subjective user evaluation data available but the marking manager seems to be convinced of the service

3.1.2.MPA by NeoGLS

Bordeaux DS implements MPA service using cellular communication. Data about truck parking occupancy on the A63 highway is provided by Atlandes, the highway manager. Truck drivers can access this information in real-time for all 12 lorry parking lots along the A63.

The driver can visualize the truck parking facilities on a map and select the one based on availability. Once selected the application keeps the driver informed if the availability changes.

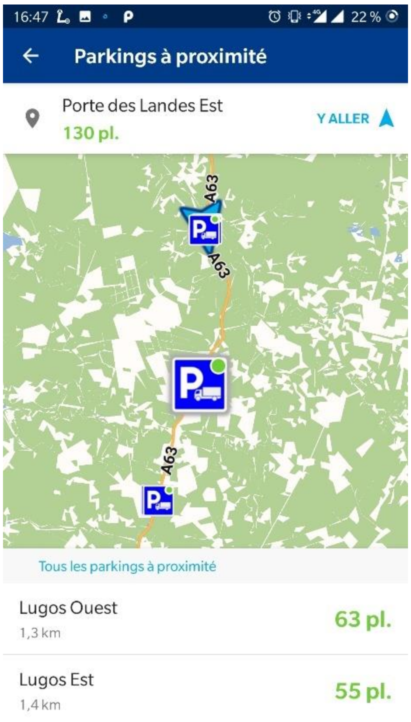


Figure 2: MPA Service parking selection in BOR PID

3.1.2.1. Bordeaux deployment (large-scale deployment)

The area covered by the MPA use case in Bordeaux DS is the A63 highway in the south-west of the city. The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

/ Post-Questionnaire (Experience)

6 participants (3 female) shared their actual experience through the short questionnaire. The mean age of these participants were 44 years (SD = 10 years). The results are presented on Figure 3. Participants tended to agree that MPA makes it easier to them to find a parking space (M = 3.83; SD = 0.90). Usually, information from MPA was received timely (M = 0.0; SD = 0.0). The amount of displayed information was perceived as ideal (M = 0.0; SD = 0.0). Usually, the signals/notifications sent by MPA was perceived as ideal (M = 0.0; SD = 0.0).

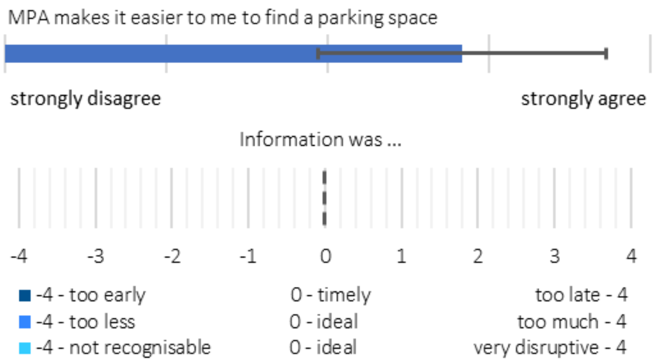


Figure 3 BOD – MPA Post Experiment Questionnaire

Integration of results and conclusions

MPA is perceived as useful and information presentation occurs to be ideal.

3.1.3.Summary and comparison of different service versions and deployments

Both service deployments (BIL, BOD) received little but very positive feedback.

3.2.Urban Parking Availability (UPA)

Urban parking availability provides parking availability information and guidance for drivers to make informed choices about available parking places. This service aims to reduce congestion, time loss, pollution, and stress caused by cruising for parking.

3.2.1.UPA by GERTEK/CEIT

In Bilbao DS, UPA was originally planned to cover the whole on-street parking service of the city including cargo and reduced mobility people's parking slots. This service is fed from the Open Data Platform of the Municipality which publishes the information that the ALPR cars collect in real-time. However, due to delays on the tender related to the on-street parking service of Bilbao, currently a mitigation plan is being executed and will be available in spring 2021. This mitigation plan covers 170-180 parking spots distributed in several zones of the urban area by using 11 PTZ cameras (nine of them are new cameras, specifically installed for the project). It is worth noting that these parking spots are also for regular users, cargo or PRM spots. This solution will cover also some taxi ranks.

Figure 4: C-MobILE UPA app from Bilbao DS

3.2.1.1. Bilbao deployment (PoC)

The service covers the urban area of the city. In Bilbao the on-street parking has more than 90.000 users and the daily occupancy is usually at maximum. The target users of this service are car and truck drivers that use the on-street parking in Bilbao. The app is developed but still not available for users since data collection has been delayed (currently pending the finalization of the mitigation plan).

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

26 participants (12 female, 1 diverse) filled the first questionnaire. The mean age of these participants were 47 years (SD = 9 years). The results showed that participants heard about this or a similar service (M = 2.50; SD = 1.15). Based on the service description, participants think that this service would be useful (M = 3.69; SD = 1.17) for their daily driving and stated that they would use (M = 4.15; SD = 0.66) this service once it is available.

Integration of results and conclusions

No data on actual service experience available.

3.2.2. UPA by NeoGLS

Bordeaux DS implements UPA service in both 4G and G5 technologies. The information about real-time parking occupancy is provided by Bordeaux Métropole through OpenData, and broadcasted to users to provide them with relevant advice on available parking spaces in every parking lot in the city centre (and P+R). The service allows the user to select a parking log based on its availability or status, and launch navigation to drive to it. While driving, the user will receive real time updates about the parking occupancy.

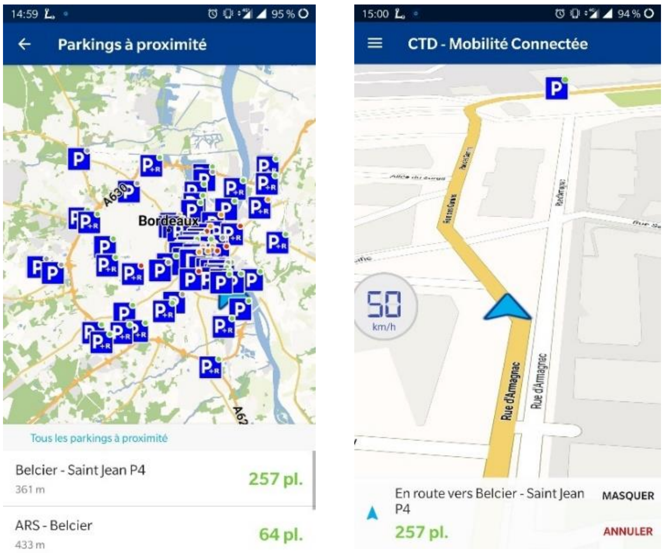


Figure 5: NeoGLS UPA service interface

3.2.2.1. Bordeaux deployment (large-scale deployment)

The area covered by the UPA use case in Bordeaux DS is mostly the city centre where parking lots are very frequent. The service extends to the whole urban area when applicable and at the airport and also along the tramway lines.

The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

/ Post-Questionnaire (Experience)

10 participants (5 female) shared their actual experience through the short questionnaire. The mean age of these participants were 44 years (SD = 10 years). The results are presented on Figure 6. Participants tended to agree that UPA makes it easier to them to find a parking space (M = 3.50; SD = 0.50). Usually, information from UPA was received timely (M = 0.0; SD = 0.0). The amount of displayed information was perceived as ideal (M = 0.00; SD = 0.77). Usually, the signals/notifications sent by UPA was perceived as ideal (M = 0.0; SD = 0.45).

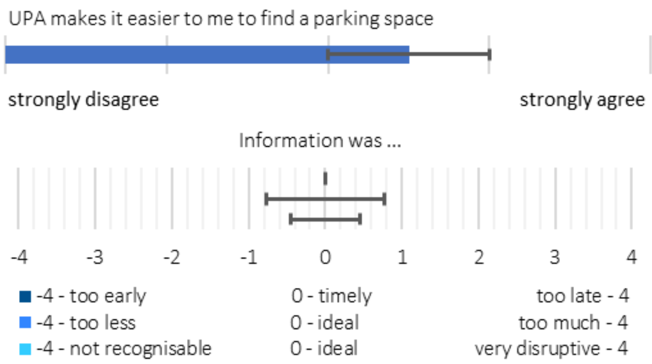


Figure 6: BOD – UPA Post Experiment Questionnaire

Integration of results and conclusions

UPA is perceived as useful and information presentation occurs to be ideal.

3.2.3. Summary and comparison of different service versions and deployments

Since there is only data for Bordeaux a comparison is not possible.

3.3.Road Works Warning (RWW)

Road works warning aims to inform the drivers in a timely manner about road works, restrictions, and instructions. This allows them to be better prepared for potential works downstream on the road, therefore reducing the probability of collisions.

Since from the users' perspective Road Works and Road Hazard Warning are very similar and thus hard to distinguish, experience with both services was evaluated together in one questionnaire item that summarized both services as RHW. This applies to the evaluation of all deployments of the NeoGLS and IDIADA app.

3.3.1.RWW by IDIADA

The Road Works Warning service aims to increase the awareness of the drivers about incoming roadworks situations in their way. In the Barcelona DS, the primary target is any kind of road users that may be affected by the roadworks areas, being motorized users the most interested ones, even though the RWW service can also be offered for other road users such as cyclists.

The users of this service receive information about the roadworks quite in advance to be able to take a decision on either avoiding the area or slowing down for precaution. The minimum information that is provided to the users is the distance to the roadworks area, but it can be extended to give also lanes affectation or new speed limits to go through the roadworks area safely, depending on the data sources' availability.

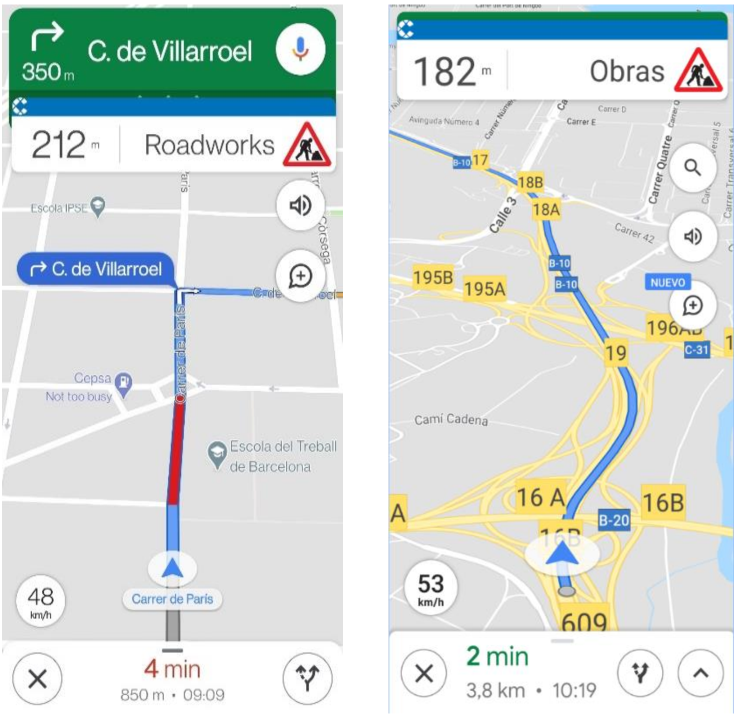


Figure 7: RWW service in C-MobILE Barcelona app

3.3.1.1. Barcelona deployment (large-scale deployment)

Two different roadworks data sources are available in the Barcelona DS, with the objective to cover the entire deployment are with this service. While one is focused on the Barcelona city, another gives information from the metropolitan area (excluding cities). The service has been enabled for only two user groups; drivers and motorcyclists since there is no information of the affectation of the roadworks concerning bike lanes. The C-MobILE Barcelona app provides this service as a Road Hazard Warning use case in order to ease the services selection from the users.

All users can enjoy the RWW service from the C-MobILE Barcelona Android application, which means that around 2000 users have been using the app, and consequently this service, for more than a year and a half since October 2019. The number of currently active users is nearly 900.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years. The results showed that participants heard (M = 2.22; SD = 1.24) about this service or a similar service. Based on the service description, participants think

that this service would be useful (M = 3.97; SD = 1.13) for their daily driving and stated that they would use (M = 4.00; SD = 0.95) this service once it is available.

/ User Training (Expectation)

57 participants (17 female) joined the user training. The mean age of these participants were 44 years (SD = 11 years). The results showed that participants are familiar (M = 2.93; SD = 1.28) this service or a similar service but never user it before. Based on the service description, participants think that this service would be useful (M = 4.37; SD = 0.98) for their daily driving and stated that they would use (M = 4.35; SD = 0.61) this service once it is available. After the user training the majority of participants thought that the RHW would allow them to quickly identify hazardous locations (M = 4.21; SD = 0.67).

/ Post-Questionnaire (Experience)

As stated above, experience with RWW in the IDIADA app was evaluated together with RHW; results can be found in the respective section.

3.3.1.2. North Brabant deployment (large-scale deployment)

The service is deployed in The Netherlands through the so-called Talking Traffic infrastructure. As a result, the service operates national wide. The users are (mainly) employees from the City of Helmond and the TNO office in Helmond. It concerns a restricted user group, and 44 participants have downloaded the app from the Google play store through a personal link since the app for North Brabant has not been published publicly due to privacy restrictions.

Subjective service evaluation

/ Post-Questionnaire (Experience)

As stated above, experience with RWW in the IDIADA app was evaluated together with RHW; results can be found in the respective section.

3.3.2. RWW by NeoGLS

Bordeaux DS implements RWW service using both cellular and G5 communication. The roadworks information comes from the « Bison Futé » database called « TIPI » (and provides roadworks on highways and inter-urban roads) and also from Bordeaux Métropole OpenData (providing roadworks in the city center).

When driving towards a roadworks situation, the driver will be warned and will know the distance to the roadworks. The service aims to let the driver react on time to the roadworks situation and adapt his speed.

Figure 8: NeoGLS RWW service interface

3.3.2.1. Bordeaux deployment (large-scale deployment)

The area covered by the RWW use case in Bordeaux DS is mostly the city center where planned roadworks are common. The service extends to the inter-urban area when applicable (e.g.: roadworkds on the ring-road or highway).

The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

As stated above, experience with RWW in the NeoGLS app was evaluated together with RHW; results can be found in the respective section.

3.3.2.2. Bilbao deployment (large-scale deployment)

Bilbao RWW deployment is fed from the Open Data platform for the Municipality. NeoGLS reads this data and distributes the C-ITS messages through Bilbao's geo messaging server. The service covers the entire urban area. The target users for this service are any motorized users from the city area. Within the project some users were specifically engaged such as municipality's maintenance vehicles who normally circulate in the city during their working day. The first group of users consisted of 7 users. However, after a short time they reported high battery consumption and their feedback prevented the recruitment of new users. In March 2021 NeoGLS reported 5 active users from Bilbao DS.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

29 participants (7 female, 1 diverse) filled the first questionnaire. The mean age of these participants were 49 years (SD = 9 years). The results showed that participants heard about this or a similar service (M = 2.24; SD = 1.38). Based on the service description, participants think that this service would be useful (M = 3.79; SD = 1.13) for their daily driving and stated that they would use (M = 3.93; SD = 0.58) this service once it is available.

/ Post-Questionnaire (Experience)

As stated above, experience with RWW in the NeoGLS app was evaluated together with RHW; results can be found in the respective section.

3.3.2.3. Newcastle deployment (large-scale deployment)

The RWW data comes from the Tyne and Wear open data services, which is published periodically and converted into the appropriate format for use by ITS-G5 as well as 4G customers. The data is formatted and delivered via the NeoGLS CTD – Connected Mobility App.

The service is available across the seven mostly urban areas of the Tyne and Wear region (Newcastle, Gateshead, Sunderland, North Tyneside, South Tyneside - collectively 1 million population). It is also available on trunk roads across the whole north east region of England, with large areas of rural nature covered.

Currently, the North East Ambulance Service (NEAS) non-emergency patient transfer vehicles and some private motorists. Selected drivers at Newcastle City Council (NCC) are also using the service. The private motorists are carefully selected because NCC does not wish C-ITS services to be available to all private motorists at the current time. Therefore, 38 recruited (partially professional) drivers are using the app.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

12 participants (2 female) filled the first questionnaire. The mean age of these participants were 52 years (SD = 7 years). The results showed that participants heard about this or a similar service (M = 2.42; SD = 1.32). Based on the service description, participants think that this service would be useful (M = 3.83; SD = 0.93) for their daily driving and stated that they would use (M = 3.50; SD = 0.87) this service once it is available.

/ User Training (Expectation)

9 male participants joined the user training. The mean age of these participants were 48 years (SD = 11 years). The results showed that participants are familiar (M = 3.00; SD = 1.05) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful for their daily driving (M = 4.37; SD = 0,98) and stated that they would use this service once it is available (M = 4.22; SD = 0.79).

After the user training the majority of participants expect that the RWW will enable them to spot the location of road works quickly (M = 4.00; SD = 0.71), that RWW will support their understanding of the situation (M = 3.75; SD = 0.66), that after receiving a RWW notification, they will immediately know what to do (M = 4.00; SD = 0.71), that they feel safe while using RWW (M = 3.88; SD = 0.78), and they intent to keep RWW activated while driving (M = 3.63; SD = 1.22). The amount of displayed information was perceived as ideal (M = -0.25; SD = 1.30).

/ Post-Questionnaire (Experience)

As stated above, experience with RWW in the NeoGLS app was evaluated together with RHW; results can be found in the respective section.

3.3.3. RWW by CERTH

The App developed by CERTH in the context of C-MobILE provides the service RWW to drivers driving in the road network of Thessaloniki. The objective of this service is to provide drivers timely with information about ongoing roadworks downstream, so that they are aware of such situations and adapt their driving accordingly. The information provided to the users are shown in the HMI of their personal devices (e.g., smartphones, tablets) as depicted in the figure below.

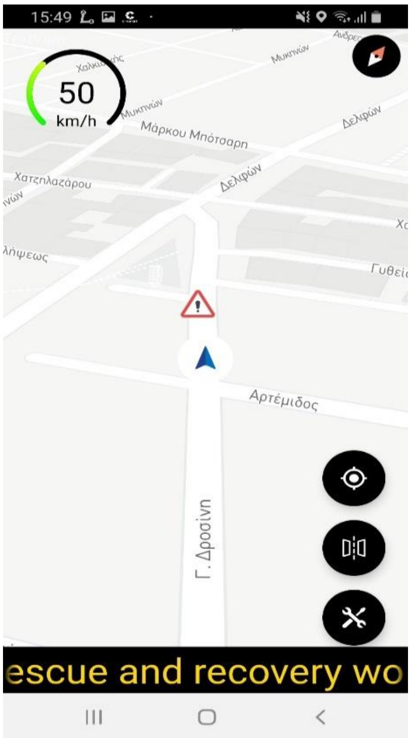


Figure 9: RWW service – CERTH App

3.3.3.1. Thessaloniki deployment (large-scale deployment)

Concerning the characteristics of Thessaloniki DS, the RWW service coverage includes multiple areas of the urban road network, mainly in and around the central business district area. The road works information includes at the current stage the locations where road works are ongoing due to the construction of the metro in Thessaloniki. The RWW services is provided to circa 1000 taxi drivers which receive the respective information through the integration of the service in their equipment (tablets) as well as to drivers of the general public which can download and use the App. The number of active users is at the current stage estimated to circa 1000 users. Due to the COVID-19 pandemic and the ongoing lockdown in Thessaloniki the number of active users from the general population remains low.

Subjective service evaluation

/ User Training (Expectation)

10 participants (2 female) joined the user training. The mean age of these participants were 50 years (SD = 22 years). The results showed that participants are familiar (M = 3.00; SD = 1.80) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful for their daily driving (M = 4.08; SD = 1.60) and stated that they would use this service once it is available (M = 4.23; SD = 1.59).

After the user training the majority of participants (strongly) expect that the RWW will enable them to spot the location of road works quickly (M = 4.80; SD = 1.91), that RWW will support their understanding of the situation (M = 4.70; SD = 1.88), that after receiving a RWW notification, they will immediately know what to do (M = 4.70; SD = 1.88), that they feel safe while using RWW (M = 4.50; SD = 1.82), and they intent to keep RWW activated while driving (M = 4.40; SD = 1.78). The amount of displayed information was perceived as ideal (M = 0.60; SD = 2.39) with a tendency towards much.

/ Post Experiment (Experience)

18 participants (5 female) shared their actual experience through the short questionnaire. The mean age of these participants were 42 years (SD = 8 years). The results are presented on Figure 10. Participants tended to agree that RWW enabled them to spot the location of roadworks quickly (M = 4.06; SD = 0.70). Usually, information from RWW was received timely (M = 0.33; SD = 0.94). The amount of displayed information was

perceived as ideal (M = -0.61; SD = 1.01) with tendency towards less. Usually, the signals/notifications sent by RWW was perceived as ideal (M = -0.35; SD = 1.03)

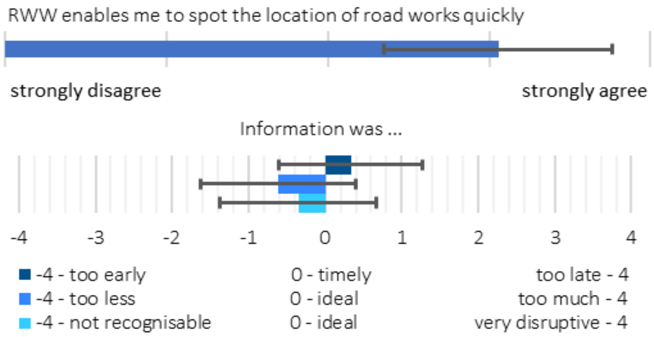


Figure 10: THE – RWW Post Experiment Questionnaire

Integration of results and conclusions

RWW in the CERTH app is well received by the users. Information on road works occurs to be helpful and its presentation is close to ideal on average.

3.3.4. RWW by CTAG

Road Works Warning provides all related information about the service. Starting with a notification in the top-right margin where we can see the icon of the event, road works in this example, and followed by the distance in meters from our placeholder to the start of the event. Moreover, on map we can see a little POI (Point of interest) indicating where exactly starts the event geographically. With these two items, notification plus POI, we achieve an accurate representation showing all the available and necessary data of the warning nearby.

Figure 11: RWW notification from C-MobILE Vigo app

3.3.4.1.Vigo deployment (large-scale deployment)

Regarding the service developed in the DS Vigo, the main source of data used for the service is the DGT (Dirección General de Tráfico) and our ITS Center as principal data providers. Thanks to these data source, it is possible to receive information from the urban area of Vigo, in particular from the central area where the greatest number of road works are usually registered (for example, the Gran Vía conditioning works) and from interurban areas, with the A-55 motorway as the main road among other roads (SISCOGA4D Corridor). The service has been enabled for all user groups (cars, motorbikes, emergencies, buses, trucks and vans) from the mobile application provided through the mobile devices delivered; a total of 80 recruited users. For all services a specific application has been developed allowing to include a baseline mode for the recruited users from where the results are received, analysed and evaluated. Another "regular" version of the application is available for free download in the Play Store which also offers this service to the general public.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

47 participants (9 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 9 years). The results showed that participants are familiar with this service but never used it before (M = 2.65; SD = 1.23). Based on the service description, participants think that this service would be useful (M = 3.85; SD = 1.10) for their daily driving and stated that they would use (M = 4.27; SD = 0.53) this service once it is available.

/ Post-Questionnaire (Experience)

41 participants shared their actual experience with this service. The mean age of these participants was 39 (SD = 9 years). The results are shown on Figure 12. The results showed that participants tended to agree that RWW enabled them to spot the location of road works quickly (M = 4.02; SD = 0.87), that RWW increased safety (M = 3.98; SD = 0.78), that RWW supported their understanding of the situation (M = 3.83; SD = 0.88), after receiving a RWW notification, they immediately know what to do (M = 3.55; SD = 0.84), that they feel safe while using RWW (M = 3.63; SD = 0.86) and that they keep RWW activated while driving (M = 4.11; SD = 0.65). Participants neither agree nor disagree that RWW worked reliably and faultlessly (M = 3.26; SD = 0.88). Usually, information from RWW was received timely (M = 0.33; SD = 0.85). The amount of displayed information was perceived as ideal (M = -0.10; SD=1.52). Usually, the signals/notifications sent by RWW was perceived as ideal (M = 0.05; SD = 1.54).

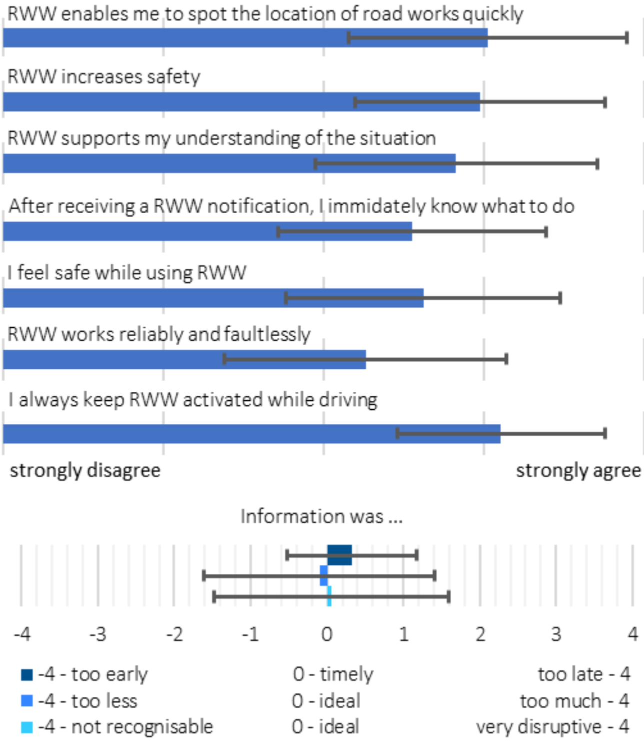


Figure 12: RWW - VIG Post-Questionnaire Results

Integration of results and conclusions

RWW in the CTAG app is well received by the users. Information on road works occurs to be helpful and meets the expectations from the pre-questionnaire. Information presentation is rated ideal on average, showing a rather large deviation for the amount of information and the salience of the warning.

3.3.5. RWW by Technolution

The RWW services provided for the City of Copenhagen by Technolution, is bundled in the multimodal GreenCatch app, where GLOSA, CTLV, RHW and WSP services are also provided to the road user. The RWW service is visualized as a small pop-up warning in the bottom of the user interface right below the GLOSA information.

3.3.5.1. Copenhagen deployment (large-scale deployment)

The RWW service covers the whole City of Copenhagen administrative area and is targeted towards all road users that are using the C-MobILE GreenCatch app in which all the services for CPH DS are bundled. The data is gathered from the open data database of the City of Copenhagen in which all road works and occupancy permits are stored and published. Visually, the RWW was shown as a pop-up text beneath the GLOSA information, but as opposed to the GLOSA information there was no audio function associated with the RWW service. This choice was made to reduce the noise interference and complexity from the app and focus the audio function to the GLOSA service, which was deemed more important for the Copenhagen DS.

Presumably due to Covid and the City of Copenhagen's reluctance to disseminate a mobility app while a lockdown was present or expected restricting mobility, very few users were recruited. The pool of potential users recruited were from the employees of the City of Copenhagen Technical and Environmental Administration and their family and friends, IT University of Copenhagen students, University of Copenhagen students, and employees of a bike currier/delivery company informally contacted, as well as friends and family of the Deployment Site Leader.

Even though the potential user group could have been large enough to acquire the potential evaluation data, two issues with remained. First, the IOS version of the app was severely delayed due to a bug, reducing the potential users to estimated less than half, as the majority of Copenhageners use IPhone IOS. Secondly, the lockdown continued in various degrees throughout most of the deployment phase, resulting in a large decrease in mobility.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

10 participants (5 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 8 years). The results showed that participants are familiar with this service but never used it before (M = 2.70; SD = 1.27). Based on the service description, participants neither agree nor disagree that this service would be useful (M = 3.40; SD = 0.92) for their daily driving and that they would use (M = 3.10; SD = 0.94) this service once it is available.

/ Post-Questionnaire (Experience)

Unfortunately, since the app deployment was impeded, there is no data available on actual experience with the service.

3.3.6. Summary and comparison of different service versions and deployments

Taking into account that RWW and RHW provide quite similar information and might be hardly distinguishable by the drivers these two services were evaluated together for the IDIADA and NeoGLS app. Looking at the other deployments it can be found that there are actually no noteworthy differences between the two services. Thus, putting them together here occurs to be legitimate.

Over all implementations and DS, RWW is well received by the users. The service is perceived as (very) useful and most HMIs were considered to provide information in an almost ideal manner. The reliability of the service should be not such an issue as with RHW since road works are by nature longer lasting events whereas road hazards—such as crashes or breakdowns—occur and disappear more rapidly. The more it should be investigated why two respondents explicitly complained about invalid RWW notifications in NBR.

3.4. Road Hazard Warning (RHW)

The road hazard warning service aims to inform the drivers in a timely manner of upcoming and possibly dangerous events and locations. This allows drivers to be better prepared for the upcoming hazards and make necessary adjustments and manoeuvres in advance.

3.4.1. RHW by IDIADA

The Road Hazard Warning service offers traffic congestion, accidents, stationary/ broken down vehicles, animals on the road, extreme weather conditions and slippery road events. The 95% of the event belong to the traffic congestion and accidents since they are the most common incidents, although the Barcelona DS systems are ready for many other types of hazardous situations.

The C-MobILE Barcelona app presents information concerning RHW with the official road sign icon and the distance to the incident location. The distance is no longer shown when the user in located inside the event relevant area. Depending on the type of road, the warning distance is larger or shorter in order to give the drivers time enough for reacting.

Figure 13: Example of RHW notification from C-MobILE Barcelona app

3.4.1.1. Barcelona deployment (large-scale deployment)

Two different data sources populate the entire deployment area with road incidents, including the Barcelona city, they are updated very frequently in order to maintain the events updated in location since most of them are dynamic events that can grow, shrink, appear and disappear quickly.

The C-MobILE Barcelona app offers this service in conjunction with RWW service, and it is offered to all kinds of users (drivers, motorcyclists and cyclists). Since October 2019, around 2000 users have used this service with a current status of 900 active users.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years). The results showed that participants heard (M = 2.22; SD = 1.24) about this service or a similar service. Based on the service description, participants think that this service would be useful (M = 3.97; SD = 1.13) for their daily driving and stated that they would use (M = 4.03; SD = 0.95) this service once it is available.

/ Pre-Questionnaire – User training (Expectation)

57 participants (17 female) joined the user training. The mean age of these participants were 44 years (SD = 11 years). The results showed that participants are familiar (M = 2.93; SD = 1.28) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful (M = 4.37; SD = 0,98) for their daily driving and stated that they would use (M = 4.35; SD = 0.61) this service once it is available. After the user training the majority of participants thought that the RHW would allow them to spot the location of hazards quickly (M = 4.21; SD = 0.67).

/ Post-Questionnaire (Experience)

16 participants (1 female) shared their actual experience through the short questionnaire. The mean age of these participants were 47 years (SD = 12 years). The results are presented on Figure 14. Participants said that RHW enabled them to spot the location of hazards quickly (M = 4,29; SD = 0,67). Usually, information from RHW was received timely (M = 0,88; SD = 1,60) with a tendency towards "late". The amount of displayed information was perceived as ideal (M = -1,00; SD=1,61) with a tendency towards "less". Usually, the signals/notifications sent by RHW was perceived as ideal (M = -0.31; SD = 0.98).

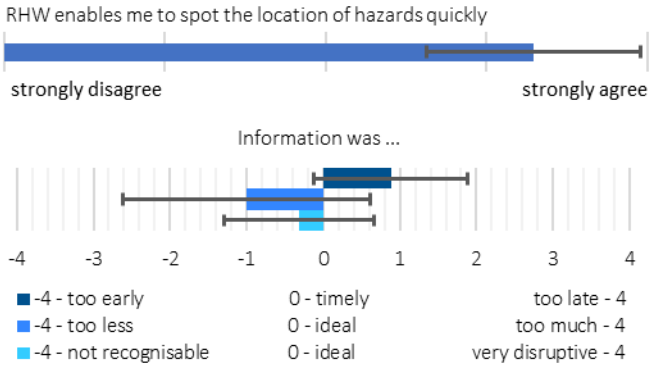


Figure 14 RHW - BCN Post Questionnaire Results

Integration of results and conclusions

RHW (and RWW, as both were evaluated together) at BCN is considered very useful by the users, the average rating meets expectations from the pre-questionnaire and the user training. Nevertheless, users wish to get a bit more information and would like get this a little earlier.

3.4.1.2.North Brabant deployment (large-scale deployment)

RHW service is deployed in The Netherlands through the so-called Talking Traffic infrastructure. As a result, the service operates national wide. The users are (mainly) employees from the City of Helmond and the TNO office in Helmond. It concerns a restricted user group, and 44 participants have downloaded the app from the Google play store through a personal link since the app for North Brabant has not been published publicly due to privacy restrictions.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

29 participants (12 female) filled the first questionnaire. The mean age of these participants were 44 years (SD = 10 years). The results showed that participants are familiar (M = 2.64; SD = 1.37) with this service but never used it before. Based on the service description, participants think that this service would be useful (M = 3.61; SD = 0.67) for their daily driving and stated that they would use (M = 3.68; SD = 0.71) this service once it is available.

/ Post-Questionnaire (Experience)

25 participants (9 female) shared their actual experience. The mean age of these participants were 48 years (SD = 9 years). The results are presented on Figure 15. The results showed that participants tended to agree with a tendency towards neutral (neither agree nor disagree) that RHW enabled them to spot the location of hazards quickly (M = 3.54; SD = 0.75), that RHW increases traffic safety (M = 3.56; SD = 0.61), that RHW supported their understanding of the situation (M = 3.60; SD = 0.49) and after receiving an RHW notification, they immediately know what to do (M = 3.50; SD = 0.73). Participants tended to neither agree nor disagree that they feel safe while using RHW (M= 3.16; SD = 0.73), that RHW worked reliably and faultlessly (M = 2.72; SD = 1.00) and that they kept RHW activated while driving (M = 3.04; SD = 1.08). Usually, information from RHW was received timely (M = 0.40; SD = 1.43). The amount of displayed information was perceived as ideal (M = -0.64; SD = 1.23) with a tendency towards "less". Usually, the signals/notifications sent by RHW was perceived as ideal (M = 0.00; SD = 0.89).

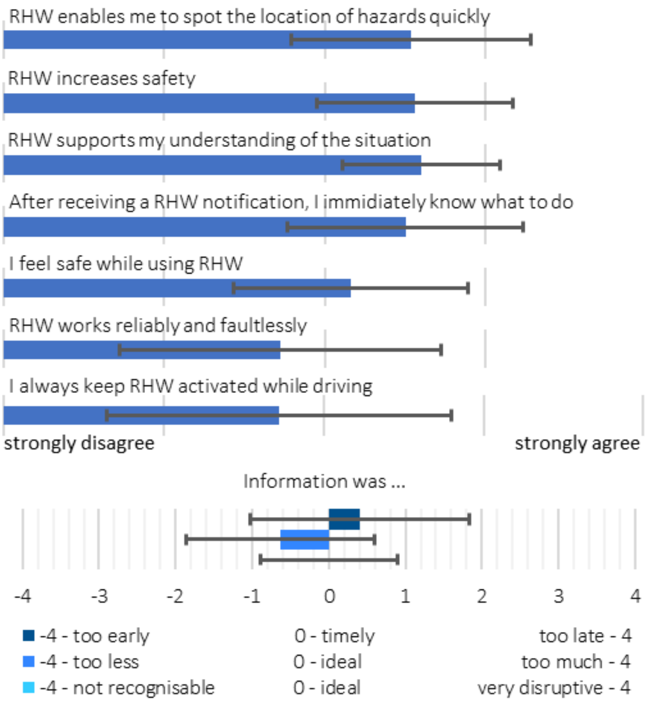


Figure 15: RHW - NBR Post Questionnaire Results

Two respondents explicitly stated that indicated incidents do actually not occur on the street. They imply that this might happen due to insufficient positioning accuracy and that such invalid notifications probably should apply to a nearby event, e.g. on a parallel street.

Integration of results and conclusions

In North Brabant, the usefulness of RHW (and RWW, as both were evaluated together) is rated good and almost exactly meets the expectations from the pre-questionnaire. Information presentation occurs to be almost ideal, while there are slight tendencies that users wish to have more and earlier information. Furthermore, the users consider the reliability of the service as subpar. This finding is supported by two respondents who explicitly complain about invalid notifications. Technical investigations are needed in order to assess if this comes from positioning inaccuracy, errors in the data fed to the app, or other currently unknown issues.

3.4.2. RHW by NeoGLS

Bordeaux DS implements RHW service using both cellular and G5 communication. The road-hazard information comes from the « Bison Futé » database called « TIPI » (and provides road-hazard on highways and inter-urban roads). It provides information about vehicle breakdowns, accidents, degraded roads, closed roads, etc. When driving towards a hazardous situation, the driver will be warned and will know the distance to the hazard. The service aims to let the driver react on time and adapt his speed.

Figure 16: NeoGLS RHW interface

3.4.2.1. Bordeaux deployment (large-scale deployment)

The area covered by the RHW use case in Bordeaux DS is the ring-road and the highways around the city.

The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

12 participants (6 female) shared their actual experience through the short questionnaire. The mean age of these participants were 46 years (SD = 11 years). The results are presented on Figure 17. Participants tended to agree that RHW enabled them to spot the location of hazards quickly (M = 3.50; SD = 0.64). Usually, information from RHW was received timely (M = 0.67; SD = 1.25) with a tendency towards "late". The amount of displayed information was perceived as ideal (M = -0.33; SD = 1.31). Usually, the signals/notifications sent by RHW was perceived as ideal (M = -0.08; SD = 0.86).

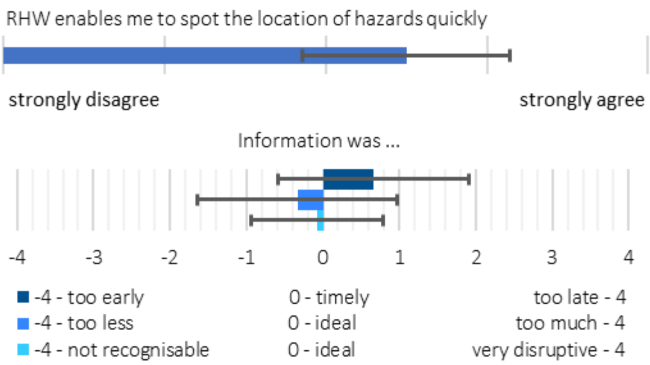


Figure 17: BOD – RHW Post Experiment Questionnaire

Integration of results and conclusions

RHW in Bordeaux is clearly perceived as useful and information presentations occurs to be almost ideal.

3.4.2.2. Bilbao deployment (large-scale deployment)

Bilbao deployment is fed from the Open Data platform for the Municipality. NeoGLS reads this data and distributes the C-ITS messages through Bilbao's Geo-messaging server. The service covers the entire urban area.

The target users for this service are any motorized users from the city area. Within the project some users were specifically engaged such as municipality's maintenance vehicles who normally circulate in the city during their working day.

The first group of users consisted of 7 users. However, after a short time they reported high battery consumption and their feedback prevented the collection of new users. In May 2021 NeoGLS reported 5 active users from Bilbao DS.

Subjective service evaluation

6 participants (2 female) shared their actual experience through the short questionnaire. The mean age of these participants were 43 years (SD = 10 years). The results are presented on Figure 18. Participants said that RHW enabled them to spot the location of hazards quickly (M = 4.17; SD = 0.37). Usually, information from RHW was received timely (M = 0.17; SD = 1) with a tendency towards "late". The amount of displayed information was perceived as ideal (M = -0.67; SD = 0.75) with a tendency towards "less". Usually, the signals/notifications sent by RHW was perceived as ideal (M = -1.20; SD = 1.17) with a tendency towards "not recognisable".

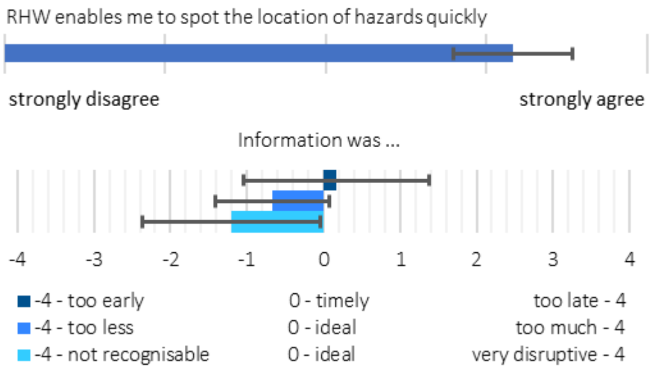


Figure 18: BIL - RHW Post Experiment Questionnaire

Integration of results and conclusions

The usefulness of NeoGLS' RHW service in Bilbao is rated very good and even higher than in Bordeaux. Information presentation was considered timely but tendentially could offer more content and should occur more conspicuous.

3.4.2.3. Newcastle deployment (large-scale deployment)

The RHW data comes from the Tyne and Wear open data services, which is published periodically and converted into the appropriate format for use by ITS-G5 as well as 4G customers. The data is formatted and delivered via the NeoGLS CTD – Connected Mobility App.

The service is available across the seven mostly urban areas of the Tyne and Wear region (Newcastle, Gateshead, Sunderland, North Tyneside, South Tyneside - collectively 1 million population). It is also available on trunk roads across the whole north east region of England, with large areas of rural nature covered.

Currently, the North East Ambulance Service (NEAS) non-emergency patient transfer vehicles and some private motorists use the service. Selected drivers at NCC are also using the service; 38 in total. The private motorists are carefully selected because NCC does not wish CITS services to be available to all private motorists at the current time.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

12 participants (2 female) filled the first questionnaire. The mean age of these participants were 52 years (SD = 7 years). The results showed that participants heard about this or a similar service (M = 2.08; SD = 1.19). Based on the service description, participants think that this service would be useful (M = 3.92; SD = 0.76) for their daily driving and stated that they would use (M = 3.75; SD = 0.60) this service once it is available.

/ User Training (Expectation)

9 male participants joined the user training. The mean age of these participants were 48 years (SD = 11 years). The results showed that participants are familiar (M = 3.33; SD = 1.05) with this service or a similar service but

never used it before. Based on the service description, participants think that this service would be useful (M = 4.11; SD = 1.29) for their daily driving and stated that they would use (M = 4.22; SD = 0.79) this service once it is available.

After the user training the majority of participants expect that the RHW will enable them to spot the location of hazards quickly (M = 4.00; SD = 0.71), that RWW will support their understanding of the situation (M = 3.75; SD = 0.66), that after receiving a RHW notification, they will immediately know what to do (M = 4.00; SD = 0.71), that they feel safe while using RHW (M = 3.88; SD = 0.78), and they intent to keep RHW activated while driving (M = 3.50; SD = 1.22). The amount of displayed information was perceived as ideal (M = -0.38; SD = 1.30).

/ Post-Questionnaire (Experience)

Only 2 participants (1 female) shared their actual experience through the short questionnaire. The mean age of these participants were 51 years (SD = 6 years). The results are presented on Figure 19. Participants neither agree nor disagree that RHW enabled them to spot the location of hazards quickly (M = 3.00; SD = 1.00). Usually, information from RHW was received late (M = 2.50; SD = 0.50). The amount of displayed information was perceived as ideal (M = 0.0; SD = 0.0). Usually, the signals/notifications sent by RHW was perceived as ideal (M = 0.0; SD = 0.0).

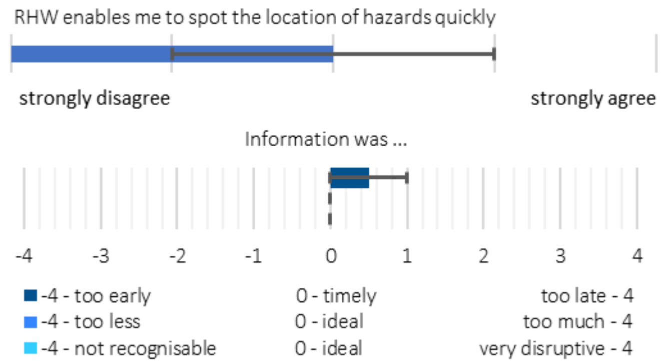


Figure 19: NEW – RHW Post Experiment Questionnaire

Integration of results and conclusions

Since only 2 participants shared their experience no conclusions should be drawn on RHW in Newcastle.

3.4.3. RHW by CERTH

The RHW service provided by the CERTH App has the objective to inform drivers driving in the road network of Thessaloniki DS about dangerous locations and situations. The target is to facilitate in more attentive driving and increase timely the awareness of the drivers about the hazardous locations and situations. The information provided by RHW include weather conditions information and locations where cyclists ride.

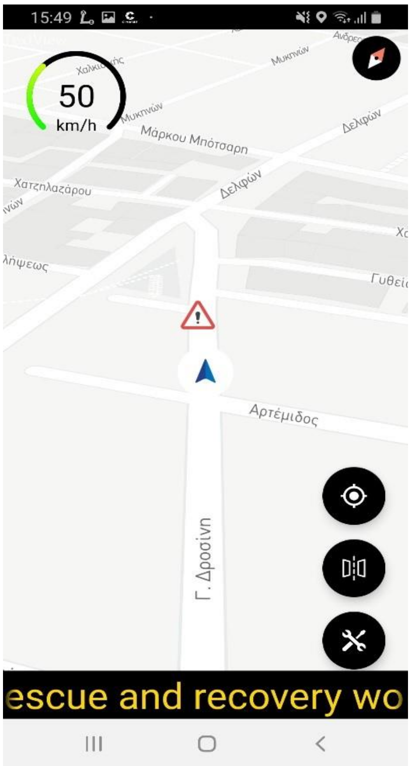


Figure 20: RWW service – CERTH app

3.4.3.1. Thessaloniki deployment (large-scale deployment)

The RHW information provide weather conditions information and the locations where cyclists ride in the road network of Thessaloniki. Weather conditions information are up to date and dynamic as this is collected by OpenWeatherMap (https://openweathermap.org) API for the city of Thessaloniki and then provided to the users via notifications in the HMI of their personal devices. The locations of cyclists are based on the information being available for the bicycles' network in Thessaloniki. The purpose is to inform the driver via a notification when he/ she drivers along a road where bicycles' network exists as well. The following figures depict the location s where RHW service is provided.

Subjective service evaluation

/ User Training (Expectation)

10 participants (2 female) joined the user training. The mean age of these participants were 50 years (SD = 22 years). The results showed that participants are familiar (M = 3.38; SD = 1.67) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful for their daily driving (M = 4.31; SD = 1.62) and stated that they would use this service once it is available (M = 4.46; SD = 1.64).

After the user training the majority of participants (strongly) expect that the RHW will enable them to spot the location of hazards quickly (M = 4.50; SD = 1.82), that RHW will support their understanding of the situation (M = 4.50; SD = 1.82), that after receiving a RWW notification, they will immediately know what to do (M = 4.50; SD = 1.82), that they feel safe while using RWW (M = 4.40; SD = 1.78), and they intent to keep RWW activated while driving (M = 4.40; SD = 1.78). The amount of displayed information was perceived as ideal (M = 0.90; SD = 2.57) with a tendency towards much.

/ Post-Experiment (Experience)

14 participants (4 female) shared their actual experience through the short questionnaire. The mean age of these participants were 43 years (SD = 8 years). The results are presented on Figure 21. Participants tended to agree that RHW enabled them to spot the location of hazards quickly (M = 4.00; SD = 0.65). Usually, information from RHW was received timely (M = 0.23; SD = 1.12). The amount of displayed information was perceived as ideal (M = -0.29; SD = 1.10). Usually, the signals/notifications sent by RHW was perceived as ideal with a tendency towards "not recognisable" (M = -0.50; SD = 1.05)

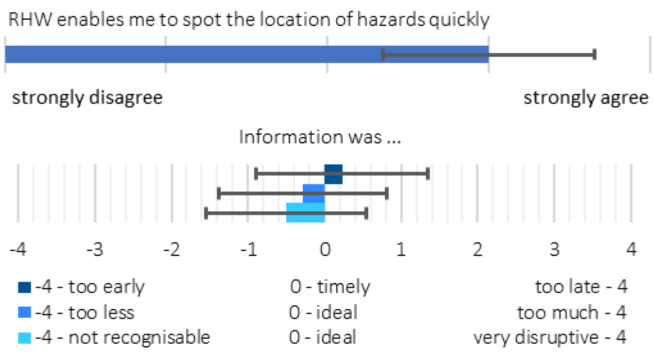


Figure 21: THE – RHW Post Experiment Questionnaire

Integration of results and conclusions

Perceived usefulness of RHW in Thessaloniki is high and information presentation is considered almost ideal. Notifications could be a bit more conspicuous.

3.4.4. RHW by CTAG

Road Hazard Warning provides all related information about the service. Starting with a notification in the top-right margin where we can see the icon of the event, traffic congestion in this example, and followed by the distance in meters from our placeholder to the start of the event. Moreover, on map we can see a little POI (Point of interest) indicating where exactly starts the event geographically. With these two items, notification plus POI, we achieve an accurate representation showing all the available and necessary data of the warning nearby.

Figure 22: RHW notification from C-MobILE Vigo app

3.4.4.1. Vigo deployment (large-scale deployment)

The information provided by the RHW service related to weather conditions on the road network in the Vigo area are from the data provided by the DGT, HereWeGo, BingMap and our ITS Centre. This data is processed to obtain updated information in the C-MobILE application available to users. The aim is for this service to be useful to drivers and allow them to react in time to conditions and adapt their speed accordingly.

This service is available within the SISCOGA4D corridor, which includes urban and interurban areas in the area of influence of the city of Vigo. The service has been enabled for all user groups (cars, motorbikes, emergencies, buses, trucks and vans) from the mobile application provided through the mobile devices delivered; a total of 80 recruited users. For all services a specific application has been developed allowing to include a baseline mode for the recruited users from where the results are received, analysed and evaluated. Another “regular” version of the application is available for free download in the Play Store which also offers this service to the general public.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

47 participants (9 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 9 years). The results showed that participants are familiar with this service but never used it before (M = 2.65; SD = 1.13). Based on the service description, participants think that this service would be useful (M = 4.25; SD = 0.75) for their daily driving and stated that they would use (M = 4.40; SD = 0.53) this service once it is available.

/ Post-Questionnaire (Experience)

25 participants shared their actual experience with this service. The mean age of these participants was 37 (SD = 9 years). The results are shown on Figure 23. The results showed that participants tended to agree that RHW enabled them to spot the location of road works quickly (M = 4.02; SD = 0.87), that RHW increased safety (M = 4.04; SD = 0.71), that RHW supported their understanding of the situation (M = 3.83; SD = 0.88), that after they receive a RHW notification, they immediately know what to do (M = 3.62; SD = 0.74), that they feel safe while using RHW (M = 3.52; SD = 0.85) and that they keep RHW activated while driving (M = 4.00; SD = 0.66). Participants neither agree nor disagree that RHW worked reliably and faultlessly (M = 3.04; SD = 0.73). Usually, information from RHW was received timely (M = 0.28; SD = 1.04). The amount of displayed information was perceived as ideal (M = -0.29; SD=1.46). Usually, the signals/notifications sent by RHW was perceived as ideal (M = 0.08; SD = 1.55).

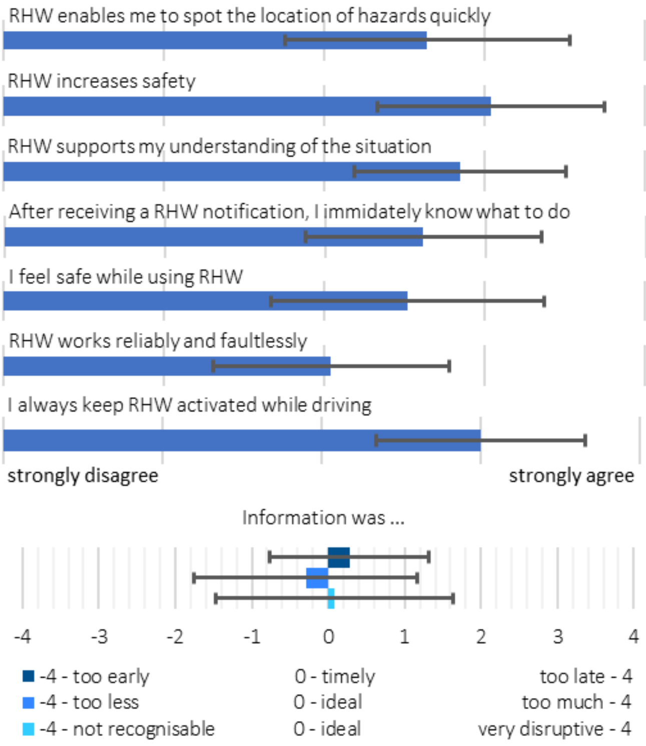


Figure 23: VIG – RHW Post Questionnaire Results

Integration of results and conclusions

CTAG's RHW is rated very positive by the users while the reliability of the service leaves room for improvement. Information presentation assessment is rather widely distributed but very close to ideal on average.

3.4.5. RHW by Technolution

Like RWW, RHW is an icy roads warning, which is supplied by the same app (GreenCatch) as the GLOSA, CTLV, RWW and WSP services. A small warning pops up below the GLOSA information when road surface temperatures are below freezing.

3.4.5.1.Copenhagen deployment (large-scale deployment)

With regard to coverage, UI, and user groups, the RHW was very similar to the RWW as deployed in Copenhagen. In Copenhagen the RHW was developed as a “Icy Roads Warning” intended to warn road users of potentially slippery roads. The data source was different than RWW, as the data was gathered from the National Access Point of Denmark, as opposed to the City of Copenhagen open data database. But the data itself came from street level temperature sensors on various location in Copenhagen.

Though there were a number of very cold days in the beginning of 2021, where, under normal circumstances, there would have been much data collected, the lockdown most likely has resulted in few users commuting regularly or even venturing out on car or bicycle in this period.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

10 participants (5 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 8 years). The results showed that participants are familiar with this service but never used it before (M = 2.50; SD = 1.02). Based on the service description, participants tended to agree that this service would be useful (M = 4.00; SD = 0.45) for their daily driving and that they would use (M = 4.00; SD = 0.45) this service once it is available.

Integration of results and conclusions

Since no responses on actual service experience were gathered user acceptance cannot be assessed.

3.4.6. Summary and comparison of different service versions and deployments

From the deployments evaluated there are only slight differences. Over all implementations and DS, RHW is well received by the users. The service is perceived as (very) useful and most HMIs were considered to provide information in an almost ideal manner. Nevertheless, there seems to be a general potential for improving the reliability of the service—especially regarding false positive notifications—as it turned out for the DS that used the full questionnaire version as well as from a few users’ comments on the service. This should be further investigated.

3.5. Emergency Vehicle Warning (EVW)

Emergency vehicle warning uses information provided by the emergency vehicle to inform a driver of another vehicle about an approaching emergency vehicle even when the siren and light bar of the emergency vehicle may not yet be audible or visible. This is also known as "Emergency Vehicle Alert (EVA)", which alerts the driver about the location and the movement of public safety vehicles responding to an incident so the driver does not interfere with the emergency response. The service is enabled by receiving information about the location and status of nearby emergency vehicles responding to an incident.

3.5.1. EVW by IDIADA

The Emergency Vehicle Warning service available in the Barcelona DS informs the user about the presence of emergency vehicles from the Firefighters fleet only in case of an emergency. The emergency vehicles report their position every second and this translates into a warning containing the distance from the user to the emergency vehicle and the relative direction. With this information, the user can preventively know where the emergency vehicle is coming from within a range of 200m, giving time enough for giving way even before they can hear the siren or see the vehicle.

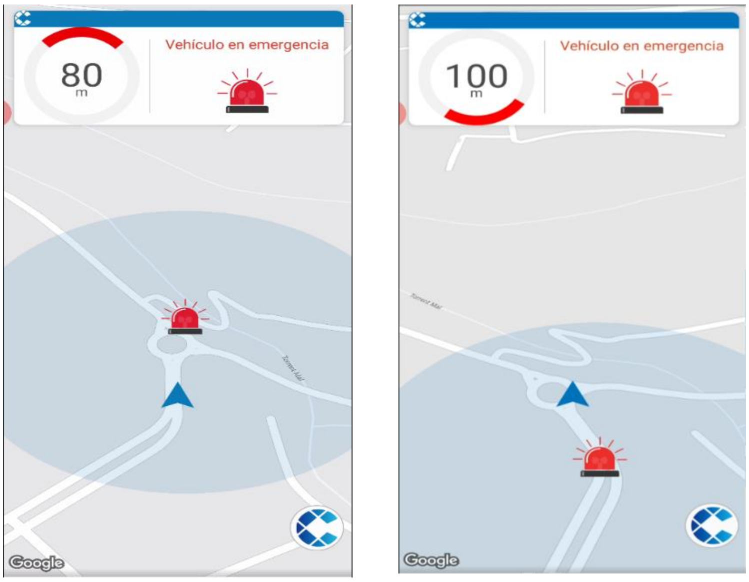


Figure 24: EVW service interface from C-MobILE Barcelona app

3.5.1.1. Barcelona deployment (large-scale deployment)

The EVW service is deployed within the Firefighters' operation area, which covers practically the entire Barcelona DS area. All kinds of users can receive the warning, including pedestrians. The service informs only when the emergency vehicles are closer than 200m with respect to the user. Nearly 900 active users enjoy this service, while 2000 have tested the service since the beginning of the deployment.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years. The results showed that participants heard (M = 2.22; SD = 1.24) about this service or a similar service. Based on the service description, participants think that this service would be useful (M = 3.97; SD = 1.13) for their daily driving and stated that they would use (M = 4.03; SD = 0.95) this service once it is available.

/ Pre-Questionnaire – User training (Expectation)

57 participants (17 female) joined the user training. The mean age of these participants were 44 years (SD = 11 years). The results showed that participants heard about this service (M = 1.96; SD = 0.97) or a similar service. Based on the service description, participants think that this service would be useful (M = 4.11; SD = 0.91) for their daily driving and stated that they would use (M = 4.20; SD = 0.87) this service once it is available. After the user training the majority of participants thought that the EVW make it easier for them to prepare when an emergency vehicle is approaching (M = 4.20; SD = 0,63).

/ Post-Questionnaire (Experience)

14 participants (1 female) shared their actual experience through the short questionnaire. The mean age of these participants were 51 years (SD = 12 years). The results are presented on Figure 25. Participants said that EVW make it easier for them to prepare when an emergency vehicle is approaching (M = 4.17; SD = 0,69). Usually,

information from EVW was received timely (M = 1.64; SD = 1.55) with a tendency towards "late". The amount of displayed information was perceived as ideal (M= -0.45; SD = 0.78). Usually, the signals/notifications sent by EVW were perceived as ideal (M = -0.83; SD = 1.21) with tendency towards "not recognisable".

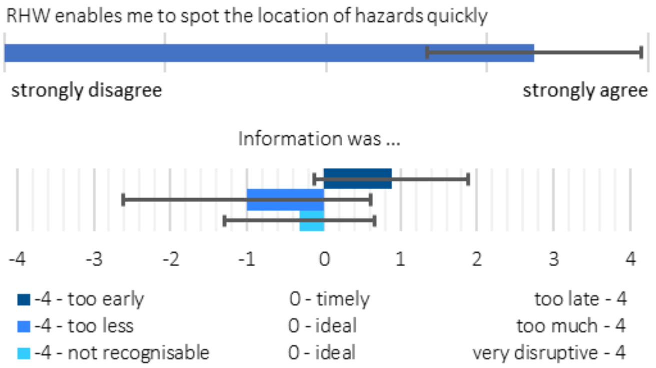


Figure 25: EVW - BCN Post Questionnaire Results

Integration of results and conclusions

EVW is perceived as very useful in BCN and information presentation is rated close to ideal. Expectations from pre-questionnaires and a user training were met. Nevertheless, there is a clear tendency that users would like to receive more information earlier.

3.5.2. EVW by Dynniq (ITS-G5)

Emergency vehicle warning uses information provided by the emergency vehicle to inform a driver of another vehicle about an approaching emergency vehicle even when the siren and light bar of the emergency vehicle may not yet be audible or visible. This is also known as "Emergency Vehicle Alert (EVA)", which alerts the driver about the location and the movement of public safety vehicles responding to an incident so the driver does not interfere with the emergency response. The service is enabled by receiving information about the location and status of nearby emergency vehicles responding to an incident.

The main goal of EVW is to decrease the emergency services' response time, since the warnings received by the road users about the presence of an EV intend to provide the relevant information timely for giving way as soon as possible. In urban roads the warnings from EVW may not always be relevant for all road users, since the EV can be approaching from different directions/roads/lanes where the users are not interfering with the EV route, but they are useful in any of the cases to increase the awareness of the situation. Like the Green Priority service, the EVW is especially relevant for emergency service managers, since they see how the fleet increases the capabilities of telling other drivers to give way, which has a direct impact on the services' response times

3.5.2.1. North Brabant deployment (large-scale deploymentlarge-scale deployment)

The city of Helmond has equipped more than 30 intersections with traffic light controllers with hybrid communication technology. All of these intersections provide the services GLOSA, EVW, and SVW, which are connected to the nation-wide cellular infrastructure offered by Talking Traffic, while ITS-G5 communication is used also for vehicles equipped with OBUs. Additionally, GP is provided for ITS-G5-equipped trucks and emergency vehicles. Only on specific routes truck drivers get priority, to avoid the route through the city centre. All equipped intersections in Helmond, except three intersections on the main East-West traffic artery (N270) in the inner-city centre, run GP for emergency vehicles. The OBUs installations in selected vehicles (heavy duty vehicles, emergency vehicles, ambulances, fire brigade vehicles, and police cars) were performed either by the supplier of the equipment or the company owning the vehicles. Most of these vehicles were equipped with OBUs in previous C-ITS projects and have had a software update to accommodate C-MobILE.

Figure 26: EVW service interface from Dynniq app

The emergency vehicle warning service is a vehicle-to-vehicle service based on DENM messages via ITS-G5. Both logistic vehicles and emergency vehicles are equipped with ITS-G5 on-board units for Green Priority services. The logistic vehicles receive the emergency vehicle warnings for fire trucks or police cars. The chance that vehicles of both types meet in an emergency situation is slim. Nevertheless 42 events occurred in a single month (February 2021).

The driver of the logistic vehicle receives a first warning when the emergency vehicle is still 300 meters away and approaching. The driver is continuously informed about the distance and orientation of the approaching emergency vehicle. When the emergency vehicle passes the logistic vehicle from ahead or from behind, the logistic vehicle typically reduces speeds to below 20 km/h or stand still, for example in a queue for the stop line. When the emergency vehicle passes only at a distance of 100 or more meters, for example on a parallel road, the logistic vehicles do not reduce speeds.

Subjective service evaluation

/ Post-Questionnaire (Experience)

4 professional drivers shared their actual experience. The results are presented on Figure 27Figure 25. Participants tended to neither agree nor disagree that EVW makes them to identify the location of the emergency vehicle quickly (M =3.17 ; SD = 0.37), that EVW make it easier for them to prepare when an emergency vehicle is approaching (M = 3.00; SD = 0.00), that EVW supported them to respond to an approaching EV quickly (M = 3.00; SD = 0.00), that EVW supported their understanding of the situation (M = 3.00; SD = 0.00), after receiving an notification, they immediately know what to do (M = 3.17; SD = 0.37), that they feel safe while EVW is activated (M = 2.83; SD = 0.69), that EVW works reliably and faultlessly (M = 2.50; SD = 0.50) and that they keep EVW always activated while driving (M = 2.83; SD = 0.69). Usually, information from EVW was received timely (M = 0.50; SD = 1.22) with a tendency towards “late”. The amount of displayed information was perceived as ideal with a tendency towards “much” (M= 0.83; SD = 1.21). Usually, the signals/notifications sent by EVW were perceived as ideal (M = -0.67; SD = 0.75) with tendency towards “disruptive”.

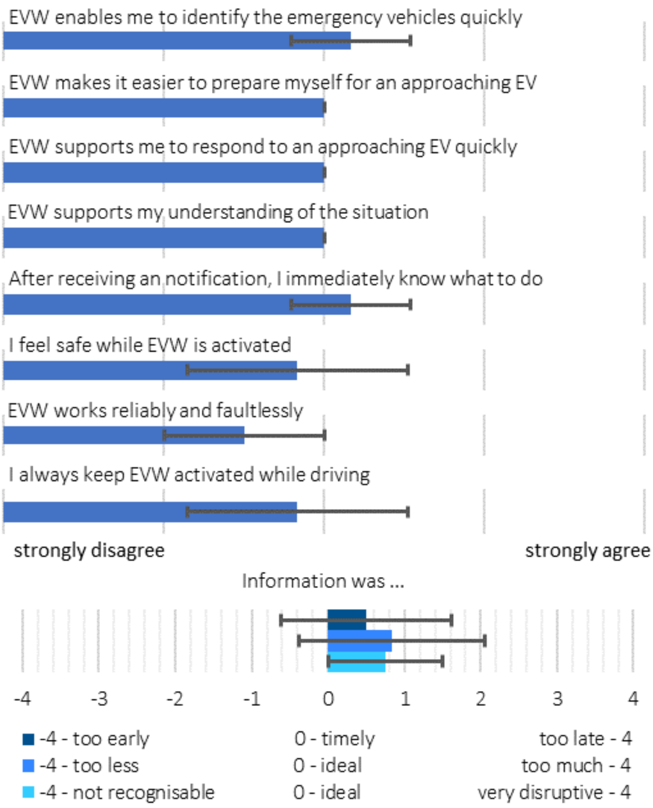


Figure 27: NBR - EVW Post Questionnaire Results Prof. Drivers

Integration of results and conclusions

EVW on ITS-G5 OBUs is rated fair but seems to lack a bit of reliability. The notifications occur to be tendentially too late, slightly overloaded, and a little disruptive but not far from ideal. Since this outcome is only based on four user responses these tendencies should not be overrated. A larger sample should help to gain more clarity if modifications to the HMI are actually needed.

3.5.3. EVW by CERTH (PoC)

The service is implemented in small scale as proof of concept. For this purpose, the operation as well as the evaluation of the service is supported through its development in a simulation environment. More specifically, the use case under testing includes 1 emergency vehicle, 1 or more connected vehicles, and the evaluation of a single emergency vehicle. This service will be simulated in combination with the service Green Priority. Thus, no subjective user evaluation data is available.

3.5.4. EVW by CTAG

Emergency Vehicle Warning provides the user all related information about the event. Starting with a notification in the top-right margin where we can see the icon of the event and followed by a little POI (Point of interest) on map indicating where exactly the vehicle is moving around us geographically each second. Besides, a halo is shown in one of the 4 cardinal points alerting us where the vehicle is approaching. With these three items, we achieve an accurate representation showing all the available and necessary data of the warning nearby.

Figure 28: EVW notification from C-MobILE Vigo app

3.5.4.1. Vigo deployment (PoC)

This service has been implemented both in the SISCOGA4D corridor and on a small scale as a proof of concept. In the SISCOGA4D corridor for the 80 recruited users. As PoC a simulation was performed in a controlled environment on tracks with an emergency vehicle and different connected vehicles evaluating the acceptance of services by the users involved during the tests. The total users involved in the controlled small-scale test were 16. The decision was made because the available emergency users could not be matched with other C-MobILE users and a small-scale deployment also allows for a second assessment and analysis of results. The results are included in D6.4.

Subjective service evaluation

The main objective of this study was to analyse the experience of 16 participants driving a car using EVW service, first, they must drive without the information of this service while an EV was approaching to participant car. Later in the second round, drivers had EVW information in a mobile. This test was a first approaching to define the behaviour of the car in both situations and the subjective perception of drivers was evaluated. Then it is important also to highlight that more studies and test will be necessary for generalizing the results and for improving it. Mainly it would be important to develop naturalistic test to evaluate it.

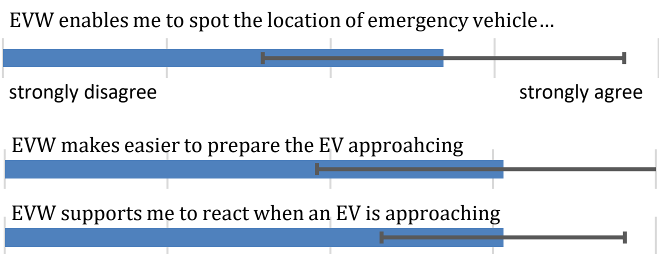
In general, participants had no knowledge about C-ITS services, and they have not heard about this service, anyway they considered that it would be useful, and they would use it even before testing EVW. No definitive trend can be defined regarding to workload for using this service, more tests are needed for defining it. It seems comfort and safety are important features of the EVW for this sample. As pointing out for Hsiao et al. (2018) time pressure is judged one of the most dangerous task characteristics of emergency vehicle driving[1].

/ Pre-Questionnaire (Expectation)

16 participants filled the first questionnaire. 16 participants (6 female) provided demographical information. The sample is young: around half of them are between 25-34 years old (56,25%) and around 35% between 35 and 50 years old. They have not heard about EVW (81%), only two participants have understood about the service and only one used it several times. Based on the service description, participants think that this service would be useful (*M* = 4.25; *SD* = 0.85) for their daily driving and stated that they would use (*M* = 3.81; *SD* = 0.83 this service once it is available.

/ Post-Questionnaire (Experience)

16 participants (1 female) shared their actual experience through the short questionnaire. The sample is young: around half of them are between 25-34 years old (56,25%) and around 35% between 35 and 50 years old. The results are presented on Figure 14. Participants said that EVW enabled them to spot the location of emergency vehicle quickly (*M* = 3,69; *SD* = 1,10). Usually, information from EVW was received ideal (*M* = 1.75; *SD* = 0.56) with a tendency towards "too late". The amount of displayed information was perceived as ideal (*M* = 1,69; *SD* = 0,46) with a tendency towards "less". For them, EVW makes easier to prepare the EV approaching (*M* = 4.06; *SD* = 1.10). They considered that EVW supports me to react when an EV is approaching (*M* = 4.56; *SD* = 0.75). Drivers thought that EVW helps me to understand the situation (*M* = 3.94; *SD* = 0.84). Finally, after receiving EVW information, they know what they have to do (*M* = 3.50; *SD* = 0.79).



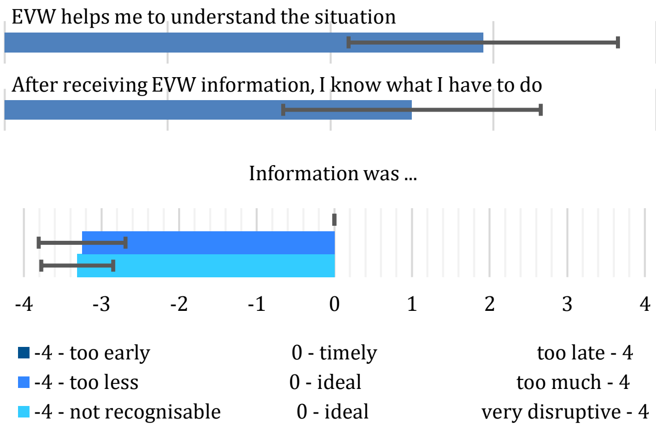


Figure 29: EVW - Vigo Post Questionnaire Results

Integration of results and conclusions

With the use of this service, drivers had the feeling that they know how to react when an EV is approaching and therefore, it supports to prepare themselves to provide free way to the EV. Facilitating the way to these vehicles would probably help emergency drivers to deal with their driving reducing time and risks. This information that could help drivers to deal with this situation arrived just in time. Users would prefer to have more information. Concretely, some participants stated that they would appreciate to have more specific information as distance or time for arriving the EV. This could be improved with a sound or a vocal warning.

3.5.5. Summary and comparison of different service versions and deployments

In the only large-scale deploymentlarge-scale deployment of EVW with an interpretable amount of responses the service is perceived as very useful and information presentation is rated close to ideal. Nevertheless, there is a clear tendency that users would like to receive more information earlier.

In an experiment at a closed track the service was similarly appreciated by the users. However, they demanded that the warning would be more conspicuous and to get more concrete information on the distance to the EV. Enhancing the HMI in this respect occurs to be strongly recommended.

3.6. Signal Violation Warning (SVW)

Signal Violation Warning aims to reduce the number and severity of collisions at signalised intersections by warning drivers who are likely -due to high speed- to violate a red light. Also known as the "Signal violation / Intersection Safety" or "Red Light Violation Warning".

3.6.1.SVW by IDIADA

This is an extension of the GLOSA service where the users are alerted when they are about to pass the traffic light in red unless an immediate reaction is performed to avoid it. This service is implemented in the C-MobILE Barcelona app with a stop sign shown in the relevant lane, while the rest of the GLOSA information is present at the same time. A sound is also played when the SVW applies in order to demand a user reaction.

Figure 30: SVW notification from C-MobILE Barcelona app

3.6.1.1. Barcelona deployment (large-scale deploymentlarge-scale deployment)

The service is available for drivers and motorcyclists in the 30 GLOSA intersections placed at the entrance and city centre of Barcelona. The locations of such intersection have been chosen to maximize the impact based on their good location, high amount of daily traffic and simple layout.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years). The results showed that the majority of the participants never heard (M = 1.38; SD = 0.89) anything about this service or a similar service. Based on the service description, participants think that this service would be useful (M = 3.78; SD = 1.05) for their daily driving and stated that they would use (M = 3.91; SD = 0.95) this service once it is available.

/ Post-Questionnaire (Experience)

3 male participants shared their actual experience through the short questionnaire. The mean age of these participants were 46 years (SD = 12 years). The results are presented on Figure 31. Participants said that SVW did not effectively prevented them from making red light violations (M = 2.33; SD = 0.94). Usually, information from SVW was received timely (M = -0.67; SD = 2.49) with a tendency towards “early”. The amount of displayed information was perceived as ideal (M= 0; SD= 0). Usually, the signals/notifications sent by SVW were perceived as not recognizable (M = -1.67; SD = 1.67).

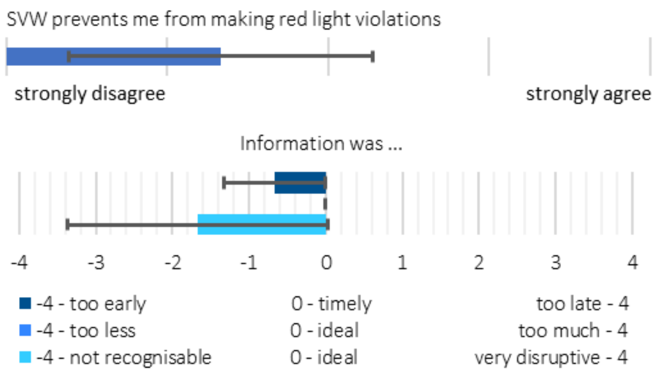


Figure 31: SVW - BCN Post Questionnaire Results

Integration of results and conclusions

From those three respondents who actually experienced the service SVW is perceived not very useful for preventing red light violations. They consider the warning hardly recognisable and its occurrence as tendentially too early. The service clearly falls behind expectations. A larger sample for drawing profound conclusions is certainly needed.

3.6.1.2.North Brabant deployment (large-scale deployment)

The service is deployed in The Netherlands through the so-called Talking Traffic infrastructure. As a result, the service operates national wide at equipped intersections, of which the highest density can be found in Helmond (around 50). The users are (mainly) employees from the City of Helmond and the TNO office in Helmond. It concerns a restricted user group, and 44 participants have downloaded the app from the Google play store through a personal link since the app for North Brabant has not been published publicly due to privacy restrictions.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

6 participants (1 female) filled the first questionnaire. The mean age of these participants were 44 years (SD = 13 years). The results showed that the majority of the participants heard (M = 1.50; SD = 0.76) about this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful (M = 3.50; SD = 0.50) for their daily driving and stated that they would use (M = 3.50; SD = 0.76) this service once it is available.

/ Post Questionnaire

16 participants (5 female) shared their actual experience. The mean age of these participants were 48 years (SD =10 years). The results are presented on Figure 32. The results showed that participants tended to neither agree nor disagree that SVW prevented them from making red light violations (M = 2.73; SD = 1.00), that SVW makes crossing signalised intersections safer (M = 3.19; SD = 0.81), that they feel safe while SVW is activated (M = 2.96; SD = 0,98), that SVW works reliably and faultlessly (M = 2.67; SD = 0.90), that they always kept activated while driving (M = 3.00; SD = 1.22). Usually, information from SVW was received timely (M = 0.20; SD = 1.51). The amount of displayed information was perceived as ideal (M =-0.54; SD = 0.93). Usually, the signals/notifications sent by EVW were perceived as ideal (M = 0.21; SD = 1.47).

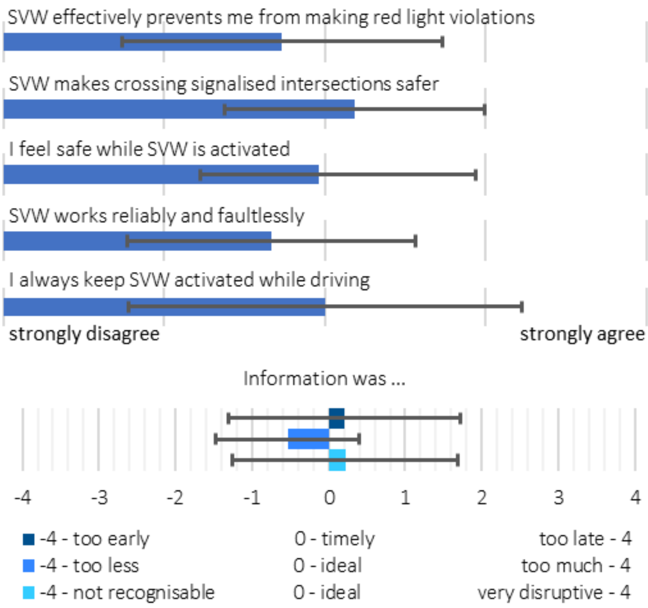


Figure 32: NBR - SVW Post Questionnaire Results

3.6.2. SVW by NeoGLS

The SVW service is warning the driver is closely related to GLOSA. This service is aiming to warn the driver of an imminent red-light violation. The alert is shown when the traffic lights ahead are red and the driver won't be able to stop before arriving to the stop line. The alert shown is intrusive so that the driver is aware of an imminent dangerous situation.

Figure 33: NeoGLS SVW interface

3.6.2.1. Bordeaux deployment (large-scale deploymentlarge-scale deployment)

The area covered by the SVW use case in Bordeaux DS is the same as for the GLOSA service, which represents 588 intersections in the whole urban area. Intersections are located on the main roads of the city.

The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

/ Post-Experiment (Experience)

5 participants (4 female) shared their actual experience through the short questionnaire. The mean age of these participants were 40 years (SD = 10 years). The results are presented on Figure 34. Participants neither agree nor disagree that SVW makes crossing signalised intersections safer (M = 3.20; SD = 0.75). Usually, information from SVW was received timely (M = 1.00; SD = 1.55) with a tendency towards "late". The amount of displayed information was perceived as ideal (M = 0.60; SD = 1.20) with a tendency towards "much". Usually, the signals/notifications sent by SVW were perceived as ideal with a tendency towards "disruptive" (M = 0.60; SD = 1.20).

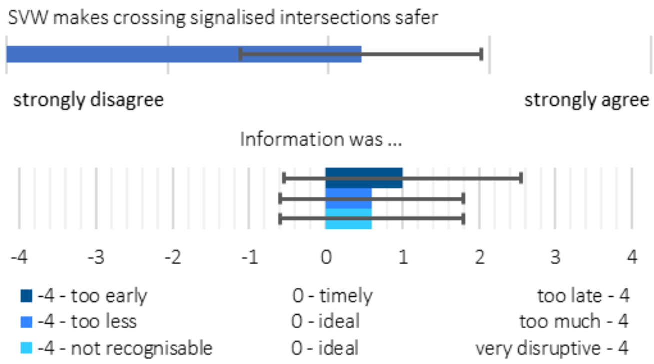


Figure 34: BOD - SVW Post Questionnaire Results

Integration of results and conclusions

SVW in BOD is perceived as useful and information presentation occurs to be tendentially too late but overall almost ideal in average. In any case, the small sample size does not allow robust conclusions.

3.6.3. SVW by CERTH

The SVW service is provided by the CERTH App with the objective to inform the driver when he/ she is about to pass a red light. The service aims to notify drivers timely whether they are about to cross a signalized intersection when the state of the traffic light is ready and subsequently contribute in safety and accidents reduction. The following figure presents the notification provided in the drivers' HMI for the SVW service.

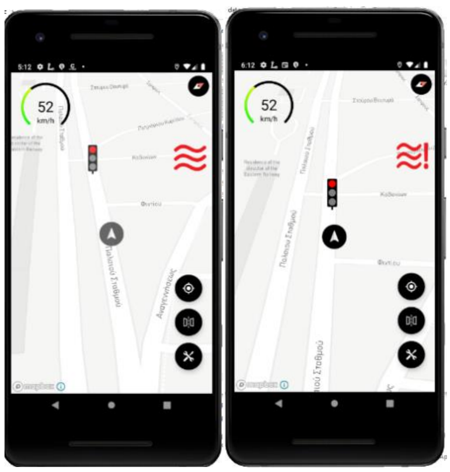


Figure 35: SVW notification from CERTH app

3.6.3.1. Thessaloniki deployment (PoC)

The SVW service in Thessaloniki DS is provided along a network of signalized intersections in the city center as well as in the western entrance of the city. The data of the traffic lights are collected by CERTH as this information is provided by the technical partners Swarco Hellas and Traffic Technique who are responsible for the operation and maintenance of the respective signalized intersections. Since the information about the state of the traffic lights are dynamically available, the proper message is provided to the drivers according to their driving speed, their location (and time remaining to reach the location of the signalized intersection), and the state of the traffic light. The figure below presents the network of signalized intersections in Thessaloniki DS where the SVW is provided.

Subjective service evaluation

/ Proof of concept

4 participants participated a controlled experiment. The mean age of these participants were 45 years (SD = 2 years). The results showed that the majority of the participants never heard (M = 3.00; SD = 0.71) heard about this or a similar service. Based on the service description, participants think that this service would be useful (M = 4.25; SD = 0.83) for their daily driving and stated that they would use (M = 4.25; SD = 0.43) this service once it is available.

The results of the post experiment questionnaire presented on Figure 36. Participants neither agree nor disagree said that SVW effectively prevents them making red light violations (M = 3.00; SD = 1.22), that SVW effectively saves them from crashing into red light violators (M = 3.25; SD = 1.30), that they feel safe while SVW is activated (M = 3.25; SD = 0.83). Participants tended to agree that SVW makes crossing signalised intersections safer (M = 3.75; SD = 1.09, that they always keep SVW activated while driving (M = 4.00; SD = 0.71). Usually, information from SVW was received timely (M = 0; SD = 0). The amount of displayed information was perceived as ideal (M = 0; SD = 0). Usually, the signals/notifications sent by SVW were perceived as ideal with a tendency towards "not recognizable" (M = -1.00; SD = 1.73).

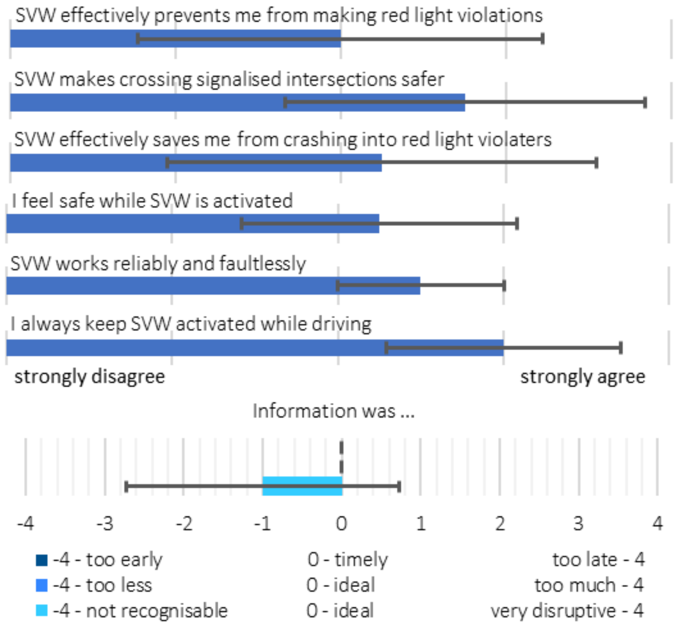


Figure 36: THE – SVW Post Experiment Questionnaire

Integration of results and conclusions

In the Thessaloniki PoC test SVW performance is perceived fair; information timing and amount are considered ideal while the notification could be more conspicuous. Results stem from a small sample of users who experienced the service in a controlled environment which questions their generalizability.

3.6.4. SVW by CTAG

Signal Violation Warning provides the user all related information about the service. As GLOSA extension, user is alerted when they are about to pass the traffic light in red unless an immediate reaction is performed to avoid it. In that way, whenever the conditions to go through the red traffic light are accomplished, C-MobILE receives the message that shows an invasive warning on the full screen accompanied with an alarming sound to inform the user about this infringement.

Figure 37: SVW notification from C-MobILE Vigo app

3.6.4.1. Vigo deployment (large-scale deploymentlarge-scale deployment)

This service is available at all those intersections where the GLOSA service is also available, therefore at a total of 116 intersections in the urban area of Vigo, mainly in the city centre where the highest concentrations of traffic arise. The service has been enabled for all user groups (cars, motorbikes, emergencies, buses, trucks and vans) from the mobile application provided through the mobile devices delivered; a total of 80 recruited users. For all services a specific application has been developed allowing to include a baseline mode for the recruited users from where the results are received, analysed and evaluated. Another "regular" version of the application is available for free download in the Play Store which also offers this service to the general public.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

47 participants (9 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 9 years). The results showed that participants heard about this or a similar service (M = 1.90; SD = 1.16). Based on the service description, participants think that this service would be useful (M = 4.00; SD = 1.06) for their daily driving and stated that they would use (M = 4.17; SD = 0.92) this service once it is available.

/ Post-Questionnaire (Experience)

37 participants shared their actual experience with this service. The mean age of these participants were 37 years (SD = 9 years). The results are presented on Figure 38. Participants mean response were between neither agree nor disagree and agree for the items that SVW did effectively prevented them from making red light violations (M = 3.35; SD = 1.28), that SVS makes crossing signalised intersections safer (M = 3.51; SD = 1.13). Participants neither agree nor disagree that SVW works reliably and faultlessly (M = 2.86; SD = 1.00). Participants indicated that they always kept SVW activated while driving (M =4.09; SD = 0.76). Usually, information from SVW was received timely (M = 0.81; SD = 1.96) with a tendency towards "late". The amount of displayed information was perceived as ideal (M= -0.08; SD= 0.83). Usually, the signals/notifications sent by SVW were perceived as not recognizable (M = 0.19; SD = 1.06).

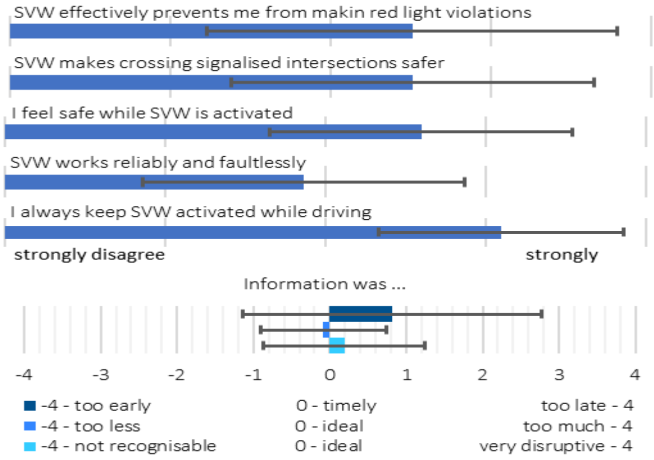


Figure 38: VIG – SVW Post Questionnaire Results

Integration of results and conclusions

In Vigo, SVW is perceived as useful but the rating stays slightly behind expectations which might come from the users' impression that the service is not very reliable. Information amount and conspicuity is considered ideal on average but the warning clearly comes too late in the eyes of the respondents.

3.6.5. Summary and comparison of different service versions and deployments

SVW warnings normally should occur rather infrequently which might limit users' experience with the service. There is no clear picture on the perceived usefulness of SVW, ranging from rather poor through good. This variety is obviously not only a result of the less compelling data from some small samples and/or PoC tests in non-naturalistic environments. Rather, users are questioning the reliability, timing, and conspicuity of warnings. Definitely, the implementations of this service need further investigation and a readjustment in this regard.

3.7.Warning System for Pedestrians (WSP)

Warning system for pedestrian aims to detect risky situations (e.g. road crossing) involving pedestrians, allowing the possibility to warn vehicle drivers. Hence, the warning is based on pedestrian detection. The scope of the service can be extended to cover other VRUs (e.g. cyclists). The service is particularly valuable when the driver is distracted or visibility is poor. Also known as "Vulnerable road user Warning".

3.7.1. WSP by IDIADA

The Warning System for VRUs aims to warn the motorized users about the presence of a vulnerable road user nearby. The users receive an alert very similar with the EVW service where they can easily understand that there is a cyclist close to them, within a range of 15m, when both are in the same dangerous area from Barcelona. The main objective is to increase the awareness of the drivers and motorcyclists about their vicinity and make them pay attention when turning, changing lanes or any other manoeuvre that may invade bike lanes or affect VRUs.

In this case, since both users are already close enough, there is no distance information, but just the relative direction where the VRUs are present, in order to advice the drivers where to look at first when doing a manoeuvre.

Figure 39: WSP service alert from C-MobILE Barcelona (in Spanish)

3.7.2.1. Barcelona deployment (large-scale deployment)

A total amount of 165 intersections have been considered to deploy this WSP service. They are statically dangerous intersections where at least more than 10 incidents involving cars, motorcycles and VRUs have happened in both 2018 and 2019. Since two different users of the app need to be close each other, the chances for this service to apply are low. During the 9 months years of large-scale deployment, almost 100 cyclists have used the app, while 1900 others have done it as drivers or motorcyclists.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years. The results showed that the majority of participants never heard (M = 1.31; SD = 0.58) about this service or a similar service. Based on the service description, participants think that this service would be useful (M = 4.28; SD = 0.84) for their daily driving and stated that they would use (M = 4.28; SD = 0.72) this service once it is available.

/ Post-Questionnaire (Experience)

4 male participants shared their actual experience through the short questionnaire. The mean age of these participants were 46 years (SD = 12 years). The results are presented on Figure 40. Participants said that WSP enabled them to spot the position of pedestrians quickly. (M = 3.75; SD = 0,83). Usually, information from WSP was received timely (M = 0.67; SD = 0.47) with a light tendency towards “late”. The amount of displayed information was perceived as ideal (M=-0.25; SD= 0.43). Usually, the signals/notifications sent by WSP were perceived as ideal (M = 0.33; SD = 0.47).

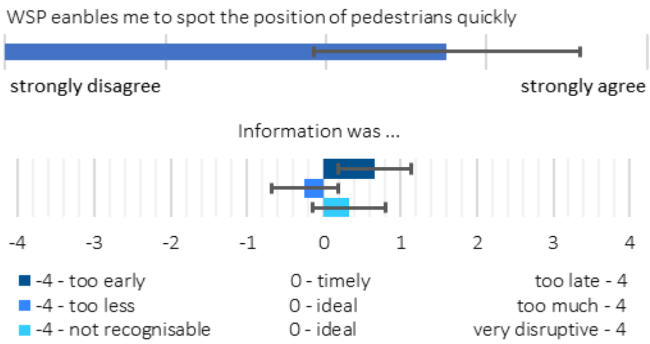


Figure 40: WSP - BCN Post Questionnaire Results

Integration of results and conclusions

Based on only four responses from users who actually experienced WSP in BCN the service is well received regarding usefulness and information presentation. However, expectations from the pre-questionnaire are not met.

3.7.2. WSP by CERTH (PoC)

The WSP service is provided by the CERTH App with the objective to notify drivers when a pedestrian is near to pedestrian crossing and will probably pass it. The information is provided to the driver via a warning notification in the HMI of his/ her personal device and the target is to increase the driver attendance and achieve safety increase and accidents including VRUs reduction. The following figure presents the warning notification provided via the CERTH App for the WSP service.

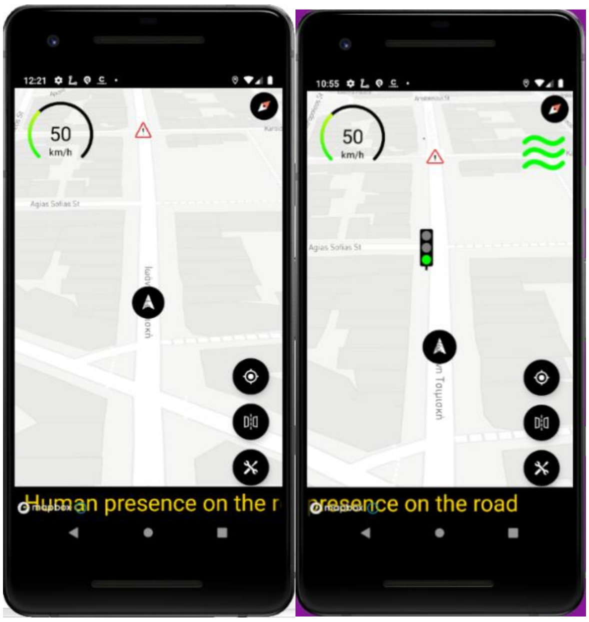


Figure 41: CERTH - WSP interface

3.7.2.1. Thessaloniki deployment (PoC)

The WSP service is provided by the CERTH App with the objective to notify drivers when a pedestrian is near to pedestrian crossing and will probably pass it. The information is provided to the driver via a warning notification in the HMI of his/ her personal device and the target is to increase the driver attendance and achieve safety increase and accidents including VRUs reduction. The figure below depicts the specific pedestrian crossing where WSP is provided in Thessaloniki DS.

Subjective service evaluation

/ Proof of Concept

4 participants conducted a controlled experiment. The mean age of these participants were 45 years (SD = 2 years). The results showed that the majority of participants heard (M = 3.25; SD = 1.48) about this service or a similar service. Based on the service description, participants think that this service would be very useful (M = 5.00; SD = 0.00) for their daily driving and stated that they would use (M = 5.00; SD = 0.00) this service once it is available.

The results are presented on Figure 42Figure 40. Participants said that WSP enabled them to spot the position of pedestrians quickly (M = 4.00; SD = 0.71), that WSP supports them to break safely so they are able to avoid a collision (M = 4.00; SD = 0.71), that WSP increases their comfort while driving (M = 4.25; SD = 0.43), that they feel safe while using WSP (M = 3.50; SD = 0.87) and that they always keep WSP activated while driving (M = 4.50; SD = 0.50). Participants neither agree nor disagree that WSP work reliably and faultlessly (M = 3.00; SD = 0.71). Usually, information from WSP was received timely (M = 0.0; SD = 0.0). The amount of displayed information was perceived as ideal (M = 0.0; SD = 0.0). Usually, the signals/notifications sent by WSP were perceived as ideal (M = 0.0; SD = 0.0).

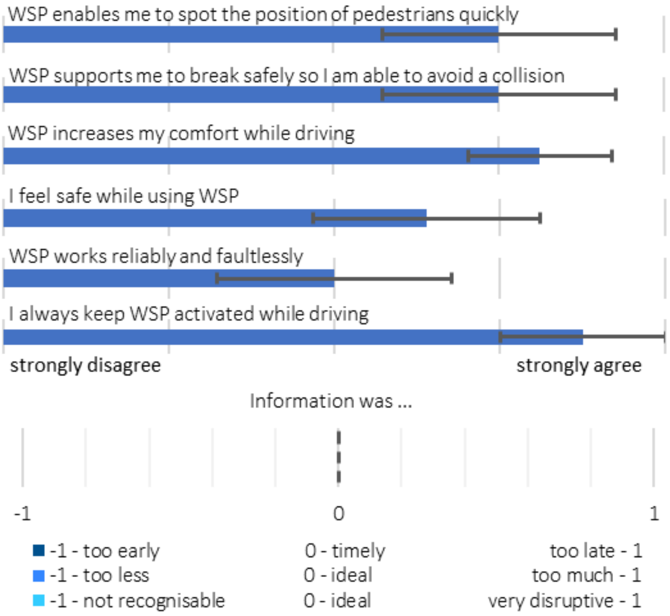


Figure 42: THE – WSP Post Experiment Questionnaire

Integration of results and conclusions

In the Thessaloniki PoC test the usefulness of WSP is perceived good; information presentation is considered ideal while reliability occurs to be just fair. Results stem from a small sample of users who experienced the service in a controlled environment which questions their generalizability.

3.7.3. WSP by CTAG

Warning System for Pedestrian provides the user all related information about the service. Starting with a notification in the top-right margin where we can see the icon of the event, pedestrian for this example, and followed by the distance in meters from our placeholder to the pedestrian's actual position. On map we can see a little POI (Point of interest) indicating where exactly the pedestrian is moving around us geographically each second. With these two items, notification plus POI, we achieve an accurate representation showing all the available and necessary data of the warning nearby.

Figure 43: WSP notification from C-MobILE Vigo app

3.7.3.1. Vigo deployment (PoC)

This service has been developed as a proof of concept and the appropriate urban environment simulation tests have been carried out on the CTAG tracks to obtain data that have subsequently enabled a user and service evaluation. Details on the experimental setup and procedure can be found in the annex of this document. Further results and conclusions of the objective service evaluation have been included in deliverable D6.4.

Subjective service evaluation

/ Proof of Concept (controlled experiment)

9 male participants conducted the controlled experiment. The mean age of these participants was between 25 - 34 years. The results showed that the majority of participants never heard about this service or a similar service (M = 1.67; SD = 0.94). Based on the service description, participants think that this service would be useful (M = 4.67; SD = 0.47) for their daily driving and stated that they would use (M = 4.67; SD = 0.94) this service once it is available.

After the experiment (Figure 44) the majority of participants expect that that WSP will support their understanding of the situation (M = 3.56; SD = 0.68) and that WSP will increase their comfort while driving (M = 3.67; SD = 1.05). Participants neither agree nor disagree that WSP will enable them to spot the position of pedestrians quickly (M = 3.33; SD = 1.05), that after receiving a WSP notification, they immediately know what to do (M = 2.89; SD = 0.99 that they feel safe while using WSP (M = 3.22; SD = 0.79) and that WSP will work reliably and faultlessly (M = 2.89; SD = 0.57). Usually, information from WSP was received timely (M = -0.11; SD = 0.74). Participants tend to not pay for this service (M = 2.00; SD = 0.94). The amount of displayed information was perceived as ideal with a tendency towards less (M=-0.47; SD= 1.56). Usually, the signals/notifications sent by WSP were perceived as ideal (M = -0.11; SD = 1.89).

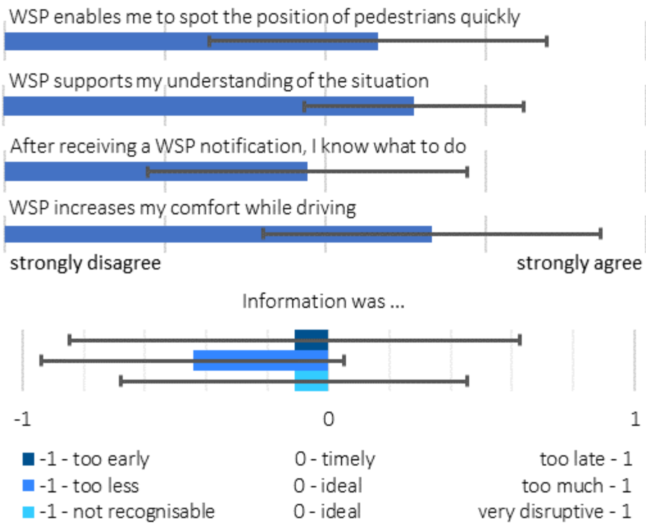


Figure 44: VIG – WSP Proof of Concept Post Experiment Questionnaire

Integration of results and conclusions

In the Vigo PoC test WSP is well received by the participants of the study. Timing and conspicuity of the warning are considered ideal on average whereas the amount of provided information is rated to be too low. Results stem from a small sample of users who experienced the service in a controlled environment which questions their generalizability.

3.7.4. WSP by Technolution

Like all other services in Copenhagen, except Green Priority, the WSP is bundled in the same app (GreenCatch). The WSP pops up below the GLOSA service on the app interface, when the user approached the equipped intersection and a person is either preparing to cross or crossing.

3.7.4.1.Copenhagen deployment (PoC)

With regard to the proof of concept that was WSP, the user interface was the same as for RWW and RHW. A message popped up below the GLOSA message interface. WSP was implemented in Copenhagen as a warning for cyclists and motorists about pedestrians in one traffic signal actuated by pedestrians waiting to cross as detected by infrared cameras.

All users who had the app running and were passing the specific signalised pedestrian crossing got the warning when a pedestrian was detected at the crossing. But as it was only deployed in one crossing in Copenhagen it was defined as a proof of concept.

In line with the constraints mention for Copenhagen mentioned in RHW and RWW, app downloads were few. Furthermore, as the service was only deployed in one location and would only be activated if there were pedestrians detected, likelihood of acquiring sufficient data was small.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

1 female participant filled the first questionnaire. The results showed that she participants never heard about this service before. Based on the service description, she tended to agree that this service would be useful for her daily driving and that she would use this service once it is available.

Integration of results and conclusions

Since no responses on actual service experience were gathered user acceptance cannot be assessed.

3.7.5. WSP by Zircon

In Newcastle, WSP was not deployed on the road. The investigation was carried out using an online survey. Prior to the experiment, participants were given a brief introduction about the purpose of the study. Participants were asked to watch the first video-clip of WSP-HMI, and subsequently evaluated it by completing the questionnaire. After that, the participants were asked to repeat this process to evaluate the other four WSP-HMIs. In total, 24 participants were involved in the study. A detailed description can be found in the annex.

Subjective service evaluation

Generally, most participants agreed that using WSP may help improve their driving performance. Moreover, they may choose to use this service if someone important recommends it to them. Most agree that they may use this service in the future.

Integration of results and conclusions

Evaluation of users' acceptance towards C-ITS services is crucial before deployment of such services into the transportation system. From this proof of concept study, we found that most end-users believe that using WSP may help them to improve their driving performance and they may intend to use it in the future if this service becomes available. These findings provide evidence to increase our understanding of public acceptance of this C-ITS application. They will be shared with our local stakeholders, in particular the fleet operators. A more detailed academic paper is being prepared for submission to the Journal of Intelligent Transport Systems: Technology, Planning and Operations.

3.7.6. Summary and comparison of different service versions and deployments

On the acceptance of WSP very little robust data is available. Some initial findings from a few large-scale deployment users, PoC tests, and a lab experiment indicate potential for this service but no conclusions on the actual usefulness can be drawn on this weak basis, so further investigations are certainly needed.

3.8.Green Priority (GP)

Green priority aims to change the traffic signals status in the path of an emergency or high priority vehicle (e.g., public transportation vehicles), halting conflicting traffic and allowing the vehicle right-of-way, to help reduce response times and enhance traffic safety. This service is also known as "Traffic signal priority request by designated vehicles" or "Priority Request". Different levels of priority can be applied, e.g. extension or termination of current phase to switch to the required phase. The appropriate level of green priority depends on vehicle characteristics, such as type (e.g. HGV or emergency vehicle) or status (e.g., public transport vehicle on-time or behind schedule). The vehicles request priority for an intersection, and the traffic light controller determines in what way it can and will respond the request.

3.8.1.GP by Zircon (ITS-G5)

Zircon has developed a bespoke HMI interface for use by express bus drivers in Newcastle. The interface design and the manner in which the information is presented was developed through a participatory design approach with drivers, management and unions at the bus operator. The HMI is integrated with a Dynniq OBU and Siemens UK roadside infrastructure to deliver priority and GLOSA via ITS-G5. The HMI also displays RWW/RHW from the open data service at other times, but priority and GLOSA remain the primary services. Zircon is now looking at creating a version in Play Store, but for this project it remains an independent App.

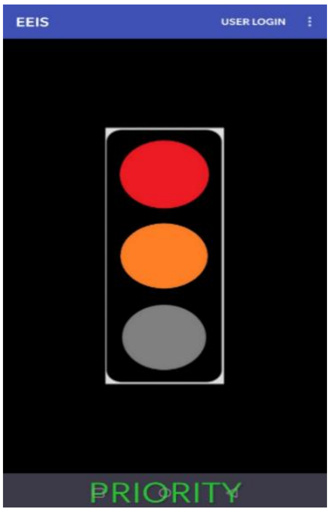


Figure 45: Zircon GP interface

3.8.1.1.Newcastle deployment (large-scale deployment)

Priority is one of two ITS-G5 services delivered on the Gosforth Corridor in Newcastle. When priority or GLOSA are not shown on the interface RWW or RHW may be presented. This Corridor runs for approximately 6kms through a suburban route, including a High Street retail area with a number of pedestrian crossings. There is a total of 18 intersections/ crossings equipped with roadside units (RSU). This includes one fairly complex multi-lane intersection where buses pull into an interchange and then back out onto the road. The service is used by 34 express buses operating from Newcastle to Ashington (distance of 30 kms). The operator is Arriva (part of Db group).

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

12 participants (2 female) filled the first questionnaire. The mean age of these participants were 52 years (SD = 7 years). The results showed that participants heard about this or a similar service (M = 1.82; SD = 0.72). Based on the service description, participants think that this service would be useful (M = 3.64; SD = 0.77) for their daily driving and stated that they would use (M = 3.73; SD = 0.62) this service once it is available.

/ User Training (Expectation)

9 male participants joined the user training. The mean age of these participants were 48 years (SD = 11 years). The results showed that participants are familiar (M = 3.11; SD = 0.87) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful (M = 3.67; SD = 1.33) for their daily driving and stated that they would use (M = 4.22; SD = 0.79) this service once it is available.

After the user training the majority of participants expect that GP makes it easier to drive through congested intersection (M = 3.88; SD = 0.60), that GP improves their punctuality / travel time (M = 3.75; SD = 0.66), that

GP increase the comfort while driving (M = 3.63; SD = 0.70) and that they feel safe GP is activated (M = 3.38; SD = 0.78). The amount of displayed information was perceived as ideal (M = -0.25; SD = 1.30).

/ Post-Questionnaire (Experience)

No post experience responses were gathered due to delays in the service deployment.

Integration of results and conclusions

Since no responses on actual service experience were gathered user acceptance cannot be assessed.

3.8.2. GP by Dynniq (ITS-G5)

This service is also known as "Traffic signal priority request by designated vehicles" (EC: C-ITS Deployment Platform, 2016) or "Priority Request" (Sambeek et al., 2015). Different levels of priority can be applied, e.g. extension or termination of current phase to switch to the required phase. The appropriate level of green priority depends on vehicle characteristics, such as type (e.g. HGV or emergency vehicle) or status (e.g., public transport vehicle on-time or behind schedule). The vehicles request priority for an intersection, and the traffic light controller determines in what way it can and will respond the request.

Goal of the service is to change the traffic signal status in the path of an emergency or designated vehicle (e.g., public transportation vehicles, trucks), halting conflicting traffic and allowing the vehicle right-of-way, thereby decrease the number of stops at intersections on corridors, hence lowering emissions while also increasing punctuality and response time of designated vehicles

3.8.2.1. North Brabant deployment (large-scale deployment)

The city of Helmond has equipped more than 30 intersections with traffic light controllers with hybrid communication technology. All of these intersections provide the services GLOSA, EVW, and SVW, which are connected to the nation-wide cellular infrastructure offered by Talking Traffic, while ITS-G5 communication is used also for vehicles equipped with OBUs. Additionally, GP is provided for ITS-G5-equipped trucks and emergency vehicles. Only on specific routes truck drivers get priority, to avoid the route through the city centre. All equipped intersections in Helmond, except three intersections on the main East-West traffic artery (N270) in the inner-city centre, run GP for emergency vehicles. The OBUs installations in selected vehicles (heavy duty vehicles, emergency vehicles, ambulances, fire brigade vehicles, and police cars) were performed either by the supplier of the equipment or the company owning the vehicles. Most of these vehicles were equipped with OBUs in previous C-ITS projects and have had a software update to accommodate C-MobILE.

Figure 46: Dynniq GP interface

Subjective service evaluation

During an evaluation meeting with the representatives of the drivers we learned that the drivers accepted the services and also perceived an improved traffic efficiency and reduction of travel time. We also learned that information on the equipped and non-equipped intersections is important and should be repeated regularly to keep the acceptance and use of the system high.

Important aspect for the drivers of emergency vehicles is beside the time gain is the increased safety. It makes a huge difference if an emergency vehicle has to cross an intersection with a red mitigation and other traffic on the intersection or if the vehicle can pass the intersection with a green light and even higher speed.

/ Post-Questionnaire (Experience)

5 professional drivers shared their experience. The results are presented on Figure 51. Participants neither agree nor disagree that GP makes it easier to drive through congested intersections (M = 3.40; SD = 1.02), that GP improves their punctuality / travel time (M = 3.40; SD = 1.36), that GP increases their comfort while driving (M = 3.20; SD = 1.17) and that they feel safe while GP is activated (M = 3.20; SD = 1.17). Participants do not agree

that GP works reliably and faultlessly (M = 2.20; SD = 0.75). Usually, information from GP was received timely (M = 0.40; SD = 1.36). The amount of displayed information was perceived as ideal (M=1.00; SD= 1.26) with a tendency towards much. Usually, the signals/notifications sent by GP were perceived as ideal with a tendency towards "disruptive" (M = 0.80; SD = 0.98).

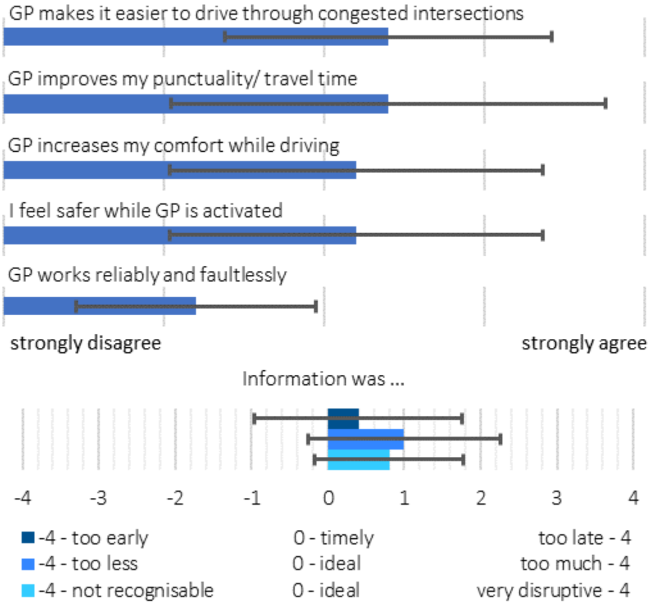


Figure 47: NBR - GP Questionnaire Results Prof. Drivers

Objective service evaluation

Emergency vehicles from the police and fire brigade request priority in emergency situations in combination with the use of sirens and blue lights. When priority is granted, all signal groups on the approach of the emergency vehicle is set to green in order to clear the approach and conflict areas. Preliminary results show that in about 90% of the granted situations, emergency vehicles can pass without stopping or obstruction from other vehicles. The number of conflict-free passes increases by 30% and the number of red-light crossings decrease by 15%. Also, the number of unsafe crossings in which the emergency vehicle is both blocked by traffic and has to cross with red light decreases. Response times in emergency situations also improves by several seconds per intersection on average, and adds up considerably on selected routes. Priority cannot always be granted though for various reasons. Success rates of requesting and granting priority varies per intersection, length of the ingress approaches, turn directions, and obviously the traffic situation.

Selected logistic vehicles can request green priority on selected routes. In contrast to emergency vehicles, logistic vehicles only receive priority on signal groups of their selected route. The objective of this Green Priority service is to help the driver decide whether a free pass, without stopping or significant decelerations and accelerations, is possible and fuel can be saved. Upon requesting priority, the driver receives a speed advice to follow. When the driver manages to comply, priority is granted till the vehicle has passed. Priority is only granted though when traffic permits. In practice, priority is granted in about 30% of the requests. In the other 70%, a logistic vehicle may still be able to pass the intersection, but without priority. Overall the service intends to safe fuel, but does not significantly reduce the number of stops or travel time.

Integration of results and conclusions

Overall conclusion is that we see an improved time gain, especially for emergency vehicles, a good user acceptance and all user groups (logistics and emergency vehicles) would like to continue to use the services after the project period. According to the respondents, the reliability of the service leaves room for improvement.

3.8.3.2. Copenhagen deployment (large-scale deployment)

The Green Priority service was deployed in 7 intersections in the inner city of Copenhagen. There was no UI associated to the GP service as logistics companies were not interested in having their drivers distracted by additional screens. Therefore, the GP service was developed simply as a system functioning in the background, giving priority if the right conditions were present.

12 vehicles from 3 companies/organisations, including the City of Copenhagen, were chosen for installation of the OBUs, but right as the installation was to commence the Covid related lockdown started. The problem was

not so much that the trucks did not drive on the route in the city, but rather the inability for the OBUs to be installed in the trucks due to concerns of spreading the disease via contact between installers and the logistics company employees. For that reason, no OBUs were ever installed.

3.8.3. GP by CTAG

Green priority provides the user all related information about the service. In collaboration with C-Roads project, we use their HMI app in order to activate the priority with a button in the bottom-left margin. Grey button indicates disabled priority while tapping on the button demands the priority and it will be given if the button changes to a green state. Moreover, with the given priority, every traffic light state in our trajectory changes to a different state from normal, always showing a flashing amber traffic light.

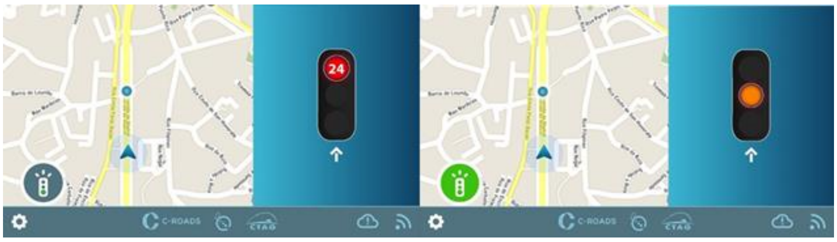


Figure 48: CTAG GP interface

3.8.3.1. Vigo deployment (PoC)

The Green Priority service is one of the ITS-G5 services that was tested in an experiment. A total of 6 drivers were selected to perform the pass priority test on a circuit set up on the CTAG tracks. During the test, other drivers were involved to simulate dense traffic conditions and traffic jam conditions at traffic lights to evaluate the service.

The Green Priority service was tested in close collaboration to C-Roads European Project. For this service, the user's vehicle is equipped with an OBU connected by ITS-G5 to the traffic lights and to the HMI by WiFi. The priority is requested by means of the HMI. The scenario for this test was set at the CTAG's test tracks with two traffic lights with the priority service implemented and 5 vehicles simulating the traffic flow. The evaluation of user acceptance could not be carried out since the controlled test was done with professional drivers and not with emergency vehicle drivers. A focus group/interview/questionnaire evaluation was planned but due to internal organizational problems it could not be carried out.

3.8.5. GP by CERTH (PoC)

The GP service is implemented by CERTH as proof of concept in a simulated environment. This service is combined with the EVW service. All related information is provided in the section for EVW service.

3.8.6. Summary and comparison of different service versions and deployments

Coming from a very small sample from only one DS the service acceptance appears to be promising but further investigations are absolutely needed.

3.9. Green Light Optimal Speed Advisory (GLOSA)

GLOSA provides drivers an optimal speed advice when they approach to a signalized intersection. This advice may involve maintaining actual speed, slowing down, or adapting a specific speed. If a green traffic light cannot be reached in time, GLOSA may also provide time-to-green information when the vehicle is stopped in the stop bar. Application of GLOSA takes advantage of real-time traffic sensing and infrastructure information, which can then be communicated to a vehicle aiming to reduce fuel consumption and emissions.

3.9.1. GLOSA by IDIADA

The GLOSA service developed by IDIADA for the Barcelona DS gives speed advices and key information indicating to start slowing down or keep the pace. It shows the current vehicle speed, the current traffic light status (phase colour and remaining time) and then either speed advice in blue colour or lanes in green or red if going to pass in green with current speed or won't pass at all.

The speed advices are constrained to the road min and max speed and the application will never advice the driver to increase his speed in order to pass the next traffic light in green, since the main objective of this service is to avoid accelerations, hard braking and other manoeuvres that lead to higher pollution levels.

Figure 49: GLOSA interface from C-MobILE Barcelona app

3.9.1.1. Barcelona deployment (large-scale deployment)

Drivers and motorcycles can enjoy this service with the C-MobILE Barcelona app in 30 intersections, the location of which have been chosen considering the number of cars driving around those areas and the simplicity of road layouts (to avoid too complex information from GLOSA), to maximize the impact. A total of 2000 users have been able to enjoy this service, with a total amount of 900 current active users.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years. The results showed that the majority of the participants never heard (M = 1.31; SD = 0.63) about this service or a similar service. Based on the service description, participants think that this service would be useful (M = 3.91; SD = 0.98) for their daily driving and stated that they would use (M = 3.75; SD = 1.06) this service once it is available.

/ Post-Questionnaire (Experience)

13 male participants shared their actual experience through the short questionnaire. The mean age of these participants were 44 years (SD = 11 years). The results are presented on Figure 50. Participants neither agree nor disagree with the statement that GLOSA enabled them to cross equipped intersections more efficiently (M = 3.42; SD = 0.95). Usually, information from GLOSA was received timely (M = 1.09; SD = 1.93) with a tendency towards “late”. The amount of displayed information was perceived as ideal (M=-0.28; SD=1.19). Usually, the signals/notifications sent by GLOSA were perceived as ideal (M =-0.18; SD = 1.19).

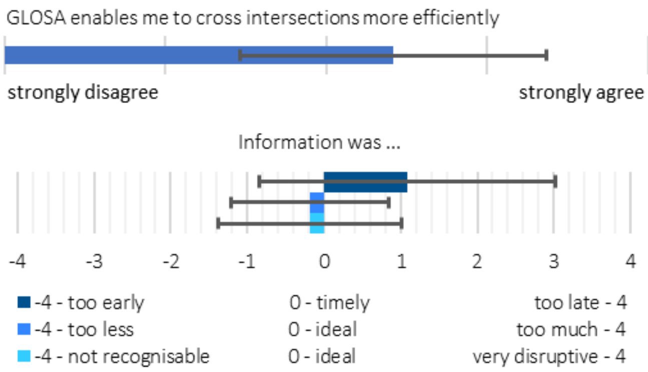


Figure 50: GLOSA - BCN Post Questionnaire Results

Integration of results and conclusions

GLOSA in BCN is well received by the users; information presentation occurs to be ideal on average while users wish to receive notifications a bit earlier.

3.9.1.2.North Brabant deployment (large-scale deployment)

The service is deployed in The Netherlands through the so-called Talking Traffic infrastructure. As a result, the service operates national wide at equipped intersections, of which the highest density can be found in Helmond (around 50). The users are (mainly) employees from the City of Helmond and the TNO office in Helmond. It concerns a restricted user group, and 44 participants have downloaded the app from the Google play store through a personal link since the app for North Brabant has not been published publicly due to privacy restrictions.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

29 participants (12 female) filled the first questionnaire. The mean age of these participants were 44 years (SD = 10 years). The results showed that participants are familiar (M = 3.04; SD = 1.24) with this service but never used it before. Based on the service description, participants think that this service would be useful (M = 4.11; SD = 0.56) for their daily driving and stated that they would use (M = 4.25; SD = 0.57) this service once it is available.

/ Post-Questionnaire (Experience)

22 participants (5 female) shared their actual experience. The mean age of these participants were 46 years (SD = 9 years). Results are presented on Figure 51. The results showed that participants neither agree nor disagree that they can cross intersections with GLOSA without stopping (M = 2.83; SD = 1.09), that GLOSA increases their comfort while driving (M = 3.22; SD = 1.14), that they drove eco-friendlier with GLOSA (M = 3.05; SD = 1.26) and that they used GLOSA regularly when they are driving (M = 2.96; SD = 1.37). Participants tended to disagree that they feel safe while using GLOSA (M = 2.17; SD = 0.75). Usually, information from GLOSA was received timely (M = 1.05; SD = 1.63) with a tendency towards "late". The amount of displayed information was perceived as ideal (M=-0.48; SD=1.47). Usually, the signals/notifications sent by GLOSA were perceived as ideal (M =0.09; SD = 1.56).

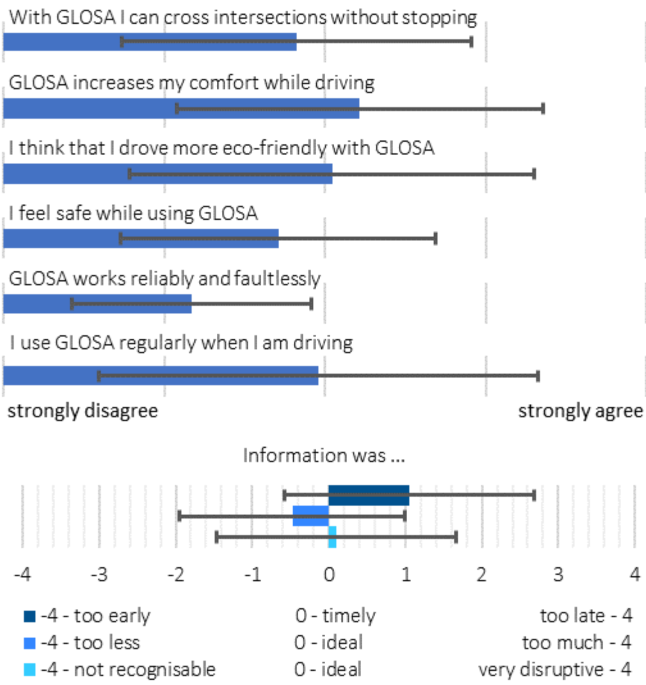


Figure 51: NBR -GLOSA Post Questionnaire Results

5252Integration of results and conclusions

In NBR, GLOSA is rated only fair. Information was received tendentially too late and the reliability of the service occurs to be rather poor. Most probably this is caused by dynamic signal phase timing at NBR DS which necessarily evokes abrupt changes in speed advices or time to green information.

3.9.2. GLOSA by NeoGLS

Bordeaux DS is implementing GLOSA and SVW in both 4G and G5 technologies. 588 intersections are configured available to the 4G users in Bordeaux and its surroundings. Gertrude provides the timing information in real time. The 11 RSUs deployed in the city-centre are also broadcasting MAP and SPaT information for intersections close to them.

The PID receives the SPaT MAP information and determines the approach lanes on which the PID is located. Each relevant lane is displayed on the application along with the current traffic light color, the GLOSA advice, and eventually the "Time to Green".

The GLOSA advice can be of different natures: A green arrow indicates to continue at current speed. A red arrow indicates to stop, A blue arrow indicates a speed advice (if the driver slows down to the advised speed, the light will be green on time)

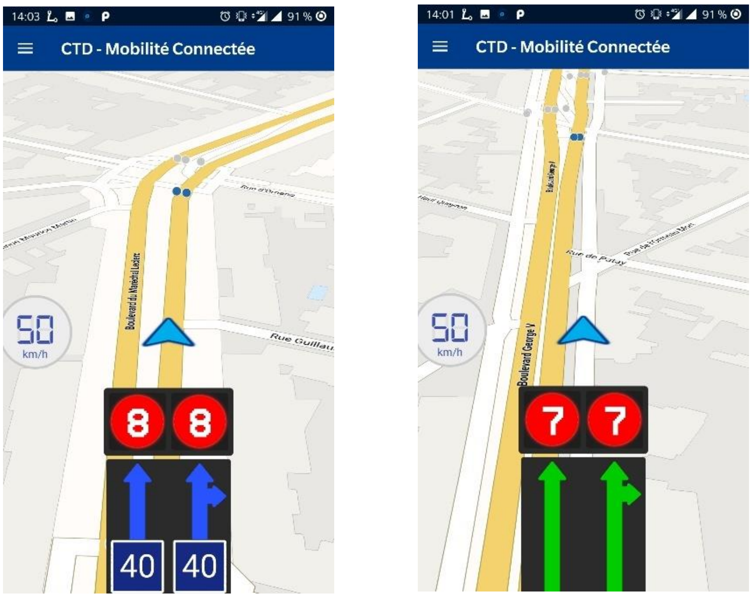


Figure 53: C-MobILE logo

3.9.2.1. Bordeaux deployment (large-scale deployment)

The area covered by the GLOSA use case in Bordeaux DS is represented by 588 intersections in the whole urban area. Intersections are located on the main roads of the city. The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

/ Post-Questionnaire (Experience)

9 participants (6 female) shared their actual experience through the short questionnaire. The mean age of these participants were 46 years (SD = 10 years). The results are presented on Figure 54. Participants neither agree nor disagree with the statement that GLOSA enabled them to cross equipped intersections more efficiently (M = 3.11; SD = 0.74). Usually, information from GLOSA was received timely (M = -0.11.; SD = 0.31). The amount of displayed information was perceived as ideal (M = 0.11; SD = 0.31). Usually, the signals/notifications sent by GLOSA were perceived as ideal (M = -0.11; SD = 0.31).

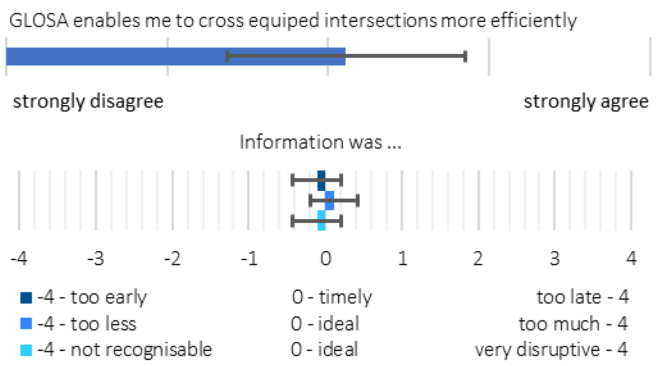


Figure 54: BOD – GLOSA Post Experiment Questionnaire

Integration of results and conclusions

Bordeaux' implementation of GLOSA is rated fair; notifications occur ideal according to the users.

3.9.2.2. Newcastle deployment (large-scale deployment)

GLOSA is primarily delivered by ITS-G5 in Newcastle, however working with NeoGLS and Siemens (system integrator) the DS has implemented cellular GLOSA at one intersection on the Gosforth Corridor. This involved upgrade of the roadside infrastructure to 4G, something that will ultimately be extended to other intersections. All 38 users of cellular services including NEAS, NCC drivers and selected private motorists were able to enjoy the service.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

12 participants (2 female) filled the first questionnaire. The mean age of these participants were 52 years (SD = 7 years). The results showed that participants heard about this or a similar service (M = 1.75; SD = 0.72). Based on the service description, participants think that this service would be useful (M = 3.92; SD = 0.64) for their daily driving and stated that they would use (M = 3.92; SD = 0.64) this service once it is available.

/ User Training (Expectation)

9 male participants joined the user training. The mean age of these participants were 48 years (SD = 11 years). The results showed that participants are familiar (M = 2.78; SD = 1.03) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful (M = 3.44; SD = 1.17) for their daily driving and stated that they would use (M = 3.78; SD = 1.23) this service once it is available.

After the user training the majority of participants expect that GLOSA will enable them to cross equipped intersection without stopping (M = 4.00; SD = 0.71), that GLOSA increase their comfort while driving (M = 3.75; SD = 0,83), that they will drive eco-friendlier with GLOSA (M = 4.00; SD = 0.71) and that they would use GLOSA regularly when they are driving (M = 3.50; SD = 1.22). The amount of displayed information was perceived as ideal (M = 0.13; SD = 0.93).

Integration of results and conclusions

Unfortunately, there were no responses on actual experience with cellular GLOSA from Newcastle which probably comes from the fact that users of the never experienced the service since it was only implemented in one intersection.

3.9.3. GLOSA by Zircon

Zircon has developed a bespoke HMI interface for use by express bus drivers in Newcastle. The interface design and the manner in which the information is presented was developed through a participatory design approach with drivers, management and unions at the bus operator. The HMI is integrated with a Dynniq OBU and Siemens UK roadside infrastructure to deliver priority and GLOSA via ITS-G5. The HMI also displays RWW/RHW from the open data service at other times, but priority and GLOSA remain the primary services. Zircon is now looking at creating a version in Playstore, but for this project it remains an independent App.

Figure 55: Zircon GLOSA interface

3.9.3.1.Newcastle deployment (large-scale deployment)

GLOSA is one of two ITS-G5 services delivered on the Gosforth Corridor in Newcastle. This Corridor runs for approximately 6kms through a suburban route, including a High Street retail area with a number of pedestrian crossings. There is a total of 18 intersections/ crossings equipped with roadside units (RSU). This includes one fairly complex multi-lane intersection where buses pull into an interchange and then back out onto the road. The service was meant to be used by express 34 buses operating from Newcastle to Ashington (distance of 30 kms). The operator is Arriva (part of Db group).

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

12 participants (2 female) filled the first questionnaire. The mean age of these participants were 52 years (SD = 7 years). The results showed that participants heard about this or a similar service (M = 1.82; SD = 0.72). Based on the service description, participants think that this service would be useful (M = 3.64; SD = 0.77) for their daily driving and stated that they would use (M = 3.73; SD = 0.62) this service once it is available.

/ Post-Questionnaire (Experience)

Unfortunately, since the service deployment was impeded, there is no data available on actual experience with the service.

Integration of results and conclusions

Since no responses on actual service experience were gathered user acceptance cannot be assessed.

3.9.4. GLOSA by Technolution

The GLOSA service is bundled with all the other services, except Green Priority, in the Copenhagen GreenCatch app. The user interface for the GLOSA services comprises of the majority of the app interface. On the left side of the screen the users speed is displayed as a blue arrow pointing towards a certain speed on a scale, behind the blue arrow, on the speed scale one sees a green field. If the arrow is within the green field, the user will catch the green light. If the arrow is either above or below the green field within the speed scale, then the user is asked to either speed up or slow down.

On the right side of the screen there are three circles with a +, 0, or – sign in them, each of which corresponds with the speed advice given in relation to the left-hand side speed scale and green field. Furthermore, when a speed advice is given, this is also indicated with a pop up in the bottom of the screen saying either "speed up" or "slow down"

3.9.4.1. Copenhagen deployment (large-scale deployment)

The GLOSA was deployed in >100 intersections in the City of Copenhagen. It was regarded as the flagship service which would drive the adoption of the app and therefore the other services, which were bundled together with GLOSA in the same app.

The UI featured GLOSA as the central, most visible service and there was an audio feature associated with the service which allowed bicyclists to listen to speed advice through headphones. This was chosen as most cyclists in Copenhagen do not have handlebar mounts.

With regards to users the same applies for the number of downloads for this service, as for the RWW, RHW, and WSP, as all services were bundled together in the same app.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

10 participants (5 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 8 years). The results showed that participants are familiar with this service but never used it before (M = 3.00; SD = 1.18). Based on the service description, participants tended to agree that this service would be useful (M = 4.30; SD = 0.64) for their daily driving and that they would use (M = 4.10; SD = 0.70) this service once it is available.

/ Post-Questionnaire (Experience)

Unfortunately, since the service deployment was impeded, there is no data available on actual experience with the service.

Integration of results and conclusions

Since no responses on actual service experience were gathered user acceptance cannot be assessed.

3.9.5. GLOSA by CTAG

Green Light Optimal Speed Advisory provides the user all related information about the service. Intersections are represented on map with a little circle which illuminates itself to a blue state when receiving information from it. Each intersection may contain up to 3 traffic lights to show. Each traffic light provides data about their actual state (Green, amber, red), countdown in seconds for next phase change and lane direction (Straight, Left-Straight, Right, etc..).

Figure 56: GLOSA notification from C-MobILE Vigo app

3.9.5.1. Vigo deployment (large-scale deployment)

This service is available at all those intersections where the SVW service is also available, therefore at a total of 116 intersections in the urban area of Vigo, mainly in the city centre where the highest concentrations of traffic arise. The service has been enabled for all user groups (cars, motorbikes, emergencies, buses, trucks and vans) from the mobile application provided through the mobile devices delivered; a total of 80 recruited users. For all services a specific application has been developed allowing to include a baseline mode for the recruited users from where the results are received, analysed and evaluated. Another "regular" version of the application is available for free download in the Play Store which also offers this service to the general public.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

47 participants (9 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 9 years). The results showed that participants are heard about this or a similar service (M = 1.96; SD = 1.18). Based on the service description, participants think that this service would be useful (M = 4.15; SD = 0.87) for their daily driving and stated that they would use (M = 4.19; SD = 0.79) this service once it is available.

/ Post-Questionnaire (Experience)

26 participants shared their actual experience with this service. The mean age of these participants were 37 years (SD = 9 years). Results are presented on Figure 57. The results showed that participants agree that they can cross intersections with GLOSA without stopping (M = 4.15; SD = 0.86), that GLOSA increases their comfort while driving (M = 4.35; SD = 0.83), that they drove eco-friendlier with GLOSA (M = 4.12; SD = 0.83), that they feel safe while using GLOSA (M = 4.00; SD = 0.85) and that they used GLOSA regularly when they are driving (M = 4.08; SD = 0.84). Participants tended to neither agree nor disagree that GLOSA worked reliably and faultlessly (M =3.36; SD = 0.97). Usually, information from GLOSA was received timely (M = 0.20; SD = 0.57). The amount of displayed information was perceived as ideal (M=-0.20; SD=0.75). Usually, the signals/notifications sent by GLOSA were perceived as ideal (M =0.20; SD = 0.94).

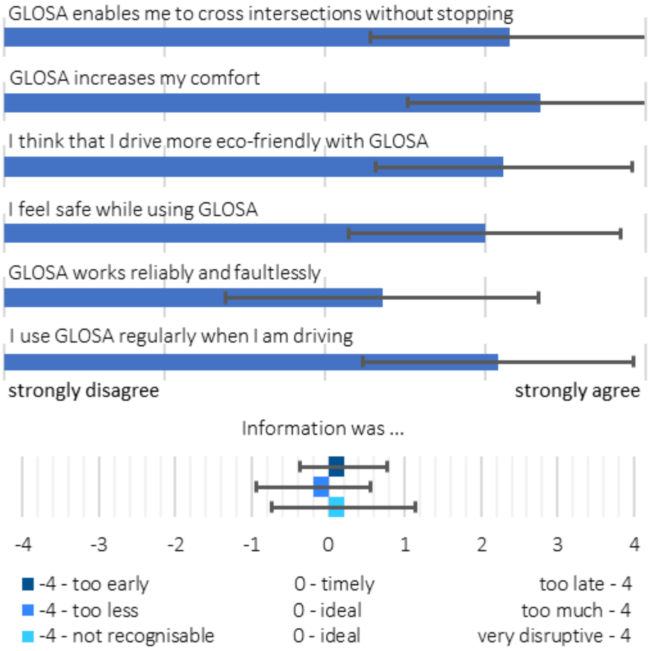


Figure 57: VIG – GLOSA Post Questionnaire Results

Integration of results and conclusions

The Vigo deployment of GLOSA is rated very good by the users including close to ideal information presentation.

3.9.6. GLOSA by CERTH

The CERTH App provides the GLOSA service by notifying the drivers in the road network of Thessaloniki whether they will catch the “green wave” when approaching a signalized intersection. This information facilitates to adjust their driving as they are aware of whether they will pass with a green light and subsequently they adjust the driving speed. The following figure depicts the information shown in the drivers’ HMI for the GLOSA service.

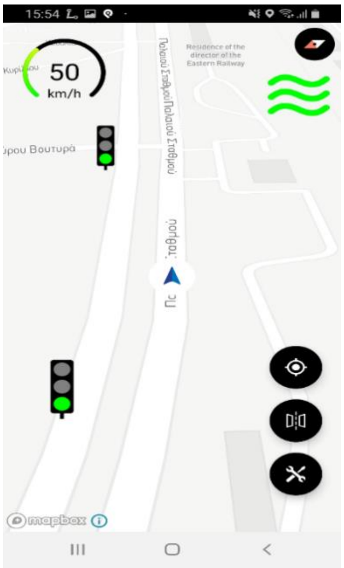


Figure 58: GLOSA - "green wave" notification by CERTH App

3.9.6.1.Thessaloniki deployment (large-scale deployment)

The GLOSA service in Thessaloniki covers a number of sequential signalized intersections in the center of the city as well as in the western entrance to the city. The service is provided to circa 1000 taxi drivers and to drivers from the general public which can download and use for free the App. Due to the COVID-19 pandemic ongoing lockdown the number of active App users from the general population remains low at this stage. The following figure presents the road network in Thessaloniki where the signalized intersections, where GLOSA is provided, are located.

Subjective service evaluation

/ User Training (Expectation)

10 participants (2 female) joined the user training. The mean age of these participants were 50 years (SD = 22 years). The results showed that participants are familiar (M = 3.15; SD = 1.58) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful for their daily driving (M = 4.15; SD = 1.59) and stated that they would use this service once it is available (M = 4.38; SD = 1.61).

After the user training the majority of participants (strongly) expect that they can cross intersections with GLOSA without stopping (M = 4.40; SD = 1.78), that GLOSA increases their comfort while driving (M = 4.40; SD = 1.78), that they drove eco-friendlier with GLOSA (M = 4.50; SD = 1.82) and that they used GLOSA regularly when they are driving (M = 4.40; SD = 1.78). The amount of displayed information was perceived as ideal (M=1.30; SD=2.83) with a tendency towards much.

/ Post-Questionnaire (Experience)

13 participants (4 female) shared their actual experience through the short questionnaire. The mean age of these participants were 43 years (SD = 7 years). The results are presented on Figure 59. Participants neither agree nor disagree with the statement that GLOSA enabled them to cross equipped intersections more efficiently (M = 3.46; SD = 0.845). Usually, information from GLOSA was received timely (M = -0.07; SD = 0.26). The amount of displayed information was perceived as ideal with a tendency towards "less" (M=-0.64; SD=1.04). Usually, the signals/notifications sent by GLOSA were perceived as ideal (M =-0.21; SD = 0.41).

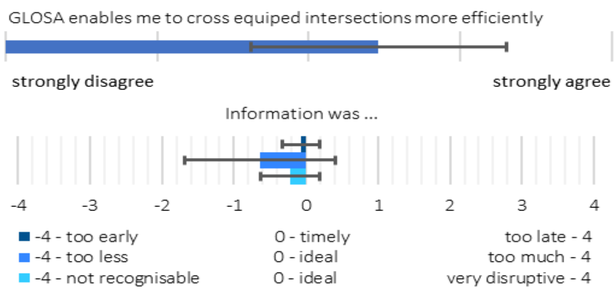


Figure 59: THE - GLOSA Post Experiment Questionnaire

Integration of results and conclusions

In Thessaloniki, GLOSA is perceived useful and notifications are considered almost ideal with a slight tendency that users wish to get more information.

3.9.7. Summary and comparison of different service versions and deployments

GLOSA is well received in most DS; information presentation generally occurs to be close to ideal with only some minor exceptions. In one deployment (NBR), GLOSA acceptance is obviously decreased due to effects of dynamic signal phase timing which evokes abrupt changes in speed advices or time to green information.

3.10. Cooperative Traffic Light for Vulnerable road users (CTLV)

Cooperative traffic light for VRUs aims to increase the safety of pedestrians through warranting priority or additional crossing time (i.e., extending the green light phase or lessening the red phase) based on pedestrian characteristics (or on special conditions, such as weather). The service can also be extended to cover other VRUs, such as cyclists. The service is also known as "Pedestrian Mobility" or "Traffic light prioritization for designated VRUs".

3.10.1. CTLV by MACQ

No information provided.

3.10.1.1. North Brabant deployment (PoC)

No information provided.

Subjective service evaluation

/ Post- Questionnaire Experience

11 participants shared their experience with CTLV in Eindhoven until end of April 2021. Unfortunately, it turned out that the service was not working correctly in this period. CTLV is now operational as of May 2021 but no questionnaire responses are available.

Integration of results and conclusions

Since no responses on actual service experience were gathered user acceptance cannot be assessed.

3.10.2. CTLV by CERTH (PoC)

The CTLV service is implemented in Thessaloniki DS in small-scale as a proof-of-concept service. The objective of the service is to assist in the safe and crossing of a VRU when passing a pedestrian crossing as well as to contribute in the reduction of VRUs' waiting time at pedestrians' crossings.

3.10.3.1. Thessaloniki deployment (PoC)

The CTLV service is implemented in a specific location in the western entrance of the city where a traffic light with a pedestrian crossing exists. The information about the existence of the VRU is provided by CERTH to the technical partner, Traffic Technique, being responsible for the operation of the traffic light. According to this data the status of the traffic light is modified properly so that the VRU is able to cross the pedestrian crossing in a safe manner and without extra waiting time.

Subjective service evaluation

No questionnaire results are available the CTLV PoC in Thessaloniki.

Integration of results and conclusions

Since no responses on actual service experience were gathered user acceptance cannot be assessed.

3.10.3. Summary and comparison of different service versions and deployments

Since no responses on any actual service experience were gathered user acceptance cannot be assessed.

3.11. Flexible Infrastructure (FI)

Flexible infrastructure aims to interchange information about the lanes provided to the traffic users according to the time of the day, also known as "peak hour lanes". It includes solutions such as reserved lane.

3.11.1. FI by IDIADA

The Flexible Infrastructure service in Barcelona gives information to the users about the lane status and speed limit of the Túnel de Vallvidera, which is a very crowded highway tunnel to enter and leave Barcelona city. The information provided by the data source is updated constantly in order to give trusted information almost in real time. It increases safety and improves the traffic efficiency in both tunnel entries.

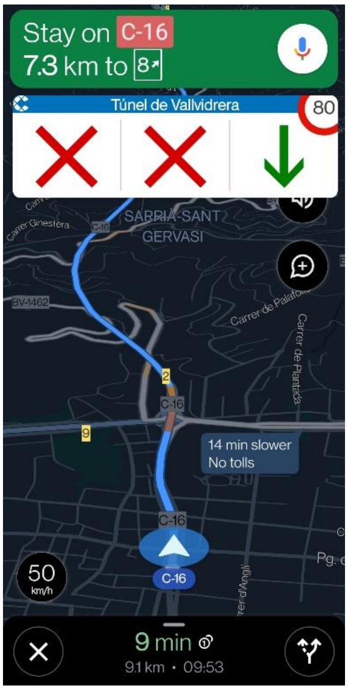


Figure 60: FI notification from C-MobILE Barcelona app

3.11.1.1. Barcelona deployment (large-scale deployment)

All users allowed to pass through the tunnel can enjoy the FI service (drivers and motorcyclists). This was one of the first services to be operative and more than 2000 users have been able to receive such notifications since early 2020. Currently, 900 users are active.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years. The results showed that the majority of the participants are familiar with this service but have never used it before (M = 3.03; SD = 1.31). Based on the service description, participants think that this service would be useful (M = 3.97; SD = 0.88) for their daily driving and stated that they would use (M = 4.00; SD = 0.90) this service once it is available.

/ Pre-Questionnaire – User training (Expectation)

57 participants (17 female) joined the user training. The mean age of these participants were 44 years (SD = 11 years). The results showed that participants heard about this service (M = 2.18; SD = 1.15) or a similar service. Based on the service description, participants think that this service would be useful (M = 4.13; SD = 0.74) for their daily driving and stated that they would use (M = 4.07; SD = 0.67) this service once it is available. After the user training the majority of participants thought that the FI would allow them to quickly identify which lanes can be used (M = 4.18; SD = 0.48).

/ Post-Questionnaire (Experience)

6 male participants shared their actual experience through the short questionnaire. The mean age of these participants were 44 years (SD = 11 years). The results are presented on Figure 61. Participants said that the FI enabled them to quickly identify which lanes can be used (M = 4.67; SD = 0.47). Usually, information from FI was received timely (M = -0.25; SD = 0.43). The amount of displayed information was perceived as ideal (M=

0; SD= 0). Usually, the signals/notifications sent by FI were perceived ideal with a tendency towards less recognisable (M = -1.20; SD = 1.60).

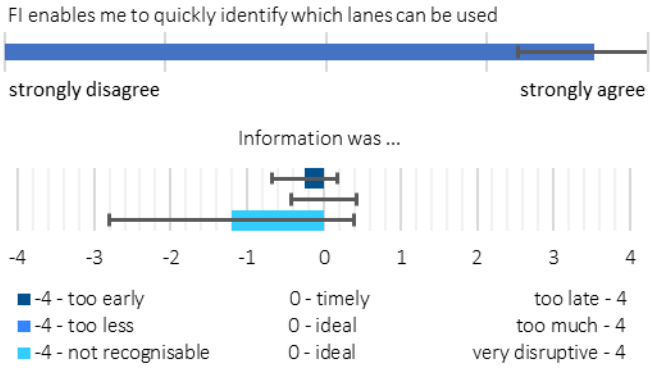


Figure 61: FI - BCN Post Questionnaire Results

Integration of results and conclusions

The FI implementation in BCN occurs to be highly appreciated by the users. Information timing and amount was rated close to ideal but the presentation should be more salient to the driver.

3.11.2. FI by NeoGLS

Bordeaux DS is implementing FI in both 4G and G5 technologies. This usecase is deployed in 3 zones, where information about the infrastructure is broadcasted to the users:

- Indication of car-pooling lanes
- Indication of bus lanes on the ring road
- Indication of open/closed lanes on Pont d'Aquitaine (in cooperation with DIRA)

The information is presented to the driver in the form of a Variable Message Sign displayed at the top of the screen. The aim is to provide additional information to the driver about a special road configuration.

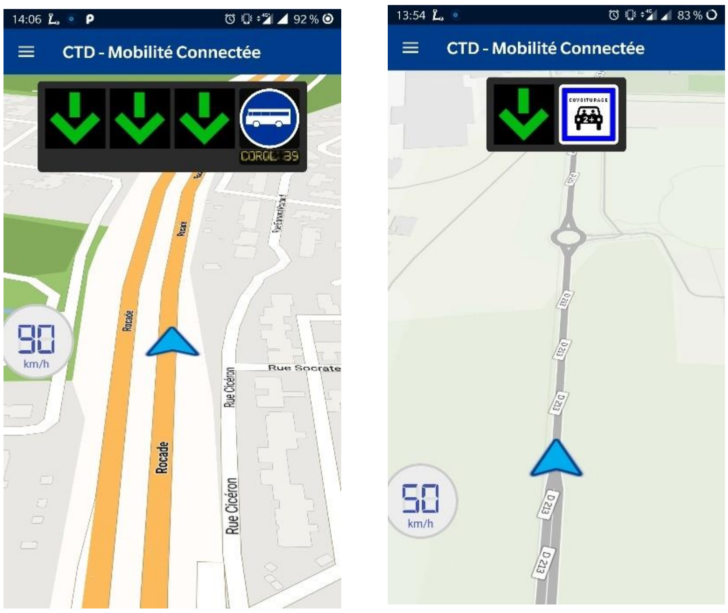


Figure 62: NeoGLS FI interface

3.11.2.1. Bordeaux deployment (large-scale deployment)

The area covered by the FI use case in Bordeaux DS is restricted by the nature of the use case. This coverage is represented by the path between exit 12 and 13 of the ring-road, a inter-urban road in the north of the airport and the "Pont d'Aquitaine" which is also part of the ring-road.

The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

/ Post-Experiment (Experience)

3 participants (2 female) shared their actual experience through the short questionnaire. The mean age of these participants were 39 years (SD = 11 years). The results are presented on Figure 63. Participants neither agree nor disagree that the FI enabled them to quickly identify which lanes can be used (M = 3.33; SD = 0.47). Usually, information from FI was received timely (M = 0.0; SD = 0.0). The amount of displayed information was perceived as ideal (M= 0; SD= 0). Usually, the signals/notifications sent by FI were perceived ideal with a tendency towards less recognisable (M = 0; SD = 0).

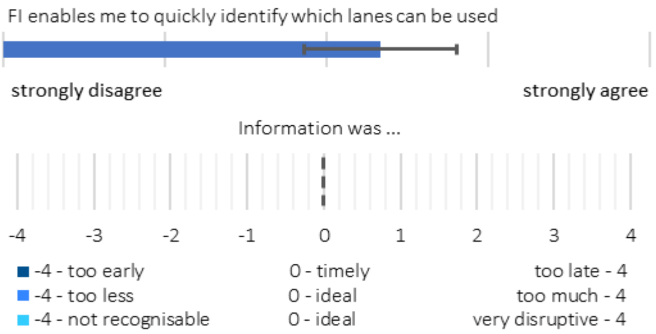


Figure 63: BOD – FI Post Experiment Questionnaire

Integration of results and conclusions

The FI service in BOD is well received by the users. Information presentation was rated absolutely ideal, coming from a very small sample of only three drivers who actually experienced the service.

3.11.3. FI by CERTH

This service is integrated with the RWW service for the case of Thessaloniki as in the city no dynamic or reversable lanes apply. The information provided for FI include closures due to road works and this information is integrated in RWW service.

Subjective service evaluation

/ User training (Expectation)

10 participants (2 female) joined the user training. The mean age of these participants were 50 years (SD = 22 years). The results showed that participants are familiar (M = 2.85; SD = 1.64) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful for their daily driving (M = 4.23; SD = 1.59) and stated that they would use this service once it is available (M = 4.46; SD = 1.64).

After the training the majority of participants expect that FI will enable them to quickly identify which lanes can be used (M = 4.50; SD = 1.82), that FI will reduce the time they get stuck in a traffic jam (M = 4.40; SD = 1.78), that they to feel safe while using FI (M = 4.40; SD = 1.78) and that they will always keep FI activated while driving (M = 4.40; SD = 1.78). The amount of displayed information was perceived as ideal (M = 0.80; SD = 2.48) with a tendency towards much.

/ Post-Experiment (Experience)

6 participants (4 female) shared their actual experience through the short questionnaire. The mean age of these participants was 40 years (SD = 8 years). The results are presented on Figure 64. Participants neither agree nor disagree that the FI enabled them to quickly identify which lanes can be used (M = 3.33; SD = 0.75). Usually, information from FI was received timely (M = -0.17; SD = 0.37). The amount of displayed information was perceived as ideal with a tendency towards "much" (M = -0.50; SD = 0.76). Usually, the signals/notifications sent by FI were perceived ideal (M = -0.33; SD = 0.47).

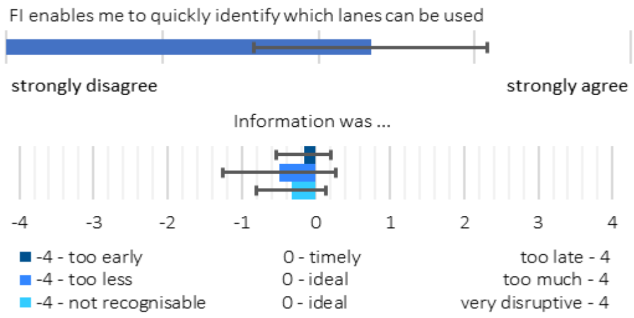


Figure 64: THE – FI Post Experiment Questionnaire

Integration of results and conclusions

The FI service in THE is well received by the users. Information presentation was rated almost ideal.

3.11.4. Summary and comparison of different service versions and deployments

All FI deployments are considered useful by the users. Information timing and amount was rated close to ideal. For one implementation (BCN) the notification should be more salient to the driver.

3.12.In Vehicle Signage (IVS)

In-vehicle signage aims to provide information to the driver about the road signs (and dynamic information, e.g., local conditions warnings identified by environmental sensors). The purpose of this service is to increase the likelihood of drivers being aware of potentially dangerous conditions in case a roadside traffic sign is not noticed.

As already mentioned briefly in the methodology chapter, utilizing parameters of driving behaviour may allow to assess users' compliance with advices, which can be seen as part of service acceptance. For that reason, in the case of In-Vehicle Signage (IVS) speed limit information, indicators for user reactions on the advice were taken from Task 6.4 in order to assess if attitudes towards the service go hand in hand with the actual driving behaviour. Concretely, the indicators “mean speed” and “number of speed violations” were chosen to investigate drivers' actual response to speed limit information. For details on data logging, indicator extraction, and data aggregation see D6.4.

3.12.1. IVS by IDIADA

In-Vehicle Signage service is deployed with many different use cases in Barcelona:

/ Variable Message Signs (VMS)

The first use case is related to the VMS where the drivers are provided with a copy of the digital panels placed at the main arteries entering and leaving Barcelona. The user interface pretends to replicate the real VMS information layout, where two icons/signs are placed at both sides and 3 lines of text information are available between them.

The information of the VMS is updated very frequently since the road operator is using them to provide many kinds of information such as roadworks, traffic jams, accidents, high-pollution zones, speed radars, CoVid-19 confinement messages, etc.

/ Virtual VMS

The same approach with the VMS is also used to announce information where there is no real VMS. For example, the Low Emission Zone in the Barcelona area is provided to the users in VMS format even though the users won't find a real VMS informing about this information.

/ Fixed road signs

The recent layout changes in Barcelona city aiming a greener mobility have led to speed limits changes in some streets. This information is taken from the OpenDataBCN platform and introduced as a IVS use case to inform the drivers about this new speed limitations. Since this is not critical information, the application shows a small icon using the regulatory speed limit sign on the bottom-left side of the screen.

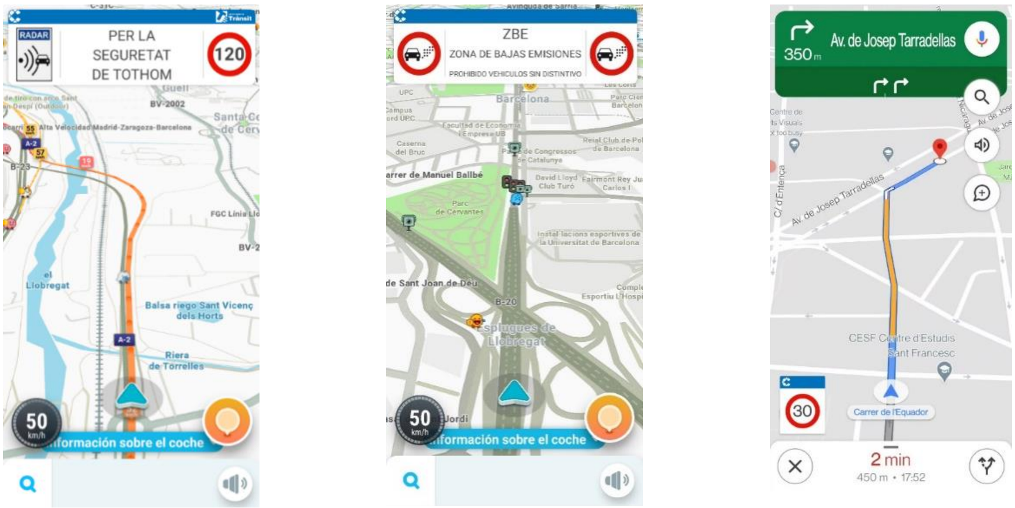


Figure 65: VMS, Virtual VMS and Fixed road signs IVS use cases

3.12.1.1. Barcelona deployment (large-scale deployment)

The three use cases are available for drivers and motorcyclists in the entire C-MobILE Barcelona area, since there is information available outside the city related to VMS and Virtual VMS use cases, and in the city (Fixed Road Signs). Almost 1900 IVS events are available in the Barcelona DS, enjoyable by more than 2000 users since October 2019. The current number of users is around 900.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years. The results showed that the majority of the participants are familiar with this service but have never used it before (M = 2.69; SD = 1.57). Based on the service description, participants think that this service would be useful (M = 4.34; SD = 0.54) for their daily driving and stated that they would use (M = 4.25; SD = 0.66) this service once it is available.

/ Pre-Questionnaire – User training (Expectation)

57 participants (17 female) joined the user training. The mean age of these participants were 44 years (SD = 11 years). The results showed that participants heard about this service (M = 2.30; SD = 1.22) or a similar service. Based on the service description, participants think that this service would be useful (M = 4.36; SD = 0.70) for their daily driving and stated that they would use (M = 4.27; SD = 0.75) this service once it is available. After the user training the majority of participants thought that the IVS would make easier for them to obey traffic rules (M = 4.00; SD = 0.63).

/ Post-Questionnaire (Experience)

10 participants (1 female) shared their actual experience through the short questionnaire. The mean age of these participants were 45 years (SD = 10 years). The results are presented on Figure 66. Participants said that the IVS makes it easier for them to obey traffic rules (M = 4.22; SD = 0.42). Usually, information from IVS was received timely (M = 0.63; SD = 0.70). The amount of displayed information was perceived as ideal (M=-0.38; SD=0.70). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.00; SD = 0.82).

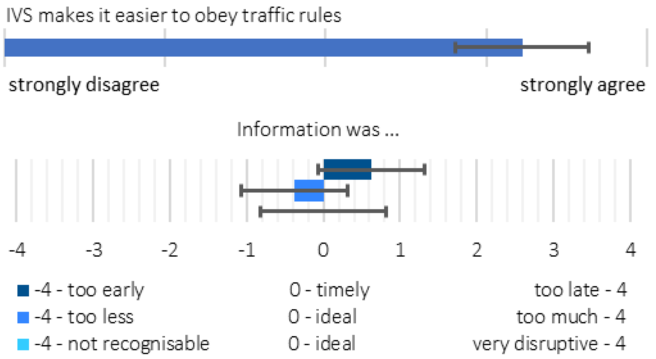


Figure 66: IVS - BCN Post Questionnaire Results

Objective service evaluation

The results from D6.4 show that with IVS speed limit information the percentage of speed violations decreases by 13.5 %. The mean speed during an event is reduced by 13.7 % and 10 s after the onset of the notification drivers are 15.2 % slower.

Integration of results and conclusions

In BCN, IVS is perceived as very useful and information presentation is rated almost ideal. This positive subjective assessment is supported from objective measures, i.e. by accordingly decreasing speeds, resulting in less speed violations. Thus, expressed and behavioural acceptance of IVS are high.

3.12.2. IVS by NeoGLS

Bordeaux DS is implementing IVS service in both 4G and G5 technologies. This use case is deployed in 3 different zones:

- The city centre, where 30 km/h speed limits close to schools are provided to the users
- The ring road, where users can enjoy seeing trip times and miscellaneous information about traffic status on the ring road
- The A63 Highway, where VMS information is also available

The aim of this service is to make the information easier to reach for the user, to increase awareness (and pedestrian security in the case of speed limit zones).

Figure 67: NeoGLS IVS use cases

3.12.2.1. Bordeaux deployment (large-scale deployment)

The area covered by the IVS use case in Bordeaux DS is the ring-road, all bridges and entrances that are leading to the ring-road and the A63 highway.

The city centre is also covered with the speed limit use case which represents IVI zones where the speed is restricted next to a school.

The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of 400 users.

Subjective service evaluation

/ Post-Experiment (Experience)

11 participants (9 female) shared their actual experience through the short questionnaire. The mean age of these participants were 43 years (SD = 8 years). The results are presented on Figure 68. Participants tended to agree that the IVS makes it easier for them to obey traffic rules (M = 3.64 SD = 0.48). Usually, information from IVS was received timely (M = 0.18; SD = 0.72). The amount of displayed information was perceived as ideal (M = 0.09; SD = 0.29). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.18; SD = 0.94).

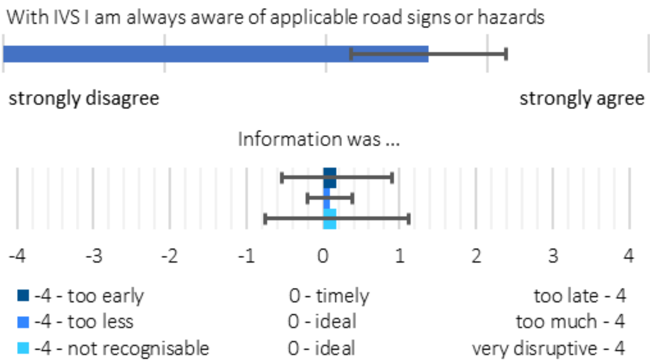


Figure 68: BOD – IVS Post Experiment Questionnaire

Objective service evaluation

Due to a too small sample size the objective IVS results from Bordeaux occur not robust enough to draw secured conclusions. While the percentage of speed violations unexpectedly increases, at least the mean speed during an event decreases by 9.7 %.

Integration of results and conclusions

IVS in Bordeaux is perceived as useful and information presentation is rated almost ideal. This positive subjective assessment could be supported from objective measures but potential positive effects are not sufficiently substantiated, yet.

3.12.2.2. Newcastle deployment (large-scale deployment)

IVS is delivered to all users of cellular services, however unlike RWW and RHW, which are available across a wide geographic region, IVS is only available on the 6 Km Gosforth Corridor. The service delivers speed limit information to drivers on a stretch of road where there are multiple speed limit changes. All 38 users of cellular services including NEAS, NCC drivers and selected private motorists were able to enjoy the service.

Subjective service evaluation

/ Post Experiment (Experience)

3 participants (1 female) shared their actual experience through the short questionnaire. The mean age of these participants were 51 years (SD = 6 years). The results are presented on Figure 69. Participants tended to agree that the IVS makes it easier for them to obey traffic rules (M = 4.33 SD = 0.47). Usually, information from IVS was received timely with a tendency towards late (M = 1.00; SD = 1.41). The amount of displayed information was perceived as ideal (M = 0.00; SD = 0.00). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.00; SD = 0.00).

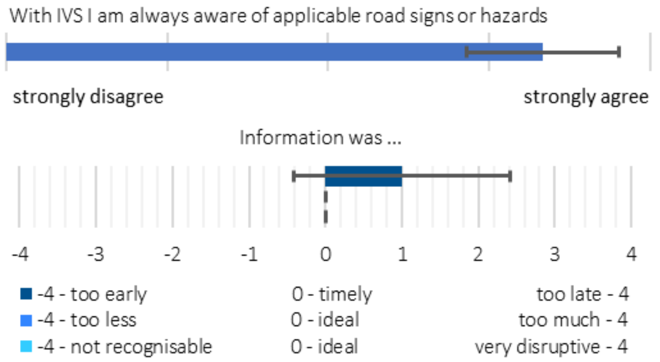


Figure 69: NEW – IVS Post Experiment Questionnaire

Objective service evaluation

There were not enough events logged for a comprehensive analysis of objective indicators from Newcastle. Interpreting the little available data cautiously, a very low number of speed violations could indicate a high compliance with speed advices.

Integration of results and conclusions

IVS in Newcastle is perceived as very useful and information timing and conspicuity is rated almost ideal but tendentially too late. Objective findings are too weak to be considered actually positive at this stage.

3.12.3. IVS by CERTH

The IVS service provided by the CERTH App has the objective to inform drivers driving in the road network of Thessaloniki DS about the existing speed limits. The information is provided to the HMI of the driver's personal device via a notification with a red indication when he/ she is above the speed limit or a green one when the driving speed is below the speed limit. The figure below presents the notification on speed limits for IVS.

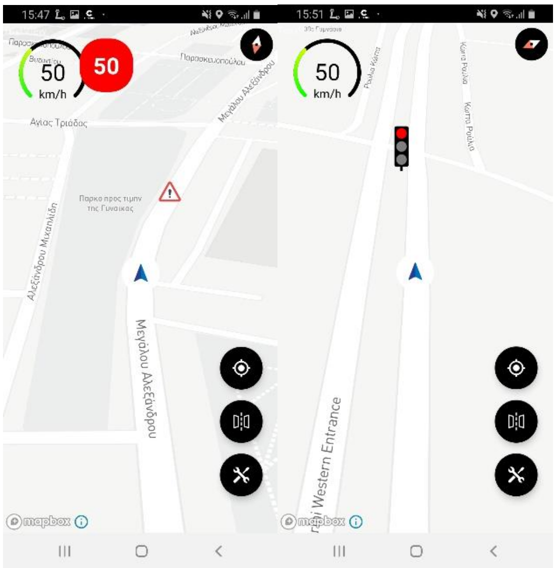


Figure 70: IVS notifications – CERTH App

3.12.3.1. Thessaloniki deployment (large-scale deployment)

The IVS service is provided along the entire road network of Thessaloniki DS. The information about the speed limits were depicted in digital map based on the real-life locations of traffic signs about speed limits in the network. This data is retrieved and processed by CERTH and then the appropriate C-ITS (IVI) messages are published and received by the users of the CERTH App.

Subjective service evaluation

/ User Training

10 participants (2 female) joined the user training. The mean age of these participants were 50 years (SD = 22 years). The results showed that participants are familiar (M = 3.08; SD = 1.72) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful for their daily driving (M = 4.31; SD = 1.62) and stated that they would use this service once it is available (M = 4.46; SD = 1.64).

After the training the majority of participants expect that with IVS they will be always aware of applicable road signs or hazards (M = 4.50; SD = 1.82), that IVS makes it easier to obey traffic rules (M = 4.50; SD = 1.82), that IVS increases their comfort while driving (M = 4.30; SD = 1.78), that they fell safe while IVS is activated (M = 4.30; SD = 1.78) and that they will use IVS regularly (M = 4.30; SD = 1.78). The amount of displayed information was perceived as ideal (M = 0.70; SD =2.53) with a tendency towards much.

/ Post-Experiment (Experience)

10 participants (4 female) shared their actual experience through the short questionnaire. The mean age of these participants were 45 years (SD = 9 years). The results are presented on Figure 71. Participants tended to agree that with IVS they are always aware of applicable road signs (M = 3.80 SD = 0.75). Usually, information from IVS was received timely (M = 0.30; SD = 0.90). The amount of displayed information was perceived as ideal (M = -0.20; SD = 0.60). Usually, the signals/notifications sent by IVS were perceived as ideal (M = -0.20; SD = 0.40).

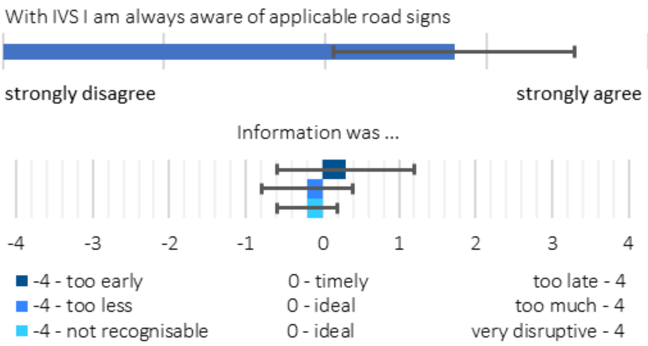


Figure 71: THE – IVS Post Experiment Questionnaire

Objective service evaluation

Despite a large number of events no noteworthy effects of IVS could be found with regard to mean speed or the occurrence of speed violations.

Integration of results and conclusions

IVS in Thessaloniki is perceived as useful and information presentation is rated almost ideal. Objective evidence that users obey more to speed limits given the respective service notifications could not be found.

3.12.4.IVS by CTAG

In-Vehicle Signage service is deployed with two different use cases in Vigo:

1. Variable Message Signs (VMS)

The first use case is related to the VMS where the drivers are provided with a copy of the digital panels placed in the outskirts of Vigo. The user interface pretends to replicate the real VMS information layout, where two icons/signs can be present at both sides and 3 lines of text information are available between them.

2. Speed limits

This data was gathered with a CTAG application to obtain all the speed limits contained along the corridor. Every speed limit is shown in the top-left margin according to our current position.

Figure 72: IVS notification from C-MobILE Vigo app

3.12.4.1. Vigo deployment (large-scale deployment)

The service has available the two aforementioned use cases in urban areas and in the outskirts of Vigo, being in this case more numerous in non-urban areas (A55, AP9, A52…). The most frequent warnings of this service are related to traffic flow, warning if there are traffic jams at any point on the road, recommendations to comply with safety regulations at the wheel and due to the current situation of information on the COVID and existing restrictions. The service has been enabled for all user groups (cars, motorbikes, emergencies, buses, trucks and vans) from the mobile application provided through the mobile devices delivered; a total of 80 recruited users. For all services a specific application has been developed allowing to include a baseline mode for the recruited users from where the results are received, analysed and evaluated. Another "regular" version of the application is available for free download in the Play Store which also offers this service to the general public.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

47 participants (9 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 9 years). The results showed that participants heard about this or a similar service (M = 1.96; SD = 1.18). Based on the service description, participants think that this service would be useful (M = 4.15; SD = 0.87) for their daily driving and stated that they would use (M = 4.19; SD = 0.79) this service once it is available.

/ Post-Questionnaire (Experience)

45 participants shared their actual experience with this service. The mean age of these participants were 39 years (SD = 9 years). The results are presented on Figure 73. Participants mean results were in between neither agree nor disagree and agree that with IVS they are always aware of applicable road signs or hazards (M = 3.58; SD = 0.86), that IVS makes it easier for them to obey traffic rules (M = 3.53; SD = 0.96), that IVS increases

comfort (M = 3.53; SD = 0.98), that IVS makes driving safer (M = 3.60; SD = 0.95), that they feel safe while using IVS (M = 3.44; SD = 0.93), that IVS works reliably and faultlessly (M = 3.79; SD = 0.85) and that they use IVS regularly when they are driving (M = 3.98; SD = 0.76). Usually, information from IVS was received timely (M = 0.07; SD = 0.62). The amount of displayed information was perceived as ideal (M=0.07; SD=0.76). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.18; SD = 1.69).

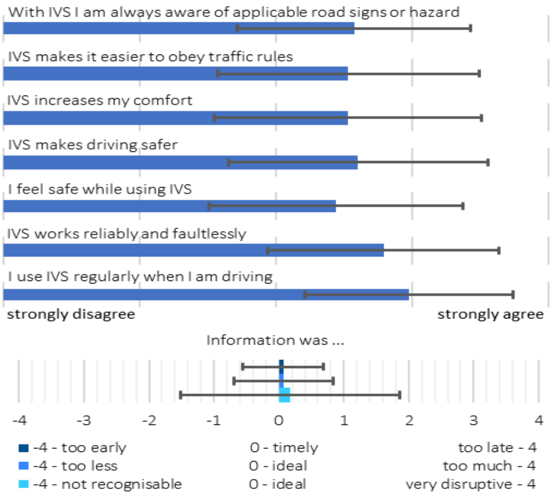


Figure 73: VIG – IVS Post Questionnaires Results

Objective service evaluation

The results from D6.4 show that with IVS speed limit information the mean speed during an event decreases by 4 %. Speed violation percentage is not available for Vigo deployment.

Integration of results and conclusions

In Vigo, IVS is perceived as useful and information presentation is rated almost ideal. A slightly decreased mean speed implies that users obey more to speed limits given the information on the current limit. Thus, expressed and behavioural acceptance of IVS occur to be in line.

3.12.5. Summary and comparison of different service versions and deployments

Over all implementations and deployments, IVS is perceived as useful and information presentation is rated almost ideal. This positive subjective assessment is supported by objective measures from some DS which imply a good compliance with service advices, i.e. by accordingly decreasing speeds and resulting less speed violations. Thus, expressed and behavioural acceptance of IVS occur to be in line.

3.13. Mode and Trip Time Advice (MTTA)

Mode & trip time advice (e.g., by incentives) aims to provide a traveller with an itinerary for a multimodal passenger transport journey, taking into account real-time and/ or static multimodal journey information.

3.13.1. MTTA by NeoGLS

Bordeaux DS is implementing MTTA service by providing free spaces in the Park & Ride facilities that are close to the user, and also promotes the use of tramway by indicating trip times to the city center with both transportations. The information is provided by Bordeaux Métropole through OpenData, and Qucit, for the number of available places in Park & Ride facilities.

When approaching a Park and Ride facility, the application will show to the user the number of spaces in the Park & Ride facility, but also in the next ones on the tramway line. This reduces traffic congestion, because what was observed before providing this service is that tramway users were driving to the next P&R without knowing it was already full and were forced to come back to the previous one, creating a lot of traffic congestion. The information is presented as a text information.

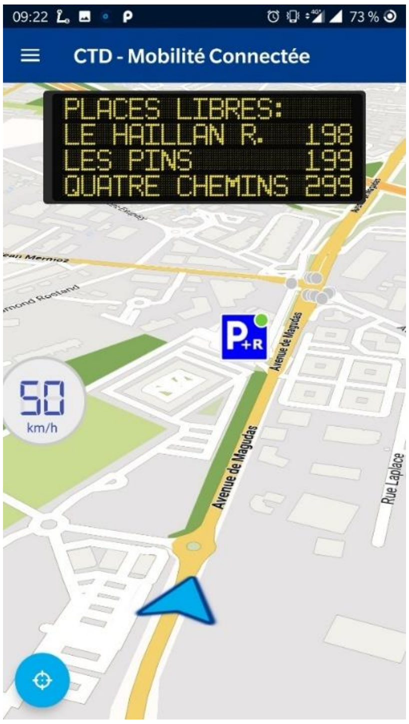


Figure 74: NeoGLS MTTA interface

3.13.1.1. Bordeaux deployment (large-scale deployment)

The area covered by the MTTA use case in Bordeaux DS is the tramway line Tram A, which crosses the whole city from the north-east to the west. The service is available on 8 Park & Ride facilities along this tramway line.

The service can be used with the CTD – Connected Mobility Android and iOS application. All users of the public application are forming a single user group for evaluation and use the same baseline rules. The user group contained around 1000 users in 2019, with a current number of about 400 users.

Subjective service evaluation

/ Post Experiment (Experience)

9 participants (5 female) shared their actual experience through the short questionnaire. The mean age of these participants were 44 years (SD = 12 years). Participant neither agree nor disagree that MTTA makes it easier to plan a journey (M = 3.33; SD = 0.47). The amount of information was perceived as ideal (M = -0.11; SD = 0.74)

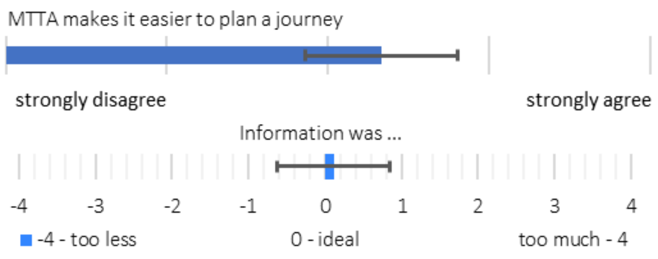


Figure 75: BOD – MTTA Post Experiment Questionnaire

Integration of results and conclusions

MTTA in BOD is perceived as useful and information presentation turns out to be considered quite ideal.

3.13.2. MTTA by CERTH

The MTTA service provided by the CERTH App has the objective to notify drivers driving in the network of Thessaloniki DS about travel times of various origin-destination pairs. The purpose is to assist driver in reducing the travel time and by being timely aware about the travel times pick then the route that is most appropriate for him/ her. The information is provided when the driver approaches specific locations in the network of the city. The figure below depicts an example of the notification shown in the HMI for the IVS service where the scrolling text below provides the travel time.

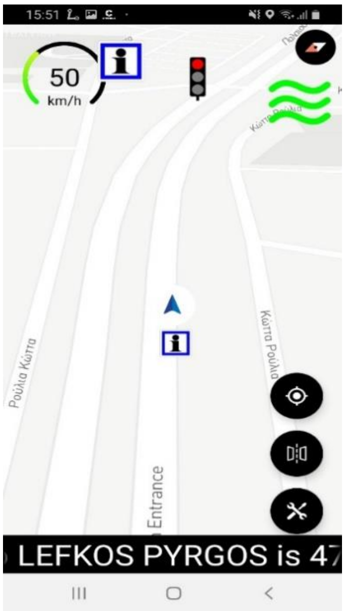


Figure 76: MTTA notification in CERTH App

3.13.2.1. Thessaloniki deployment (PoC)

The data on travel times for the MTTA service rely on the information about travel times provided via physical VMSs installed along the network of the city. This data, already being calculated and provided by CERTH, is now integrated also in the CERTH App. Moreover, additional locations where travel time information is provided have been added to the network of the city for the purposes of the service. This way MTTA servers also a digital VMS. The figure below presents the locations where the MTTA service is provided.

Subjective service evaluation

/ User training (Expectation)

10 participants (2 female) joined the user training. The mean age of these participants were 50 years (SD = 22 years). The results showed that participants are familiar (M = 3.15; SD = 1.75) with this service or a similar service but never used it before. Based on the service description, participants think that this service would be useful for their daily driving (M = 4.31; SD = 1.62) and stated that they would use this service once it is available (M = 4.46; SD = 1.64).

After the training the majority of participants expect that MTTA will make it easier to plan a journey (M = 4.40; SD = 1.78), that MTTA will make travelling more comfortable (M = 4.40; SD = 1.78), that MTTA will enable them to reduce travel costs (M = 4.40; SD = 1.78), that MTTA will enable them to reduce travel time (M = 4.40; SD = 1.78), that they feel safe while using MTTA (M = 4.30; SD = 1.78) and that they will use MTTA regularly when they are driving (M = 4.30; SD = 1.78). The amount of displayed information was perceived as ideal (M = 0.70; SD = 2.56) with a tendency towards much.

/ Post Experiment Questionnaire (Experience)

13 participants (6 female) shared their actual experience through the short questionnaire. The mean age of these participants were 40 years (SD = 9 years). Participant tended to agree that MTTA makes it easier to plan a journey (M = 3.92; SD = 0.73). The amount of information was perceived as ideal (M = 0.08; SD = 0.47)

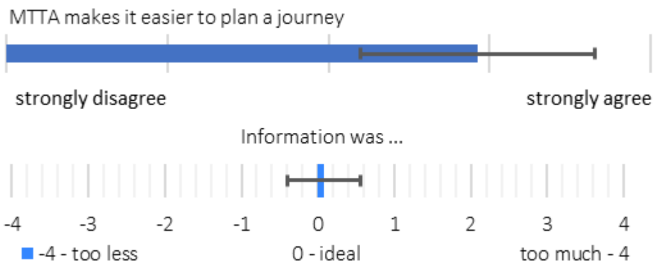


Figure 77: THE – MTTA Post Experiment Questionnaire

Integration of results and conclusions

Perceived usefulness of MTTA in THE is good and information presentation turns out to be quite ideal.

3.13.3. Summary and comparison of different service versions and deployments

Both versions of MTTA are well received by the users regarding usefulness and information presentation. A more direct comparison of the implementations seems not advisable since completely different functionalities are offered to the user.

3.14. Emergency Brake Light (EBL)

Emergency Brake Light aims to avoid (fatal) rear end collisions, which can occur if a vehicle ahead suddenly brakes, especially in dense driving situations or in situations with decreased visibility. The driver is warned before s/he is able to realize that the vehicle ahead is braking hard, especially if s/he does not see the vehicle directly (vehicles in between).

3.14.1. EBL by CTAG

Emergency Break Light provides the user all related information about the service. In collaboration with C-Roads project, we use their HMI app connected with an OBU that has access to CAN signals in order to detect brake pedal press. In that way, whenever the car in front of us with the mentioned OBU, breaks abruptly, C-MobILE receives the message that shows an invasive warning on the full screen accompanied with an alarming sound to inform the user about this car stopping.

Figure 78: EBL notification from C-MobILE Vigo app

3.14.1.1. Vigo deployment (PoC)

The EBL service is one of the ITS-G5 services that was developed as a PoC. A total of 26 drivers were selected to perform the test on the CTAG tracks. During the test, other drivers were involved to simulate a normal traffic conditions to evaluate the service. Details on the test setup and procedure can be found in the annex. Further objective results were included in D6.4.

Subjective service evaluation

/ Proof of Concept (Controlled Experiment)

26 participants (9 female) conducted the controlled experiment. The mean age of these participants between 25-34 years. The results showed that participants heard this service or a similar service before (M = 1.65; SD = 0.78). Based on the service description, participants think that this service would be useful for their daily driving (M = 4.38; SD = 0.49) and stated that they would use this service once it is available (M = 4.14; SD = 0.46).

After the trials (Figure 79) the majority of participants expects that EBL will enable them to quickly notice if a vehicle ahead suddenly brakes (M = 4.38; SD = 0.56), that EBL will increase safety (M = 4.38; SD = 0.62), that will EBL their understanding of the situation (M = 3.96; SD = 0.85), that after receiving a EBL notification, they will immediately know what to do (M = 3.92; SD = 0.78), that they feel safer while EBL is activated (M = 4.04; SD = 0.65) and that EBL will work reliably and faultlessly (M = 3.69; SD = 0.87). Usually, information from EBL was received timely (M = 0.08; SD = 0.38). The amount of displayed information was perceived as ideal (M=-0.08; SD=0.38). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.04; SD = 0.19).

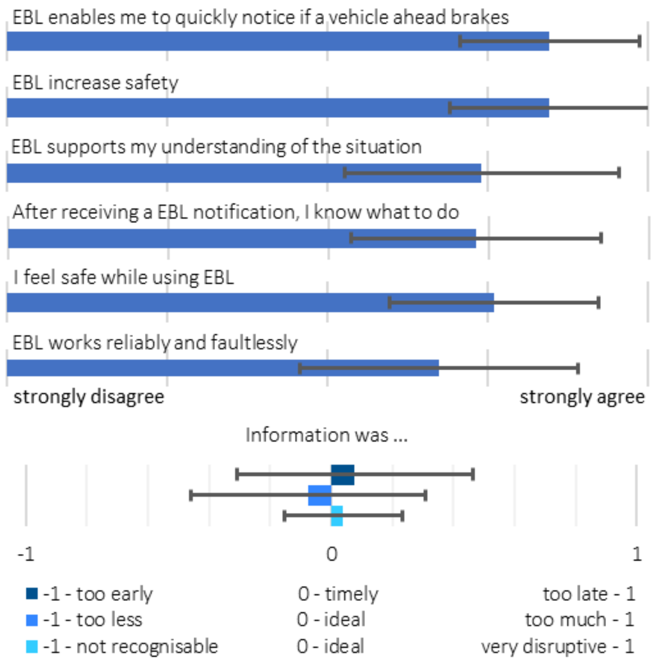


Figure 79: VIG – EBL POC Post Experiment Questionnaire

Note: information time/amount/feedback was collected with a 3-point scale instead of 9 point

Integration of results and conclusions

The only available subjective evaluation of EBL from Vigo yields a very high acceptance of the service. Since it was performed as a PoC in a closed track experiment it remains unsettled so far if this positive assessment will persist in real traffic.

3.15. Cooperative Adaptive Cruise Control (CACC)

Cooperative Adaptive Cruise Control represents an evolutionary advancement of conventional cruise control (CCC) and adaptive cruise control (ACC) by utilizing V2V communications to automatically synchronize the motion of many vehicles. While ACC uses Radar or LIDAR measurements to derive the range to the vehicle in front, CACC also takes the preceding vehicle's acceleration into account.

3.15.1. CACC by CTAG

Cooperative Adaptative Cruise Control provides all related information about the event. In collaboration with C-Roads project, we use their HMI app connected with an OBU that has access to CAN signals in order to detect cruise control management. A notification is always displayed in the top-right margin where we can see the icon of the service disabled with a grey state. When we are looking for adapting our speed with vehicle ahead, we activate our car cruise control and C-MobILE receives the message that changes our notification to green state confirming that we have adapted our speed.

Figure 80: C-ACC notification from C-MobILE Vigo app

3.15.1.1. Vigo deployment (PoC)

The CACC service is one of the ITS-G5 services that was developed on a small scale. A total of 16 drivers were selected to perform the test on the CTAG tracks. During the test, one driver was also involved to simulate being a normal driver who would be followed by the C-MobILE user to evaluate the service. Two use cases were considered, one of them with the use of the autonomous vehicle involved. Details on the setup and procedure of this test were provided in D5.6.

A total of 16 private drivers filled in the questionnaire in this CACC trial. This sample was composed by 10 men (62,5%) and 6 women (37,5%). The sample is young: around half of them are between 25-34 years old (56,25%) and around 35% between 35 and 50 years old. Taking into consideration schooling, 44% of them have graduate degree, 19% have a certificate degree and other 19% owns a Master degree or PhD. Only 12% of them have a vocational degree. Most of them work (81%) and half of the sample has a salary between 1000 and 1500 euros/month, around one quarter between 1500-2000€/month.

During the Evaluation test performance, the main objective of this study was to analyse the experience of the 16 participants driving a car, first manually, and later in autonomous mode, following a car which modifies its speed.In the autonomous mode run, CACC worked automatically adjusting the AV to the precedent car. This test was a first approach to define the behaviour of the car in both situations and the subjective perception of drivers. It is however important to highlight that more studies and test will be necessary for generalizing the results and for improving the PoC.

Once the service was introduced and before the test, the participants expressed their interest in this service and considered that it could be very useful in their driving if it was available. This aspect reinforces the idea that it is necessary to show and disseminate the advantages of these services as there is general interest on the part of potential users After testing, participants expressed a positive feel regarding its usability and they would like to use it, mainly in traffic jam situations.As for the information shown to them, the users considered it ideal although some of them expressed that it would be good to have the distance to the previous vehicle and expressed as positive to have an acoustic signal or another track to know when it starts working.

Further studies are undoubtedly needed, but it does seem that the use of this type of system would be well accepted by drivers in autonomous driving situations, mainly in urban traffic jams and on long-distance journeys where monotony and distraction could influence the correct performance of drivers.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

16 participants filled the first questionnaire. 16 participants (6 female) provided demographical information. The sample is young: around half of them are between 25-34 years old (56,25%) and around 35% between 35 and 50 years old. Based on the service description, participants think that this service would be useful (*M* = 4.25; *SD* = 0.85) for their daily driving and stated that they would use (*M* = 3.81; *SD* = 0.83) this service once it is available.

/ Post-Questionnaire (Experience)

16 participants (1 female) shared their actual experience through the short questionnaire. The results are presented on Figure 14. Participants said that CACC system status (activated/deactivated) is always visible (*M* = 3,56; *SD* = 1,06). They considered CACC makes it easier to drive within a platoon (*M* = 4,43; *SD* = 0,50). Participants believed CACC increases my comfort by driving smoothly within a platoon (*M* = 4,43; *SD* = 0,61). Moreover, CACC reduces the number of unnecessary brakes (*M* = 4,00; *SD* = 0,71) The amount of displayed information was perceived as ideal (*M* = 1,75; *SD* = 0,43) with a tendency towards "less". They felt safer while CACC is activated (*M* = 3,50; *SD* = 0,79). Finally, CACC works reliable and faultlessly for them (*M* = 3,75; *SD* = 0,90).

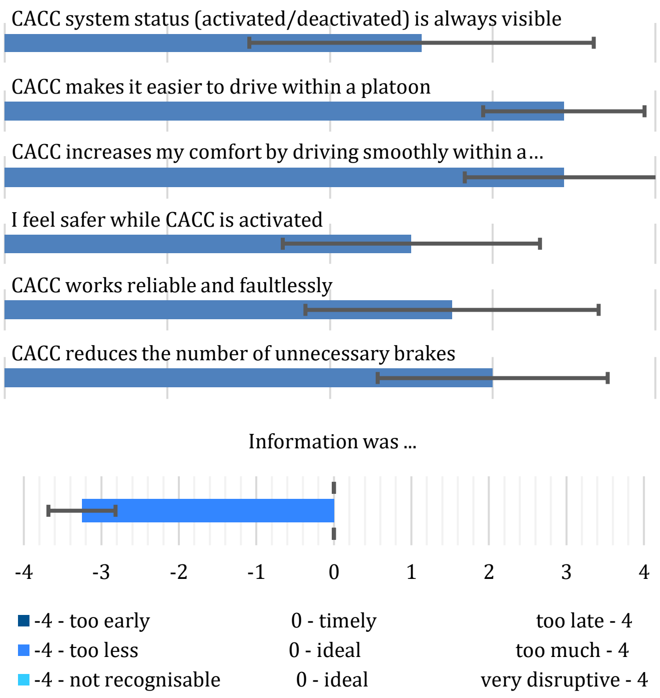


Figure 81: CACC - Vigo Post Questionnaire Results

Integration of results and conclusions

Once the service was introduced and before the test, the participants expressed their interest in this service and considered that it could be very useful in their driving if it was available. This aspect reinforces the idea that it is necessary to show and disseminate the advantages of these services as there is general interest on the part of potential users After testing, participants expressed a positive feel regarding its usability and they would like to use it, mainly in traffic jam situations.

As for the information shown to them, the users considered it ideal although some of them expressed that it would be good to have the distance to the previous vehicle and expressed as positive to have an acoustic signal or another track to know when it starts working.

Further studies are undoubtedly needed, but it does seem that the use of this type of system would be well accepted by drivers in autonomous driving situations, mainly in urban traffic jams and on long-distance journeys where monotony and distraction could influence the correct performance of drivers.

Participants in this test only had the possibility to perceive the icon in the experimental phase round then, it is important to highlight that user experience with the service icon was limited and therefore, their perceptions were restricted too. It is probable that if the drivers had the information available for a longer time, as in the case of a naturalistic study, their perception of HMI service icon would be more reliable. In this case, results only reflect preliminary impressions about user perceptions.

3.16. Slow and Stationary Vehicle Warning (SSVW)

Slow or stationary vehicle warning aims to inform/ alert approaching vehicles of (dangerously) immobilized, stationary or slow vehicles that impose significant risk.

3.16.1. SSVW by CTAG

Slow Vehicle Warning provides the user all related information about the event. Starting with a notification in the top-right margin where we can see the icon of the event, slow vehicle for this case, and followed by the distance in meters from our placeholder to the vehicle's actual position. On map we can see a little POI (Point of interest) indicating where exactly the vehicle is moving around us geographically each second. With these two items, notification plus POI, we achieve an accurate representation showing all the available and necessary data of the warning nearby.

Figure 82: SSVW notification from C-MobILE Vigo app

3.16.1.1. Vigo deployment (large-scale deployment)

This service is available throughout the corridor and to all involved users. With the information provided by this service, users can react in advance if they encounter a vehicle on their route that is travelling significantly slower than their own speed. This service has been developed mainly for interurban areas and therefore includes a filter to differentiate between situations of danger due to slow vehicles and situations of slow traffic in urban environments. The service has been enabled for all user groups (cars, motorbikes, emergencies, buses, trucks and vans) from the mobile application provided through the mobile devices delivered; a total of 80 recruited users. For all services a specific application has been developed allowing to include a baseline mode for the recruited users from where the results are received, analysed and evaluated. Another "regular" version of the application is available for free download in the Play Store which also offers this service to the general public.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

47 participants (9 female) filled the first questionnaire. The mean age of these participants were 39 years (SD = 9 years). The results showed that participants heard about this or a similar service (M = 1.70; SD = 0.95). Based on the service description, participants think that this service would be useful (M = 4.22; SD = 0.59) for their daily driving and stated that they would use (M = 4.19; SD = 0.79) this service once it is available.

/ Post-Questionnaire (Experience)

9 participants shared their actual experience with this service. The mean age of the participants was 37 (SD = 7 years). The results are presented on Figure 83. Participants tended to agree that SSVW enabled them to stop the location of the vehicles quickly (M = 3.50; SD = 0.67), that SSVW increases safety (M = 3.67; SD = 0.47), that SSVW supports their understanding of the situation (M = 3.67; SD = 0.67), that after receiving a SSVW notification, they know what to do (M = 3.30; SD = 0.64), that they safe while using SSVW (M = 3.22; SD = 0.63) and that SSVW works reliably and faultlessly (M = 3.11; SD = 0.57). Participants indicated that they always keep SSVW (M = 4.13; SD = 0.60). Usually, information from SSVW was received timely (M = 0.78; SD = 1.31) with a tendency towards late. The amount of displayed information was perceived as ideal (M= -0.38; SD = 0.70). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.42; SD = -0.22).

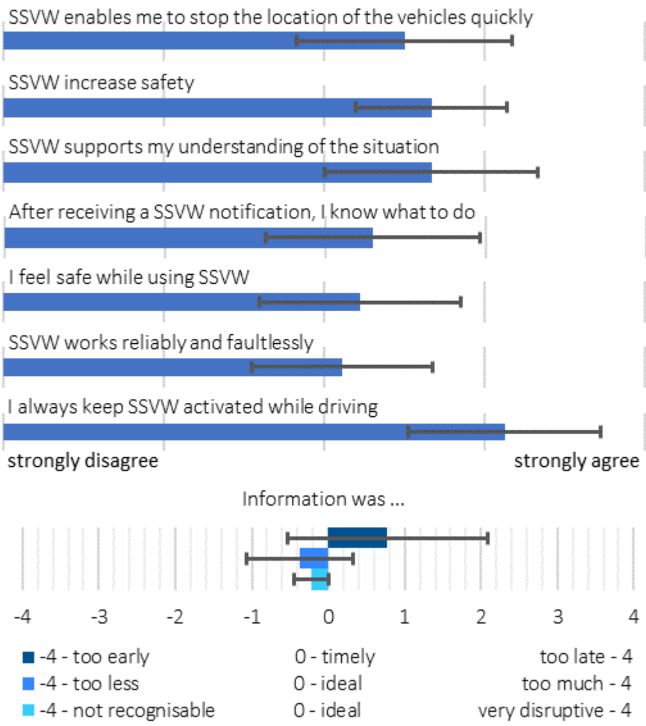


Figure 83: VIG – SSVW Post Questionnaire Results

Integration of results and conclusions

The only deployment of SSVW from Vigo yields a high acceptance of the service. The implemented functionality can be seen as a specific use case of RHW. Consequently, service acceptance is similar for both services.

3.17.Motorcycle Approach Indication (MAI)

Motorcycle approaching indication informs the driver of a vehicle that a motorcycle is approaching/passing. The scope can be extended to cover other VRUs, such as cyclists and other Powered Two Wheelers (PTW). The motorcycle could be approaching from behind or crossing at an intersection.

3.17.1. MAI by IDIADA

The MAI service in Barcelona sticks to the same implementation area and trigger conditions than the WSP service. This means that the service is offered as a pre-warning indicating about the presence of motorcycles near the cars in certain intersections. When possible, the relative direction of the motorcycle is given, otherwise, the alert is only based on a red circle around a motorcycle icon and a warning sound.

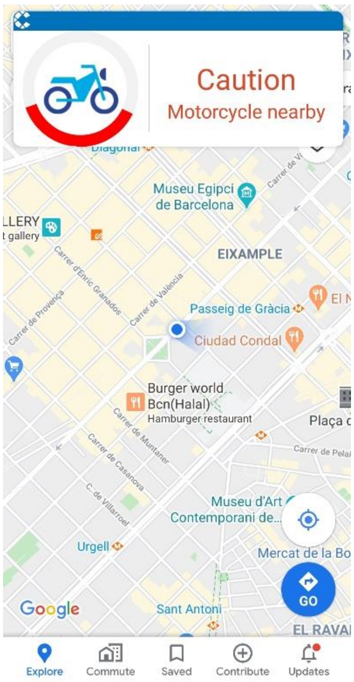


Figure 84: MAI service example from C-MobILE Barcelona app

3.17.1.1.Barcelona deployment (large-scale deployment)

A total amount of 165 intersections have been considered to deploy this MAI service. They are statically dangerous intersections where at least more than 10 incidents involving cars, motorcycles and VRUs have happened in both 2018 and 2019. Since two different users of the app need to be close each other, the chances for this service to apply are low. During the 9 months of large-scale deployment, almost 200 motorcyclists have used the app, while 1800 others have done it as drivers or cyclists.

Subjective service evaluation

/ Pre-Questionnaires (Expectation)

32 participants filled the first questionnaire. 23 participants (7 female) provided demographical information. The mean age of these participants were 49 years (SD = 9 years. The results showed that the majority of the participants never heard this service or a similar service (M = 1.37; SD = 0.58). Based on the service description, participants think that this service would be useful (M = 4.25; SD = 0.79) for their daily driving and stated that they would use (M = 4.19; SD = 0.77) this service once it is available.

Post Questionnaire (Experience)

3 male participants shared their actual experience through the short questionnaire. The mean age of these participants were 43 years (SD = 15 years). The results are presented on Figure 85. Participants stated that MAI enabled them to spot the position of motorcycles quickly. (M = 3.67; SD = 0.47). Usually, information from MAI was received timely (M = 1.00; SD = 0.82) with a tendency towards “late”. The amount of displayed information was perceived as ideal (M = -0.33; SD = 0.47). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.33; SD = 0.47).

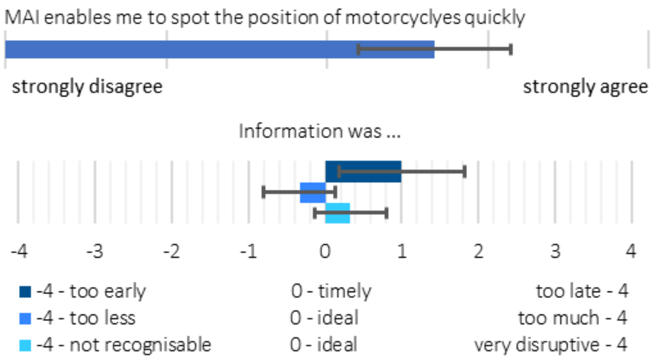


Figure 85: BCN – MAI Questionnaire Results

Integration of results and conclusions

By the very few users who experienced MAI in BCN the service is perceived as useful and information presentation is rated close to ideal. Nevertheless, there is a slight tendency that users would like to receive the notification earlier. Expectations from pre-questionnaires were met but due to the very small sample size results should not be considered robust, overall.

3.17.2. MAI by CTAG

Motorcycle Approaching Indication provides the user all related information about the service. When a motorcycle enters a radius of one kilometre from our placeholder, on map we can see a little POI (Point of interest) indicating where exactly the motorcycle is moving around us geographically each second. In that way, we consider in advance where the motorcycle is to be aware of it and avoid any possible crash.

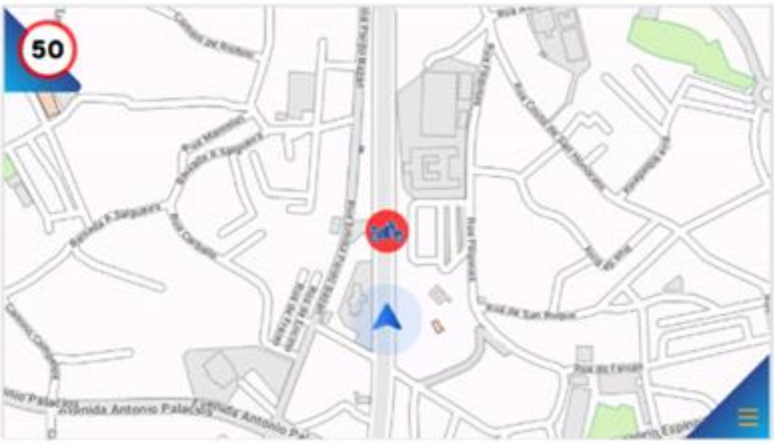


Figure 86: MAI notification from C-MobILE Vigo app

3.17.2.1. Vigo deployment (large-scale deployment)

The service has been enabled for all user groups (cars, motorbikes, emergencies, buses, trucks and vans) from the mobile application provided through the mobile devices delivered; a total of 80 recruited users. For all services a specific application has been developed allowing to include a baseline mode for the recruited users from where the results are received, analysed and evaluated. Another "regular" version of the application is available for free download in the Play Store which also offers this service to the general public.

Two different app users, at least one of them being a motorbike, have to be near each other for the motorbike proximity warning to be triggered. In this use case, there are 12 motorbikes equipped with C-MobILE mobile phones, so the chances of coincidence of this service being applied are very low.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

47 participants (9 female) filled the first questionnaire. The mean age of these participants was 39 years (SD = 9 years). The results showed that participants never heard about this or a similar service (M = 1.43; SD = 0.95). Based on the service description, participants think that this service would be useful (M = 4.00; SD = 0.93) for their daily driving and stated that they would use (M = 4.15; SD = 0.93) this service once it is available.

/ Post-Questionnaire (Experience)

7 participants shared their actual experience with this service. The mean age of these participants were 37 years (SD = 9 years). The results are presented on Figure 87. Participants mean results of the items were in between agree and neither agree nor disagree that MAI enabled them to spot the location of motorcycles quickly (M = 3.57; SD = 0.49), that MAI increase safety (M = 3.63; SD = 0.70), that MAI supports their understanding of the situation (M = 3.50; SD = 0.71), that after receiving a MAI notification, I know what to do (M = 3.63; SD = 0.48), that they feel safe while using MAI (M = 3.71; SD = 0.70), that MAI works reliably and faultlessly (M = 3.60; SD = 0.80) and that they always keep MAI keep activated while driving (M = 3.83; SD = 0.37). Usually, information from MAI was received timely (M = 0.00; SD = 0.63). The amount of displayed information was perceived as ideal (M= -0.25; SD = 0.66). Usually, the signals/notifications sent by IVS were perceived as ideal (M = 0.00; SD = 0.53).

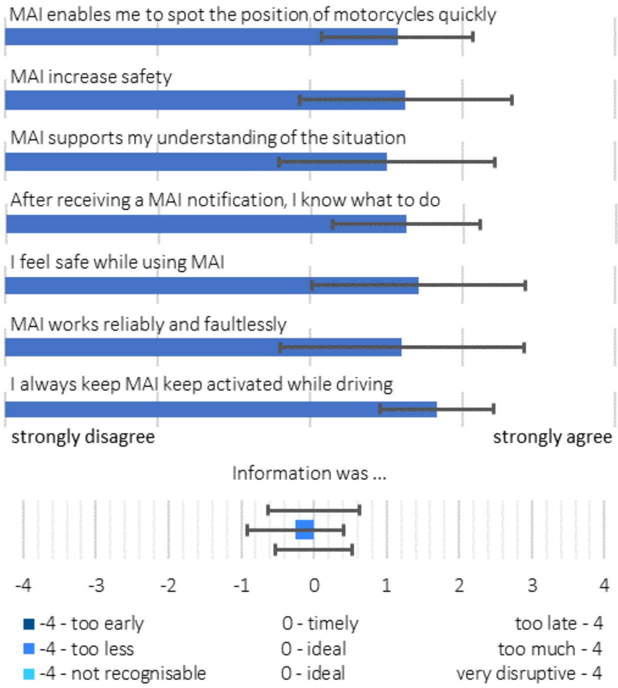


Figure 87: VIG – MAI Post Questionnaire Results

Integration of results and conclusions

In Vigo, MAI is perceived as useful and information presentation is rated almost ideal by a small sample of users. The service occurs to be reliable which should to be pointed out since MAI always requires the tracking and trajectory extrapolation for two app users.

3.17.3. Summary and comparison of different service versions and deployments

Both MAI deployments are considered useful by the users. Information presentation was rated close to ideal. However, due to very small samples results should not be overrated.

3.18. Blind Spot Detection (BSD)

Blind spot detection aims to detect and warn the drivers about other vehicles of any type located out of sight.

3.18.1. BSD by CEIT

This service was oriented in Bilbao DS to warn cyclists about a collision risk with other risky vehicles (mainly buses or municipality's trucks) at certain points in the urban area. These points are complex roundabouts or junctions where the bikes share the path with other vehicles. There are two levels of warning for this service: (1) Low-priority warning when the cyclist is inside a risky area but there is no risky vehicle in the surroundings (2) High-priority warning when the cyclist is inside a risky area and besides other risky vehicle is also in this area so the collision risk is high. For this second warning it is necessary that additional vehicles have installed the "risky vehicle" application which will trigger the event.

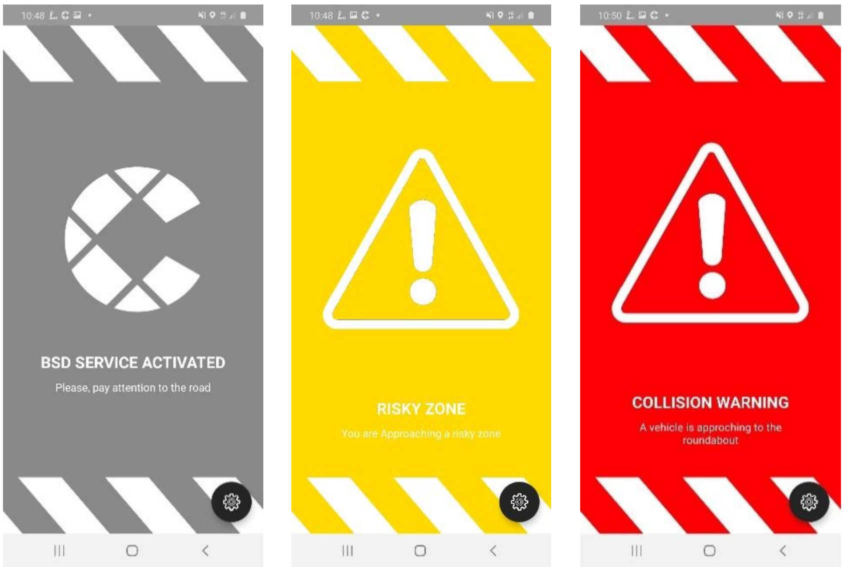


Figure 88: C-MobILE BSD app from Bilbao DS

3.18.1.1. Bilbao deployment (large-scale deployment)

Service coverage: this service covers 18 dangerous points at the city urban area (complex roundabouts and intersections) where the cyclists share the path with other vehicles. It is worth mentioning that in September 2020 a new normative was established where all urban roads are limited to 30km/h and most of them can be used by cyclists.

User group(s): The target users of this service are cyclist. Within the project specific users where engaged to use the bikes but also other municipality's fleets were engaged to use the "risky vehicle" app that will generate the collision risk events if they drive through the defined points.

The application is available since December 2019 and it was downloaded by 38 different users in the last year. Currently there are 10 active users.

The complementary "risky vehicle" application was available in July 2020 and it was downloaded by 15 different users in the last year. Currently there are 10 active users.

Subjective service evaluation

/ Pre-Questionnaire (Expectation)

23 participants (11 female, 1 diverse) filled the first questionnaire. The mean age of these participants were 47 years (SD = 11 years). The results showed that participants heard about this or a similar service (M = 1.83; SD = 1.01). Based on the service description, participants think that this service would be useful (M = 4.09; SD = 0.93) for their daily driving and stated that they would use (M = 4.17; SD = 0.70) this service once it is available.

/ Post-Questionnaire (Experience)

5 participants (1 female) shared their actual experience through the short questionnaire. The mean age of these participants were 48 years (SD = 12 years). The results are presented on Figure 89Figure 18. Participants mean rating was between disagree and neither agree nor disagree that BSD enabled them to spot the locate hidden vehicles (M = 2.50; SD = 0.87). Usually, information from BSD was received timely (M = 0.50; SD = 0.50). The amount of displayed information was perceived as ideal (M = -1.33; SD = 0.47) with a tendency towards "less". Usually, the signals/notifications sent by BSD was perceived as ideal (M = -1.00; SD = 0.82) with a tendency towards "not recognisable".

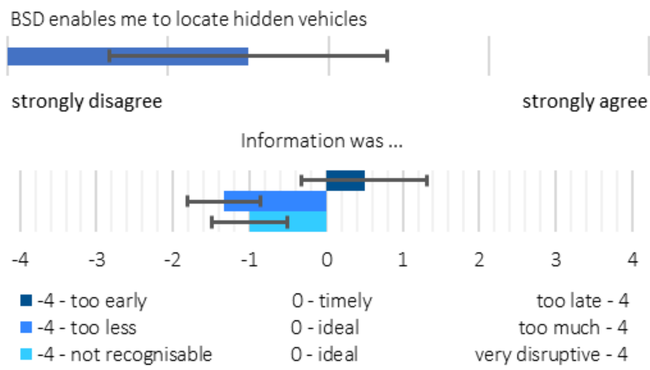


Figure 89: BIL – BSD Post Experiment Questionnaire

Integration of results and conclusions

The perceived usefulness of Bilbao's BSD service occurs to be rather poor. Notification timing is rated almost ideal whereas the amount and salience of the provided information is tendentially too low. Furthermore, the service acceptance considerably falls behind expectations. Even from the small sample given this indicates a need for adjustment of the functionality.

3.18.2. BSD by MACQ

No information provided.

3.18.2.1. North Brabant deployment (large-scale deployment)

No information provided.

3.18.3. Summary and comparison of different service versions and deployments

The very few subjective evaluation results that are available so far do not speak in favour of BSD—at least not in the current implementation. Even from the small sample given this indicates a need for adjustment of the functionality.

3.19. Summary of service evaluation results

This is a comprehensive results overview by service. Outcomes vary due to different deployments and implementations.

- Motorway Parking Availability (MPA)
  - There is very little data available but users and stakeholders seem to be convinced of this service. MPA is perceived as useful and information presentation occurs to be ideal, based on the results from Bordeaux.
- Urban Parking Availability (UPA)
  - There are hints that UPA is perceived as useful and information presentation occurs to be ideal. However, this outcome is based on small sample from just one deployment (BOD).
- Road Works Warning (RWW)
  - Over all implementations and DS, RWW is well received by the users. The service is perceived as (very) useful and most HMIs were considered to provide information in an almost ideal manner. The reliability of the service should be not such an issue as with RHW since road works are by nature longer lasting events whereas road hazards—such as crashes or breakdowns—occur and disappear more rapidly. The more it should be investigated why two respondents explicitly complained about invalid RWW notifications.
- Road Hazard Warning (RHW)
  - Over all implementations and deployments RHW is well received by the users. The service is perceived as (very) useful and most HMIs were considered to provide information in an almost ideal manner. Nevertheless, there seems to be a general potential for improving the reliability of the service—especially regarding false positive notifications—as it turned out for DS that used the full questionnaire version as well as from a few users' comments on the service.
- Emergency Vehicle Warning (EVW)
  - In an large-scale deployment of EVW the service is perceived as very useful and information presentation was rated close to ideal. Nevertheless, there is a clear tendency that users would like to receive more information earlier.
  - In an experiment at a closed track the service was similarly appreciated by the users. However, they demanded that the warning would be more conspicuous and to get more concrete information on the distance to the EV.
- Signal Violation Warning (SVW)
  - There is no clear picture on the perceived usefulness of SVW, ranging from rather poor through good. This variety is obviously not only a result of the less compelling data from some small samples and/or PoC tests in non-naturalistic environments. Rather, users are questioning the reliability, timing, and conspicuity of warnings. Definitely, the implementations of this service need further investigation and a readjustment in this regard.
- Warning System for Pedestrian (WSP)
  - On the acceptance of WSP very little robust data is available. Some initial findings from a few large-scale deployment users, PoC tests, and a lab experiment indicate potential for this service but no conclusions on the actual usefulness can be drawn on this weak basis, so further investigations are certainly needed.
- Green Priority (GP)
  - Coming from a very small sample from only one DS the service acceptance appears to be promising but further investigations are absolutely needed.
- Green Light Optimal Speed Advice (GLOSA)
  - GLOSA is well received in most DS; information presentation generally occurs to be close to ideal with only some minor exceptions. In one deployment (NBR), GLOSA acceptance is obviously decreased due to effects of dynamic signal phase timing which evokes abrupt changes in speed advices or time to green information.
- Cooperative Traffic Light for VRUs (CTLV)
  - Since no responses on any actual service experience were gathered user acceptance cannot be assessed.
- Flexible Infrastructure (FI)
  - All FI deployments are considered useful by the users. Information timing and amount was rated close to ideal. For one implementation the notification should be more salient to the driver.

/ In-Vehicle Signage (IVS)

> Over all implementations and deployments, IVS is perceived as useful and information presentation is rated almost ideal. This positive subjective assessment is supported by objective measures from some DS which imply a good compliance with service advices, i.e. by accordingly decreasing speeds and resulting less speed violations. Thus, expressed and behavioural acceptance of IVS occur to be in line.

/ Mode & Trip Time Advice (MTTA)

> All versions of MTTA are well received by the users regarding usefulness and information presentation. A more direct comparison of the implementations seems not advisable since completely different functionalities are offered to the user.

/ Emergency Brake Light (EBL)

> The only available subjective evaluation of EBL yields a very high acceptance of the service. Since it was performed as a PoC in a closed track experiment it remains unsettled so far if this positive assessment will persist in real traffic.

/ Cooperative Adaptive Cruise Control (CACC)

> The only available subjective evaluation of EBL yields a very high acceptance of the service. However, users demand more information, especially regarding the distance to other vehicles.

/ Slow and Stationary Vehicle Warning (SSVW)

> The only deployment of SSVW yields a high acceptance of the service. The implemented functionality can be seen as a specific use case of RHW. Consequently, service acceptance is similar for both services.

/ Motorcycle Approach Indication (MAI)

> Both MAI deployments are considered useful by the users. Information presentation was rated close to ideal. However, due to very small samples results should not be overrated.

/ Blind Spot Detection (BSD)

> The very few subjective evaluation results that are available so far do not speak in favour of BSD—at least not in the current implementation. Even from the small sample given this indicates a need for adjustment of the functionality.

4. Usability of Apps by provider

The usability of technical systems—such as C-ITS applications—is vital for their success. Thus, feedback from actual users is always valuable in order to identify potential for improvement. Most C-MobILE services have been deployed as cellular application, running on commercially available smart phones. Besides, a few services used ITS-G5 technology which requires RSUs and OBUs; the latter coming usually with different HMI concepts. Due to limited data availability, subjective user evaluation results are only available for the four most widely distributed cellular apps and a small ITS-G5 sample from professional drivers in North Brabant.

4.1. IDIADA App

The IDIADA App was deployed in Barcelona and North Brabant. The results are presented on Figure: 90.

> Barcelona

39 participants (2 female) completed the app evaluation in Barcelona. The mean age of these participants was 49 year (SD = 12 years). The results showed that participants do not use the app frequently (M = 2.85; SD = 1.24). Participants do not think that the application is unnecessarily complex (M = 2.49; SD = 0.81). The majority of participants said that the application was easy to use (M = 3.70; SD = 0.93). Participants found the various functions in this application were well integrated (M =3.64; SD = 0.73). Participants neither agree nor disagree that there was too much inconsistency in this application (M = 2.85; SD = 1.00). Participants would not be willing to pay for this application (M = 1.83; SD = 0.95)

> North Brabant

29 participants (normal drivers) (9 female) completed the app evaluation in North Brabant. The mean age of these participants was 48 years (SD = 10 years). The results showed that participants do not use the app frequently (M = 2.52; SD = 1.27). Participants do not think that the application is unnecessarily complex (M = 3.67; SD = 0.82). The majority of participants said that the application was easy to use (M = 3.70; SD = 0.93). Participants indicated that they do not need support of a technical person to be able to use this application (M = 1.41; SD = 0.62). Participants neither agree nor disagree that the various functions in this application were well integrated (M =3.12; SD = 0.71). Participants tended to agree that there was too much inconsistency in this application (M = 3.69; SD = 0.82). Participants may imagine that most people would learn to use this application very quickly (M = 3.78; SD = 0.74). Participants do not think that the application was very cumbersome to use. (M = 2.30; SD = 0.85). Participants neither agree nor disagree that they feel very confident while using the application (M = 2.96; SD = 0.92). Participants indicated that they did not need to learn a lot of things before they could get going with this application. (M = 1.85; SD = 0.65). Participants would not be willing to pay for this application (M = 1.96; SD = 0.92)

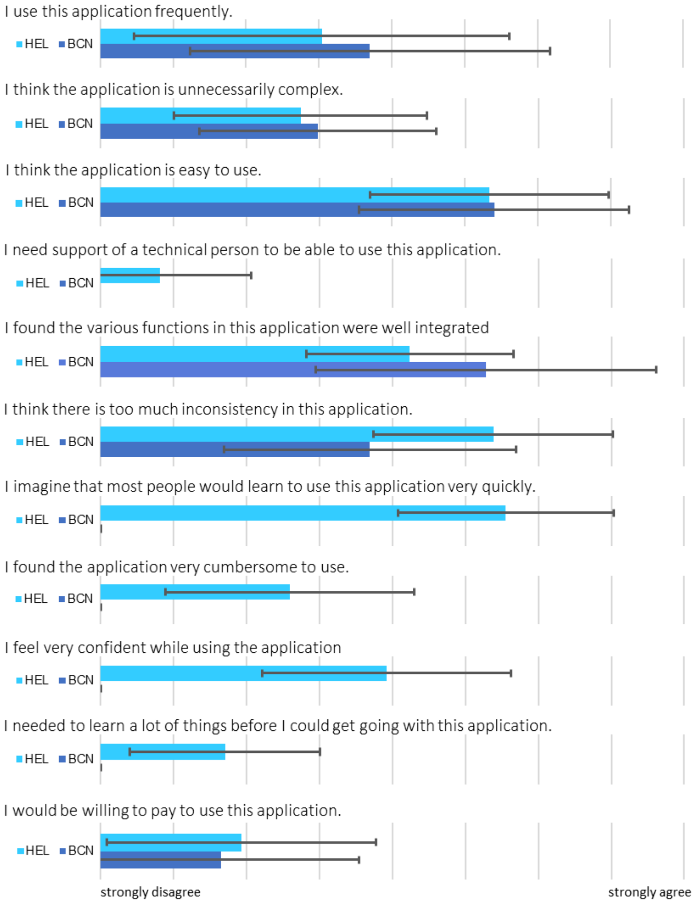


Figure: 90 Usability of IDIADA App

Since in BCN the shortened questionnaire version was distributed whereas NBR DS used the original long one not all items can be compared. At first glance it can be seen that only two items pertaining to the related concepts of functional integration and inconsistency obviously differ between both DS. To find an explanation for these differences is not easy. Maybe, adjustments made for the Dutch users altered the HMI in an unfavourable way.

Regarding overall acceptance another indicator can be considered for apps deployed publicly: the ratio of downloads and active users. For BCN—after several months of deployment—more than 2,000 people downloaded the app while in the end only about 900 (i.e. around 45 %) were actually using it.

4.2. NEO GLS App

The NeoGLS App was deployed in Bordeaux, Newcastle and Bilbao. The results are presented on Figure 91.

> Bordeaux

21 participants (10 female) completed the app evaluation in Bordeaux. The mean age of these participants was 48 years (SD = 10 years). The results showed that participants used the app neither frequently nor infrequently (M = 3.05; SD = 0.84). Participants do not think that the application is unnecessarily complex (M = 2.05; SD = 0.84). Participants neither agree nor disagree that the application was easy to use (M = 3.48; SD = 0.50). Participants neither agree nor disagree that various functions in this application were well integrated (M = 3.29; SD = 0.76). Participants disagree that there was too much inconsistency in this application (M = 2.19; SD = 0.96). Participants would not be willing to pay for this application (M = 2.67 SD = 1.13)

> Newcastle

3 professional drivers (1 female) completed the app evaluation in Newcastle. The mean age of these participants was 51 years (SD = 6 years). The results showed that participants used the app frequently (M = 4.00; SD = 0.00). Participants do not think that the application is unnecessarily complex (M = 2.33; SD = 0.47). Participants tended agree that the application was easy to use (M = 4.00; SD = 0.00). Participants tended to agree that various functions in this application were well integrated (M = 4.00; SD = 0.00). Participants disagree that there was too much inconsistency in this application (M = 2.67; SD = 0.47). Participants would not be willing to pay for this application (M = 2.00 SD = 0.87)

> Bilbao

6 participants (2 female) completed the app evaluation in Bilbao. The mean age of these participants was 43 years (SD = 10 years). The results showed that participants did not used the app frequently (M = 2.33; SD = 0.94). Participants do not think that the application is unnecessarily complex (M = 1.83; SD = 0.37). Participants tended agree that the application was easy to use (M = 4.17; SD = 0.37). Participants tended to agree that various functions in this application were well integrated (M = 3.67; SD = 0.47). Participants neither agree nor disagree that there was too much inconsistency in this application (M = 3.17; SD = 1.07). Participants would not be willing to pay for this application (M = 2.17 SD = 0.69)

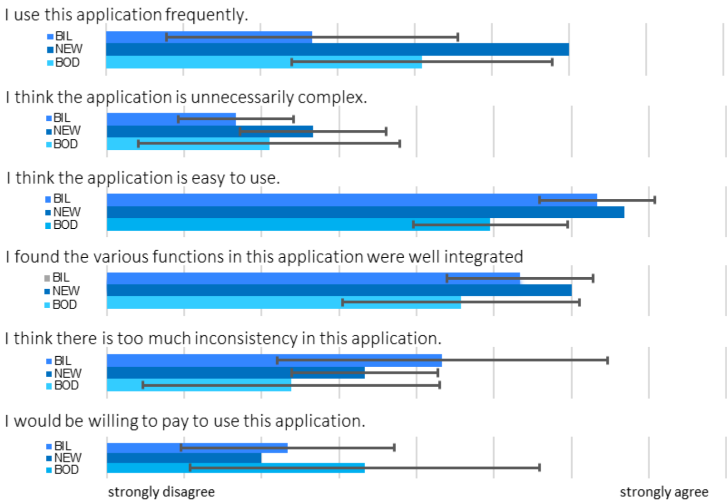


Figure 91: Usability of NeoGLS App

The subjective evaluation of the NeoGLS app yields larger differences between the three deployments but it must be stated here that results for BIL and NEW come from very few users and hence are not very robust. However, the most conspicuous finding that BIL participants are using the app considerably less is explainable from feedback by the recruited users at this DS: Obviously, running the app consumed a lot of energy from the cell phone battery what comprehensively annoyed the users. Maybe this insight could be considered for further optimization at NeoGLS.

4.3. CERTH App

The CERTH App was deployed in Thessaloniki. The results are presented on Figure 92. 30 participants (6 female) completed the app evaluation in Thessaloniki. The mean age of these participants was 48 years (SD = 9 years). The results showed that participants used the app frequently (M = 3.60; SD = 0.76). Participants do not think that the application is unnecessarily complex (M = 2.32; SD = 0.53). The majority of participants said that the application was not easy to use (M = 2.13; SD = 0.66). Participants found the various functions in this application were well integrated (M =3.71; SD = 0.63). Participants disagree that there was too much inconsistency in this application (M = 2.42; SD = 0.66). Participants would not be willing to pay for this application (M = 2.58 SD = 0.87)

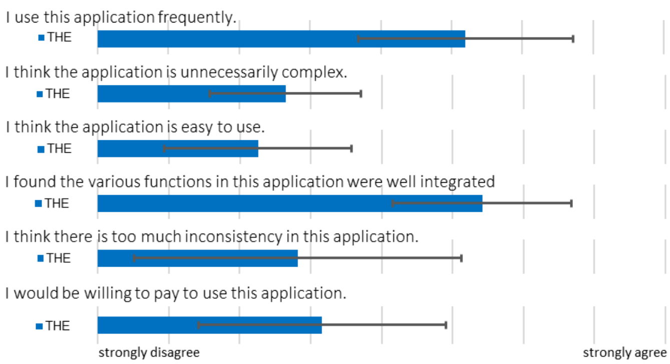


Figure 92: Usability of CERTH App

The subjective evaluation of the CERTH app turns out to be a bit inconclusive since users declare to be rather satisfied with the app but not think that it is not really easy to use. There is no plausible explanation for this finding

4.4. CTAG App

The CTAG App was deployed in Vigo. The results are presented on Figure 93. 67 participants (9 female) completed the app evaluation in Vigo. The mean age of these participants was 37 year (SD = 9 years). The results showed that participants used the app frequently (M = 3.76; SD = 1.02). Participants do not think that the application is unnecessarily complex (M = 1.87; SD = 1.02). The majority of participants tended to agree that the application was easy to use (M = 4.34; SD = 0.78). Participants indicated that they do not need support of a technical person to be able to use this application (M = 1.52; SD = 0.81). Participants tended to agree that the various functions in this application were well integrated (M =3.65; SD = 0.99). Participants tended to disagree that there was too much inconsistency in this application (M = 2.41; SD = 1.15). Participants tended to agree that most people would learn to use this application very quickly (M = 4.38; SD = 0.73). Participants do not think that the application was very cumbersome to use. (M = 1.65; SD = 0.86). Participants indicated that they feel very confident while using the application (M = 3.50; SD = 0.96). Participants tended to disagree that they did need to learn a lot of things before they could get going with this application. (M = 1.53; SD = 0.74). Participants would not be willing to pay for this application (M = 2.32; SD = 0.96)

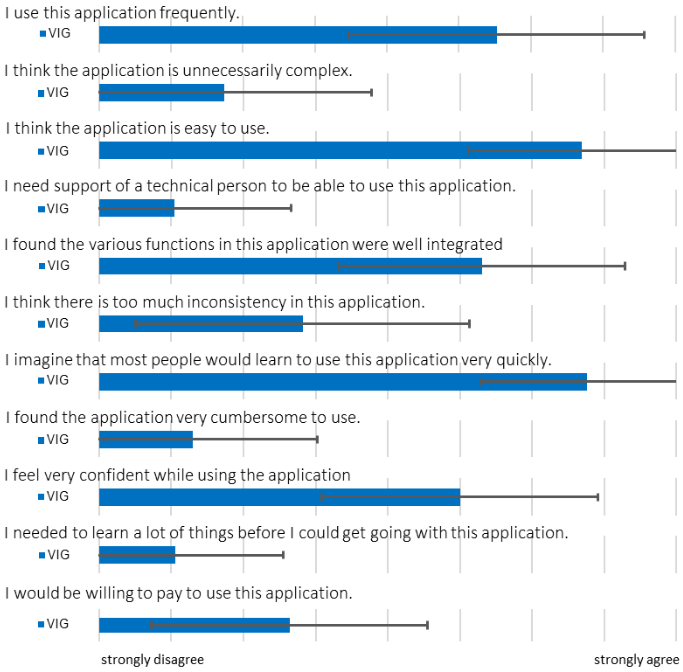


Figure 93: Usability of CTAG App

As before for the single services in Vigo, the entire app is rated very positively. Since all participants were recruited users the question arises if those could be biased in favour of CTAG products. It would be interesting to see if other agree with the recruited ones.

4.5. Dynniq ITS-G5

Dynniq deployed the services GP and GLOSA based on ITS-G5 technology. 5 professional drivers completed the app evaluation in North Brabant. The results showed that participants used the app neither frequently nor infrequently (M = 3.00; SD = 1.53). Participants neither agree nor disagree that the application is unnecessarily complex (M = 2.80; SD = 1.60). The majority of participants neither agree nor disagree that the application was easy to use (M = 3.40; SD = 1.36). Participants indicated that they do not need support of a technical person to be able to use this application (M = 2.60; SD = 0.80). Participants neither agree nor disagree that the various functions in this application were well integrated (M =3.20; SD = 1.17). Participants neither agree nor disagree that there was too much inconsistency in this application (M = 3.00; SD = 0.89). Participants neither agree nor disagree that most people would learn to use this application very quickly (M = 3.20; SD = 0.75). Participants do not think that the application was very cumbersome to use. (M = 2.40; SD = 0.49). Participants neither agree nor disagree that they feel very confident while using the application (M = 2.75; SD = 1.79). Participants neither agree nor disagree that they did not need to learn a lot of things before they could get going with this application. (M = 2.80; SD = 0.75). Participants would not be willing to pay for this application (M = 2.40; SD = 1.20)

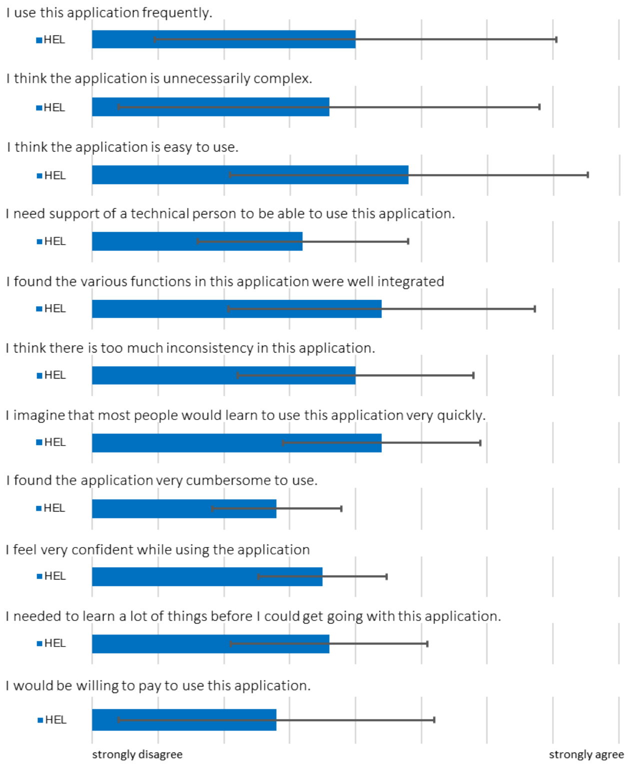


Figure 94: Usability of Dynniq App

5. Stakeholder questionnaire results

Stakeholder questionnaires were created for each deployment site which planned a stakeholder training. The stakeholder training conducted in Bordeaux delivered sufficient data for basic analysis which is presented on Table 2.

Table 2: BOD Stakeholder Questionnaire Results

For my institution, the importance that the services in the C-MobILE application...

environment	N	M	SD
have a positive effect on the fuel consumption of fleet vehicles	10	2.60	0.66
reduce CO_2 emissions from vehicles	10	2.70	0.46
have a positive influence on other pollutants (NOx, SOx)	10	2.40	0.66
reduce noise levels from road transport	10	2.00	0.45

efficiency	N	M	SD
promote eco-driving behaviour in terms of driving speed, acceleration and braking behaviour	10	2.70	0.46
reduce variations in speed	10	2.50	0.67
improve the drivers' journey times	4	2.75	0.43
reduce delays	4	2.00	0.71
improve the drivers' journey time reliability	4	2.50	0.50
reduce drivers' time in congestion	4	2.50	0.50
improve the traffic efficiency and network performance	8	2.38	0.70
improve the network journey time	2	2.00	1.00
improve journey time reliability on the network	2	2.50	0.50
reduce delays on the network	8	1.88	0.93
improve the network speed	8	1.63	0.70
improve the traffic flow	8	2.25	0.43
reduce congestion	8	2.25	0.83

safety	N	M	SD
promote a safer driving behaviour in terms of their driving speed, acceleration and braking behaviour	10	2.20	0.87
reduce the number of hard braking events	10	2.40	0.66
reduce the number of speeding events	10	2.10	0.70
improve time headways	4	2.00	0.71
reduce accidents	10	2.40	0.66
reduce fatalities	10	2.20	0.87

PVD	N	M	SD
For my institution, the importance that PVD is available is...	2	2.50	0.50
receive data about the current traffic state.	2	3.50	0.50
receive data about traffic incidents, e.g. accidents.	2	4.00	0

receive data about infrastructure conditions, e.g. surface conditions.	2	4.00	1.00
receive data about the vehicles' surrounding environment.	2	3.50	0.50
to promote measures that reduce environmental impact of road traffic.	2	3.50	0.50
to promote measures that increase efficiency, i.e. stabilize traffic flow or reroute traffic.	2	4.00	1.00
to promote measures that increase safety, i.e. improve warnings.	2	4.00	1.00
to have a basis for creating infrastructure maintenance plans	2	3.50	0.50
to have a basis for other applications that would be impossible otherwise.	2	3.50	0.50
to promote other services that it already provides.	2	3.50	0.50
to receive useful data that extents currently collected data, e.g. road sensors or cameras.	1	3.00	0.00
to receive useful data that substitutes currently collected data, e.g. road sensors or cameras.	2	4.00	1.00
to receive data from areas not covered with necessary communication infrastructure.	2	4.00	1.00
My institution intends to use PVD.	2	3.50	0.50
My institution intends to extent the amount of PVD in the future.	2	3.50	0.50

Overall, stakeholders in (French) traffic management seem to have no preferred goal among the common fields of environmental protection, safety, or efficiency. Two of them occur to be really enthusiastic about the possibilities that utilizing PVD could offer. Since no data is available from other DS insights are very limited and possible local differences cannot be revealed.

6. Discussion and conclusions

Looking at the outcome of T6.3 it can be stated that most services deployed in the C-MobILE project were well received by the users. Usability and acceptance of the apps were considered good while the willingness to pay for using the services is low which is probably no surprise to anyone working in the domain of C-ITS or app development, generally. Perceived usefulness is usually good while the presentation of information occasionally leaves room for improvement. Often, drivers wish to receive more and earlier information. This is not necessarily a question of HMI design but more likely of information availability to the service itself. This issue also pertains to the reliability of the information provided to the users which occasionally was rated rather poor. Understandably, a service has to deal with the data fed to it. However, if there is wrong or incomplete input users will attribute resulting failures to the app.

Some PoCs —especially the ones only examined at test tracks— suffer from reduced external validity of results. (Too) low sample sizes are also an issue, but even very limited data amounts can lead to secured findings. Usually, this applies when service performance is low like in the case of BSD where even just a few responses are enough to understand that service acceptance is fair at best and so there is still work ahead in order to create something that is perceived as useful. At the other end of the scale there are services that are highly appreciated over all implementations and deployments. IVS is such a service that is not only widely accepted by expressed attitude but also by behaviour, as results for the compliance with speed advice from the objective impact assessment underline.

As hinted above, for a few services there is little to none or very weak data available. For future C-ITS evaluations, having a reasonable number of users for testing the services before deployment seems to be a better idea than relying on the interest of potential users to download and use a publicly unknown app. On the other hand, these users should not be affiliated with service providers since this can (unwittingly) bias the assessment. In order to avoid both—having too few vs. enough but possibly influenced test persons—it could help to professionally recruit drivers instead of leaving this task to the deployment sites as done in some cases in C-MobILE. A Naturalistic Driving Study (NDS) with equipped private vehicles and C-ITS on top might mean effort and costs but would have the potential to substantially improve subjective and objective evaluation outcomes. Furthermore, it occurs reasonable to vary factors of interest (e.g., service implementation, HMI design) more systematically in order to assure a higher statistical and explanatory power.

References

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[2] https://ec.europa.eu/transport/sites/default/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf

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Annex 1

Controlled test C-MobILE for WSP service in Vigo

A total of 9 participants took place in this study although we have answers only for 8 questionnaires. All of them were internal workers without experience in C-Mobile project and without knowledge about it.

The test was performed on CTAG test track. The chosen zone for the test is located with letter B in the next picture.

Figure 95: CTAG track corridor for C-MobILE Vigo WSP PoC Evaluation

Figure 96: Track's picture with point B where the pedestrian crossed.

The route was a complete round to the red path and later to cross the test track by the yellow zone to get the crosswalk. All the participants run 3 rounds. They run to 30km/h in all the rounds. The sequence of the test was the following:

1. Participants signed the informed consent to participate in the test and to know the rules of driving in the test track.
2. All of them filled in the profile questionnaire.
3. After, the researcher explained them the objective of the study and some of the cooperative services. They were asked for the three question regarding services in the first iteration questionnaire (if they know the services, if they though the service is useful for them in their daily drive and if they would use it if it will be available).

4. Later, participants run a round to know how the car worked and have experience with the brake, mainly if it was the first time, they drove an automatic car.
5. Next time, they performed another round with a mobile with the app. In this case, it was obtained another run without any kind of information, they only perceived the map where the car was located. When they arrived point B, a pedestrian crossed and the participant had to brake.

Figure 97: Pedestrian crossing simulation platform during track tests.

6. Finally, they run the last round. Research explained that he/she would try another cooperative service (in fact, they are experiencing the similar situation than previous one, but this instruction was done for avoiding expectations regarding the same situation). When the car arrived point B, once more a pedestrian crossed by the cross walk, but this time the driver had the information in the app: participant received a message in the HMI to indicate that he/she had to brake. The image was together with a "beep". The researcher explained the participant, that in fact it was not a new cooperative service, it was the repetition on the previous one but with the information in the app".
7. Participants provided their opinions and feelings regarding this kind of service taking into consideration second iteration questionnaire.

Controlled test C-MobILE for EBL service in Vigo

This service was evaluated together CRoads Project. A total of 26 participants took place in this study. Except one, all of them were internal workers without experience in C-Mobile project and without knowledge about it.

The test was performed on CTAG test track. The chosen zone for the test is located with letter A in the next picture.

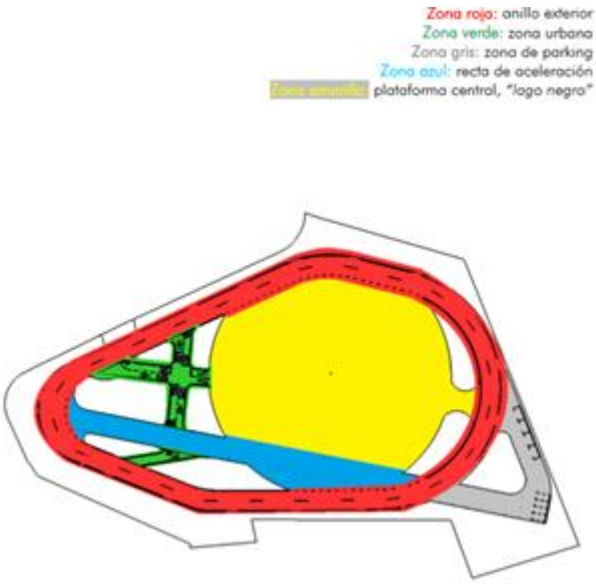


Figure 98: CTAG track corridor for C-MobILE Vigo WSP PoC Evaluation

All the participants ran 3 rounds to the external circle of the test track (red zone). They run to 30km/h in all the rounds. The sequence of the test was the following:

1. Participants signed the informed consent to participate in the test and to know the rules of driving in the test track.
2. All of them filled in the profile questionnaire.
3. After, the researcher explained them the objective of the study and some of the cooperative services. They were asked for the three question regarding services in the first iteration questionnaire (if they know the services, if they though the service is useful for them in their daily drive and if they would use it if it will be available).
4. Later, participants run a round to know how the car worked and have experience with the brake, mainly if it was the first time, they drove an automatic car.
5. Next time, they performed another round with a mobile with the app. In this case, it was obtained another run without any kind of information, they only perceived the map where the car was located; they have to follow a precedent car. When the car precedent arrived point A, this car stopped and the participant had to brake.
6. Finally, they run the last run, they have to follow a precedent car once more. Research explained that he/she would try another cooperative service (in fact, they are experiencing the similar situation than previous one, but this instruction was done for avoiding expectations regarding the same situation). When the car arrived point A, the precedent car stopped and participant receives a message in the HMI to indicate that he/she has to brake. The image was together with a "beep". The researcher explained the participant, that in fact it was not a new cooperative service, it was the repetition on the previous one but with the information in the app".
7. Participants provided their opinions and feelings regarding this kind of service taking into consideration second iteration questionnaire.

Lab experiment for BSD service evaluation in Newcastle

2. Methods

2.1 Human-machine interface of Warning System for Pedestrians

Based on the driver's first view footage of driving through a pedestrian crossing, we have developed five different WSP-HMIs, and detailed information of each HMI was shown in Table 1 and Figures 2-5.

Table 1. The characteristics of WSP HMI

HMI	Description
Auditory HMI	• Original driving footage was edited by adding warning sound.
Graphical HMI	• Original driving footage was edited by adding a pedestrian crossing warning sign.
Graphical + Textual HMI	• Original driving footage was edited by adding the pedestrian crossing warning sign and warning legend below the sign.
Graphical + Auditory HMI	• Original driving footage was edited by adding a pedestrian crossing warning sign and warning sound.
Graphical + Textual + Auditory HMI	• Original driving footage was edited by adding the pedestrian crossing warning sign, warning legend below the sign, and a warning sound.

Figure 1. Illustration of auditory HMI interface

Newcastle DS implemented a proof of concept for warning system for pedestrians (WSP). D2.2 of C-Mobile describes the WSP as aiming "to detect risky situations (e.g. road crossing) involving pedestrians, allowing the possibility to warn vehicle drivers". Hence, a WSP detects pedestrians and warns drivers. The service is particularly valuable when the driver is distracted or visibility is poor, for example, where pedestrians might emerge from between parked vehicles. The proof of concept services are envisaged as technological or user extensions. The WSP is designed to enhance safety of pedestrians, specifically the most vulnerable (disabled, older, young person), but will be of benefit both to pedestrians and drivers. This is a new type of service for the Newcastle DS, which previously has focused on environmental/operational efficiency through deploying services to fleet operators. Driver acceptance is an important criterion for evaluation of the effectiveness of in-vehicle human-machine interfaces (HMIs), but is under researched. Therefore, this document aims to evaluate end-user acceptance of the WSP.

2.2 Questionnaire design

The questionnaire contains 18 questions (Table 2) with all items measured on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Questions Q1-Q4 evaluate the effect of performance expectancy on different types of HMIs. Q5-Q8 evaluate the effect of effort expectancy on different types of HMIs. Q9-Q12 evaluate the effect of social influence on different types of HMIs. Q13-Q15 evaluate the effect of facilitation conditions on different types of HMIs. Q16-Q18 evaluate the effect of behavioural intentions on different types of HMIs.

Table 2. Questionnaire items

	Questions
Q1	I would find the system useful in my driving
Q2	Using the system would enable me to react to unsafe driving conditions more quickly
Q3	Using the system would improve my driving performance
Q4	Using the system, my risk of being involved in an accident would decrease.
Q5	I found the system to be clear and understandable.
Q6	I would quickly get used to operating the system.
Q7	I would find the system difficult to use
Q8	I would find the system a distraction whilst driving.
Q9	I would use the system if it was recommended by a trusted friend or family member.
Q10	I would use the system if it was recommended by a trusted agency (e.g. police or motoring authority like the AA)
Q11	I would use the system if it was recommended by an authority (e.g. by your insurance company)
Q12	In general, the authority would support the use of the system
Q13	I feel I have the understanding necessary to use the system.
Q14	I believe guidance will be available to me when deciding whether to use the system.
Q15	I believe specific persons (or a group) will be available for assistance with system difficulties.
Q16	If my car is equipped with a similar system, I predict that I would use the system when driving.
Q17	Assuming that the system is available, I intend to use the system regularly when I am driving.
Q18	Assuming that I had access to the system, I predict that I would use it in the future.

2.3 Experimental procedure

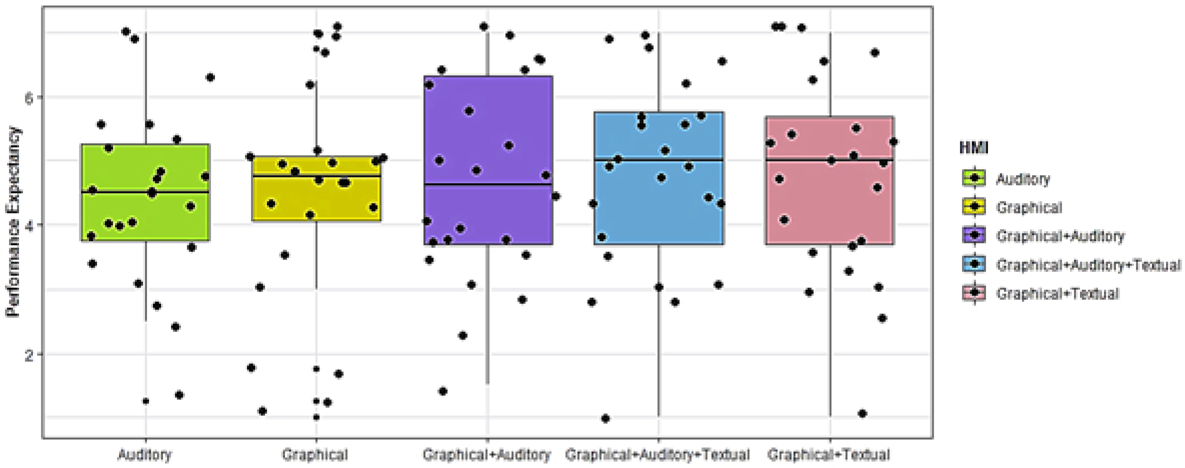
The investigation was carried out using online survey. Prior to the experiment, participants were given a brief introduction about the purpose of the study. Participants were asked to watch the first video-clip of WSP-HMI, and subsequently evaluated it by completing the questionnaire. After that, the participants were asked to repeat this process to evaluate the other four WSP-HMIs. In total, 24 participants were involved in the study.

3. Results

Generally, most participants agreed that using WSP may help improve their driving performance. Moreover, they may choose to use this service if someone important recommends it to them. Most agree that they may use this service in the future.

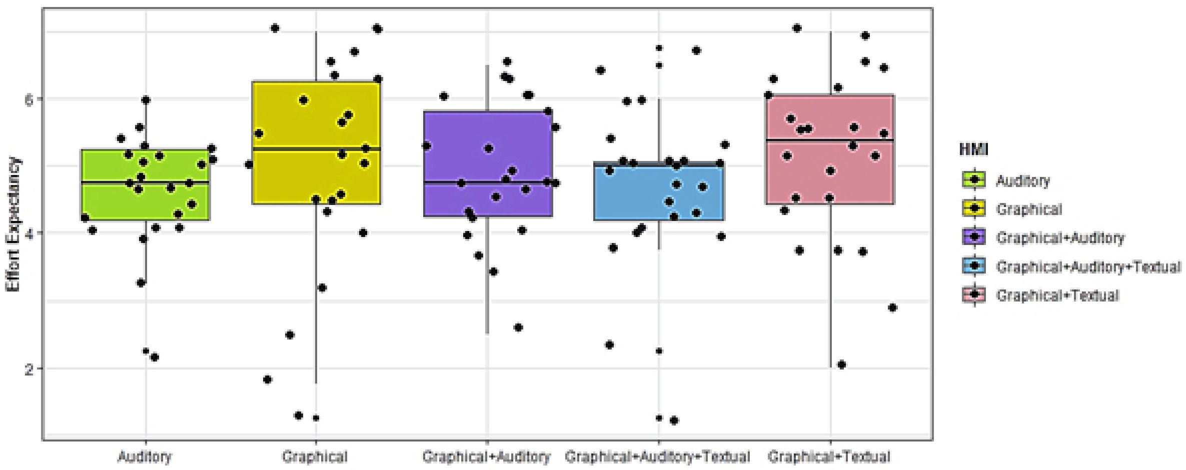
The overall responses to each HMI are shown in Figures 6-10. As Figure 6 shows, the mean scores of performance expectancy for each HMI are: Auditory HMI (M=4.43, SD=1.34), Graphical HMI (M=4.51, SD=1.75), Graphical + Auditory HMI (M=4.67, SD=1.57), Graphical + Auditory + Textual HMI (M=4.74, SD=1.54) and Graphical +Textual HMI (M=4.75, SD=1.59).

Figure 6. The mean scores of performance expectancy for each HMI



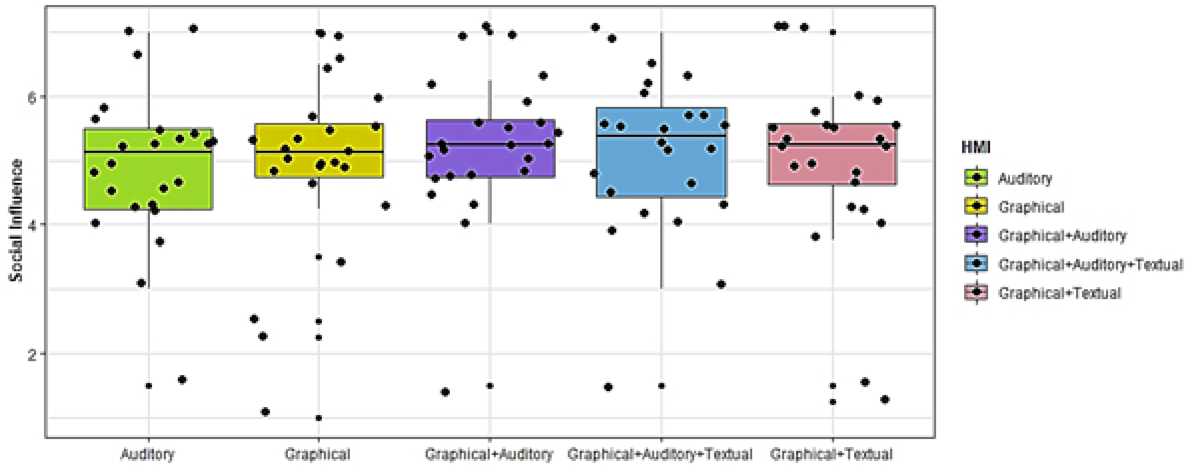
As Figure 7 shows, the mean scores of effort expectancy for each HMI are: Auditory HMI (M=4.64, SD=0.80), Graphical HMI (M=5.03, SD=1.60), Graphical + Auditory HMI (M=4.92, SD=1.00), Graphical + Auditory + Textual HMI (M=4.70, SD=1.20) and Graphical +Textual HMI (M=5.15, SD=1.26).

Figure 7. The mean scores of effort expectancy for each HMI



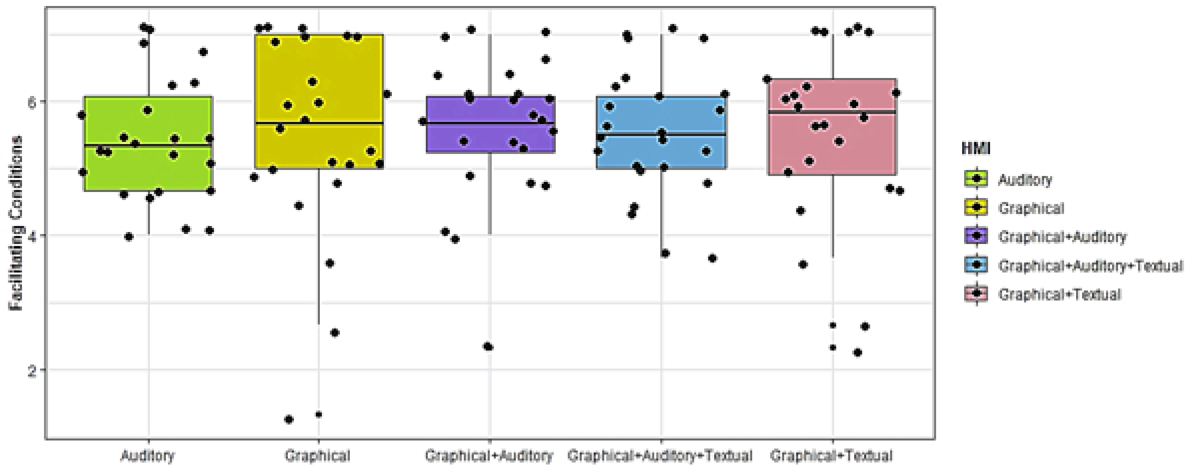
As Figure 8 shows, the mean scores of social influence for each HMI are: Auditory HMI (M=4.92, SD=1.22), Graphical HMI (M=4.95, SD=1.44), Graphical + Auditory HMI (M=5.24, SD=1.15), Graphical + Auditory + Textual HMI (M=5.14, SD=1.25) and Graphical +Textual HMI (M=5.01, SD=1.41).

Figure 8. The mean scores of social influence for each HMI



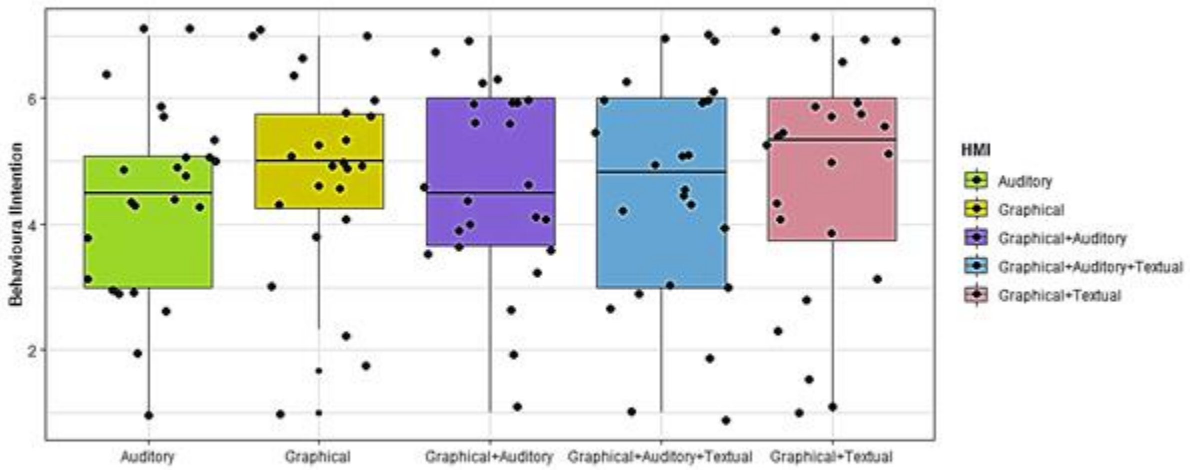
As Figure 9 shows, the mean scores of facilitating conditions for each HMI are: Auditory HMI (M=5.42, SD=0.93), Graphical HMI (M=5.49, SD=1.46), Graphical + Auditory HMI (M=5.57, SD=1.08), Graphical + Auditory + Textual HMI (M=5.54, SD=0.99) and Graphical +Textual HMI (M=5.51, SD=1.30).

Figure 9. The mean scores of facilitating conditions for each HMI



As Figure 10 shows, the mean scores of behavioural intentions for each HMI are: Auditory HMI (M=4.40, SD=1.52), Graphical HMI (M=4.85, SD=1.61), Graphical + Auditory HMI (M=4.64, SD=1.55), Graphical + Auditory + Textual HMI (M=4.54, SD=1.79) and Graphical +Textual HMI (M=4.74, SD=1.90).

Figure 10. The mean scores of behavioural intentions for each HMI



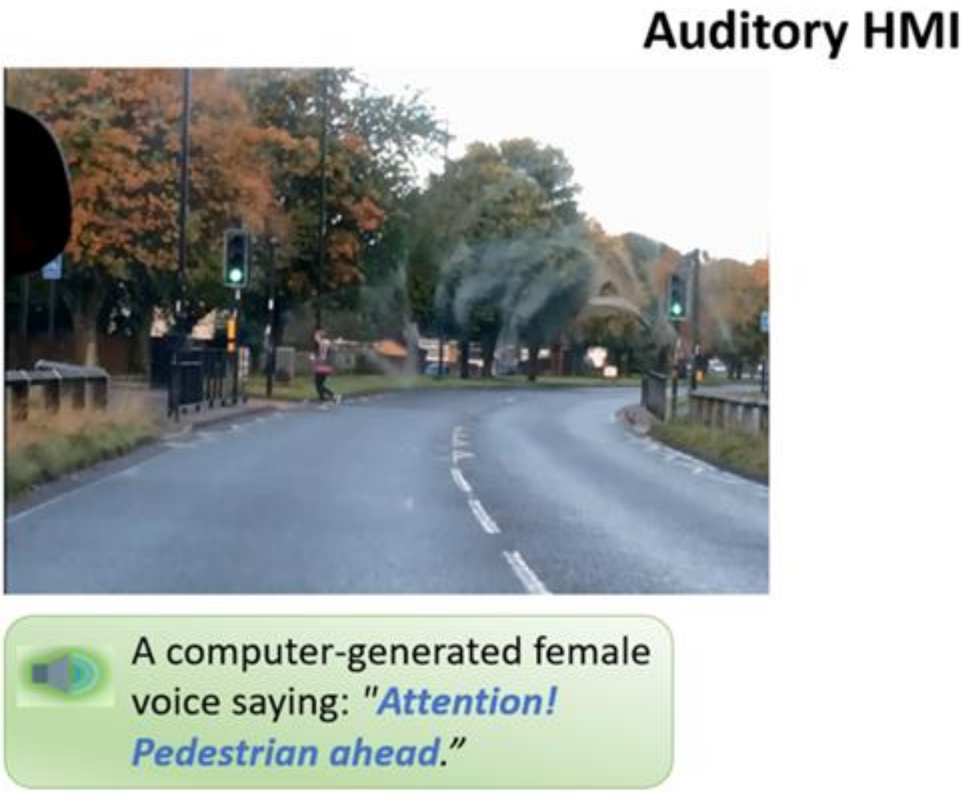


Figure 2. Illustration of graphical HMI interface

Figure 3. Illustration of graphical with textual HMI interface

Figure 4. Illustration of graphical with auditory HMI interface

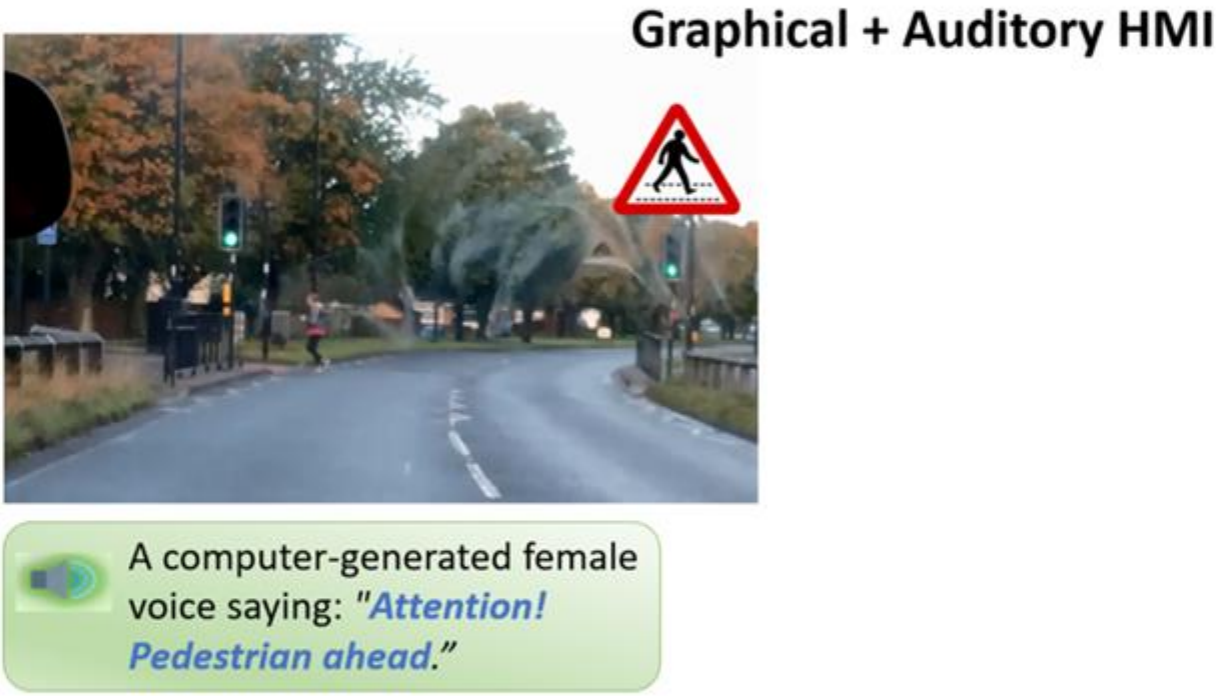
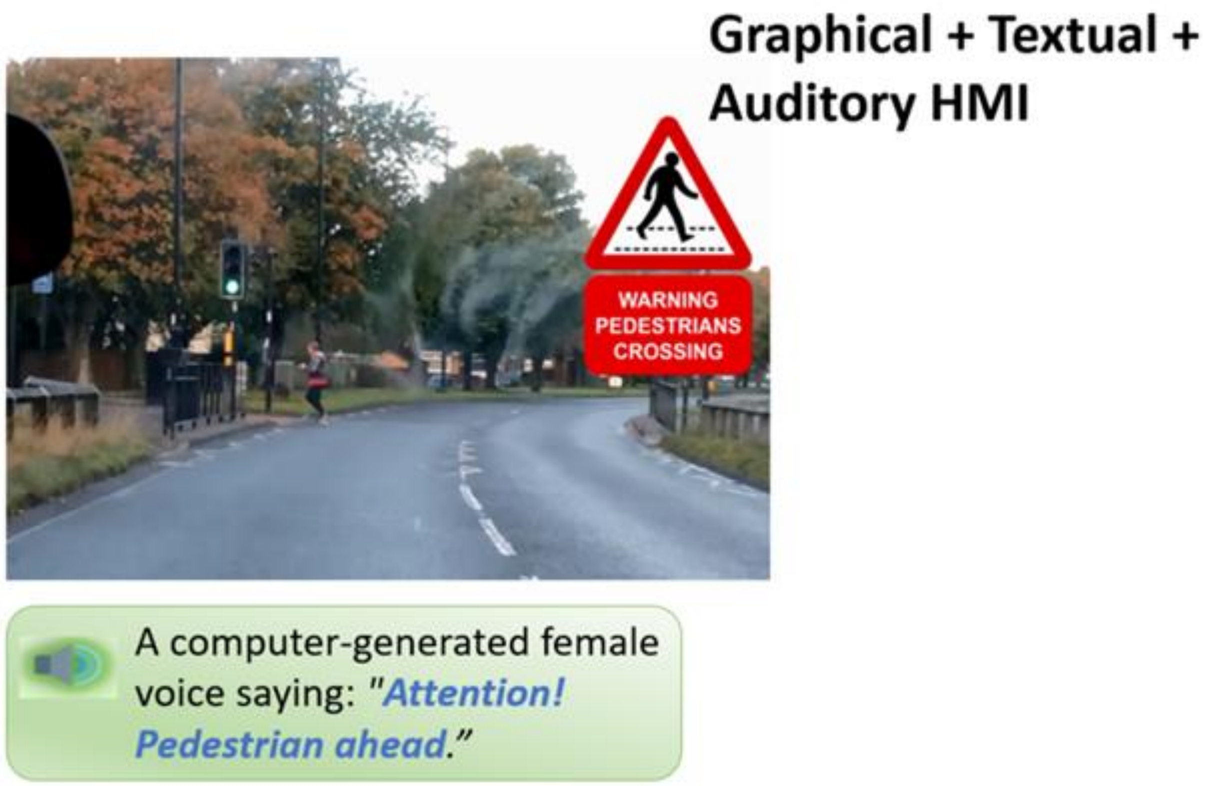


Figure 5. Illustration of graphical with textual plus auditory HMI interface



4. Conclusion

Evaluation of users' acceptance towards C-ITS services is crucial before deployment of such services into the transportation system. From this proof of concept study, we found that most end-users believe that using WSP may help them to improve their driving performance and they may intend to use it in the future if this service becomes available. These findings provide evidence to increase our understanding of public acceptance of this C-ITS application. They will be shared with our local stakeholders, in particular the fleet operators. A more detailed academic paper is being prepared for submission to the Journal of Intelligent Transport Systems: Technology, Planning and Operations.