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D3.4
Experimental protocol

Safe tolerance zone calculation and interventions for driver-vehicle-environment interactions under challenging conditions

iDREAMS

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Glossary and abbreviations

Word / Abbreviation	Description
ADAS	Advanced Driver Assistance Systems
BARRA	Barraqueiro Transportes
BE	Belgium
BSSS	Brief Sensation Seeking Scale
CTAM	Car Technology Acceptance Model
Dx.x	Deliverable
DAS	Dysfunctional Attitude Scale
DE	Germany
ECG	Electrocardiogram
EL	Greece
ESRA	E-Survey of Road Users' Attitudes
ESS	Epworth Sleepiness Scale
ERA	European Railway Agency
FCW	Forward Collision Warning
FESTA	Field opErational teSt supporT Action
FOTs	Field Operational Trials
GDPR	General Data Protection Regulation
HW	Headway Warning
ISO	the International Organization for Standardization
KSS	Karolinska Sleepiness Scale
LDW	Lane Departure Warning
LOUGH	Loughborough University
LVT	Visual Pursuit Test
ND	Naturalistic Driving
NTUA	National Technical University of Athens
OFAT	One Factor At a Time
PCW	Pedestrian Collision Warning
PSQI	Pittsburgh Sleep Quality Index
PT	Portugal
RT	Reaction Time
SDLA	Standard Deviation of Lateral Acceleration
SDLP	Standard Deviation of Lateral Position
SPAD	Signal Passed AT Danger

SSVS	Short Schwartz's Value Survey
STZ	Safety Tolerance Zone
TAM	Technology Acceptance Model
TUM	Technical University of Munich
TTC	Time-To-Collision
UHasselt	University Hasselt
UMDA	Unified Model of Driver Acceptance
UTAUT	Unified Theory of Acceptance and Use of Technology
UK	United Kingdom
VRU	Vulnerable Road User
WPx	Work Package

Executive Summary

The *i*-DREAMS project aims to establish a framework for the definition, development, testing and validation of a context-aware safety envelope for driving called the 'Safety Tolerance Zone'. Taking into account driver background factors and real-time risk indicators associated with the driving performance as well as the driver state and driving task complexity indicators, a continuous real-time assessment will be made to monitor and determine if a driver is within acceptable boundaries of safe operation. Moreover, safety-oriented interventions will be developed to inform or warn the driver in real-time as well as on an aggregated level after driving, through an app-and web-based gamified coaching platform (post-trip intervention).

The conceptual framework of the *i*-DREAMS platform integrates aspects of monitoring (such as context, operator, vehicle, task complexity and coping capacity), to develop a Safety Tolerance Zone for driving. In-vehicle interventions and post-trip interventions will aim to keep drivers within the Safety Tolerance Zone as well as provide feedback to the driver. This conceptual framework will be tested in simulator studies and three stages of field trials in Belgium, Germany, Greece, Portugal and the United Kingdom with over 600 participants representing car, bus, truck, and rail drivers.

The aim of this deliverable is to inform the planning and development of the simulator and field trials, including best practice and recommendations towards the experimental protocol, specific to the context of the *i*-DREAMS project. Overviews of the development of considerations for the simulator and field trials are detailed, and the high-risk scenarios are defined, which will be used to test the *i*-DREAMS system during the simulator trials. The information presented here will be expanded upon in future deliverables to provide a detailed methodology for the simulator and field trials.

The specific objectives of the deliverable are:

- To define the general parameters and environment for testing.
- To define the high-risk scenarios under which the *i*-DREAMS platform will be tested.

The simulator trials will act in part as a pilot study to help test the *i*-DREAMS platform. By considering specific design principles relevant to the simulator trials, these can be incorporated into the final design of the simulator study. Generic experimental designs and overviews of the trials are important to build a foundation for the further development of a specific methodology for the trials, which will be detailed in future deliverables. From this deliverable, it was decided that the simulator trials would:

- Include a fractional factorial design where only a subset of all scenarios will be selected.
- Be a within-participant design.
- Include at least three scenarios, containing 1-2 risk factors. The trials will consist of a baseline scenario with no intervention, an intervention scenario with fixed timing warnings, and an intervention scenario with an added condition to produce variable timing warnings.
- Include several practice drives to familiarise participants to the simulator and reduce the chance of simulator sickness.
- Include multiple risk events in one scenario, increasing the within participant variability, statistical power of the study and efficiency of the study as well as reducing the overall number of trials.
- Include several separate events to capture each risk factor to ensure adequate validity of the observations.

As trials are being conducted across five countries and four transport modes, it is important to outline and develop protocols and checklists to ensure consistency in approach where possible. As part of the work for this deliverable, checklists were developed for the simulator and field trials, which are included and should aid in the consistent planning of the trials across the multiple testing sites.

In order to test the *i*-DREAMS platform, risk scenarios will be used as part of the simulator trials. Although there are similarities among the on-road vehicles, there are also differences between them, and between on-road and rail in relation to target risks. These differences need to be taken in consideration when designing the high-risk scenarios and therefore scenarios will be tailored for each transport mode and vehicle type. A series of risk factors, environments, events, conditions and data are to be used for the scenarios, focused on specific target risks for each mode. The outlines detailed here will be further developed and finalised prior to the simulator trials.

Following simulator trials, field trials are to be conducted. The aim of the field trials are to assess the effect of the interventions, developed as part of the *i*-DREAMS system, for both real time and post-trip warnings. Vehicles will be instrumented across several different vehicle types and modes, which will then continue to operate as usual, all the time collecting data. By considering recommendations and learnings from previous field trials and naturalistic driving studies presented in this deliverable, similar issues can be prevented. Key aspects of successful trials include a realistic and detailed plan of approach, a carefully considered recruitment strategy including incentive and drop-out plans, detailed vehicle instrumentation timetables and plans, efficient participant handling and support, and consideration of all necessary legal and ethical issues. It is also vital that realistic timelines are developed for each of the partner trials, that take into account all aspects of the trials. These can be developed alongside the checklists to ensure nothing is missed. Contingency should also be built into the timeline where possible. An example of a more detailed timeline for passenger cars is included in this deliverable. The checklist of considerations, similar to the simulator trials and developed as part of this deliverable, is important to ensure that nothing is overlooked in the designing and conducting of the trials and will avoid delays during the actual testing period.

As participant recruitment is an important stage in the trial process, it is vital that best practice recommendations are considered when designing the *i*-DREAMS strategy. Findings from previous literature and previous trials have been considered and adapted to outline the proposed *i*-DREAMS sampling, recruitment, screening and retention strategies. Recruitment cannot be underestimated, and it is hoped that by following the strategies outlined in this deliverable, the sample size will be achieved, and the results of the trials will be able to be generalised to the wider population.

To help inform the analysis, interpretation and reporting of the results of the trials, relevant data needs to be consistently collected from participants, relating to participant characteristics, background, and opinions of technology. Two supplementary data questionnaires have been developed as part of this deliverable and are briefly outlined, the participant entry questionnaire and the technology acceptance questionnaire. Several participant competency tests are also included. It is vital that information such as this is captured consistently across all trials and transport modes, and the development of standardised questionnaires and tests within this deliverable help to ensure this.

Finally, it is important to gather all relevant information relating to legal and ethical issues prior to the start of the trials. Updating information following major project decisions and ensuring that all relevant ethical and legal issues are resolved prior to the start of the trials will help to avoid delays and potential problems from arising later. An update on the status of ethical and legal issues is presented at the end of this deliverable.

This deliverable aims to build on information provided in deliverable 5.1 (Hancox et al., 2020) and help to develop the final designs and protocols that will be used in the simulator and field trials. The considerations outlined here will be developed further into a detailed methodology for the simulator and field trials, which will be described in deliverable 5.2, 'Description of the driving simulator experiment for identifying Safety Tolerance Zones and performance of in-vehicle interventions', and deliverable 5.3, 'Description of on-road driving trials for identifying Safety Tolerance Zones and the performance of in-vehicle interventions'. In terms of preparing for the trials, it is important that the stages outlined in the checklists presented here are followed, ensuring that ethical and legal issues are resolved and in place for the start of participant recruitment, as well as the necessary protocols, procedures and screening questionnaires. The scenarios outlined here need to be finalised for the simulator trials to ensure that the risks are specifically tailored to each transport mode, and that the *i*-DREAMS platform has been tested prior to the field trials. Realistic timelines will need to be developed that are specific to each of the trials conducted in the simulator and field trials. These can be developed alongside the checklists to ensure none of the stages are missed and that everything is in place and has been considered prior to the start of the trials.

1 Introduction

1.1 The *i*-DREAMS project

The overall objective of the *i*-DREAMS project is to setup a framework for the definition, development, testing and validation of a context-aware safety envelope for driving ('Safety Tolerance Zone'), within a smart Driver, Vehicle & Environment Assessment and Monitoring System (*i*-DREAMS). The Safety Tolerance Zone (STZ) has three phases: normal driving phase where the crash risk is minimal; danger phase where the crash risk increases due to the occurrence of external or within vehicle events; and avoidable crash phase, where a crash will occur if no mitigating action is taken by the driver or another road user. Taking into account driver background factors and real-time risk indicators associated with the driving performance as well as the driver state and driving task complexity indicators, a continuous real-time assessment will be made to monitor and determine if a driver is within acceptable boundaries of safe operation. Moreover, safety-oriented interventions will be developed to inform or warn the driver real-time, in an effective way as well as on an aggregated level after driving through an app- and web-based gamified coaching platform. Figure 1 summarises the conceptual framework, which will be tested in a simulator study and three stages of field trials in Belgium, Germany, Greece, Portugal and the United Kingdom on a total of over 600 participants representing car drivers, bus drivers, truck drivers and rail drivers.

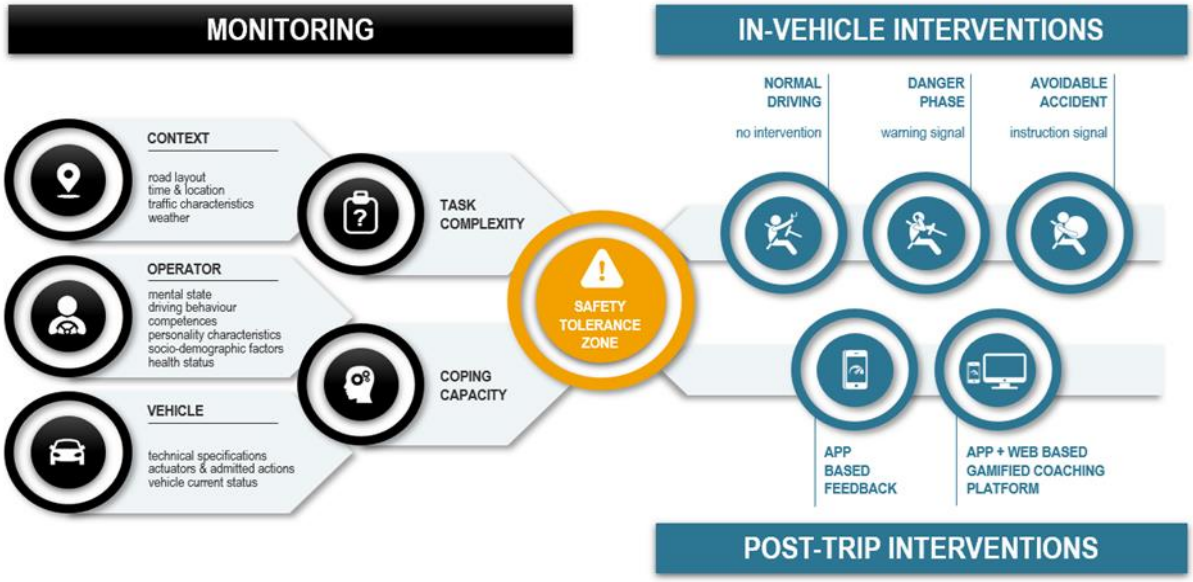


Figure 1: Conceptual framework of the i-DREAMS platform

The key output of the project will be an integrated set of monitoring and communication tools for intervention and support, including in-vehicle assistance and feedback and notification tools, as well as a gamified platform for self-determined goal setting, working with incentive schemes, training and community building tools[1].

[1] Further general project information can be found on the website: https://idreamsproject.eu

1.2 Current status of *i*-DREAMS

As *i*-DREAMS is an ongoing project, decisions are made, and work is completed at different stages throughout the project duration (36 months in total).

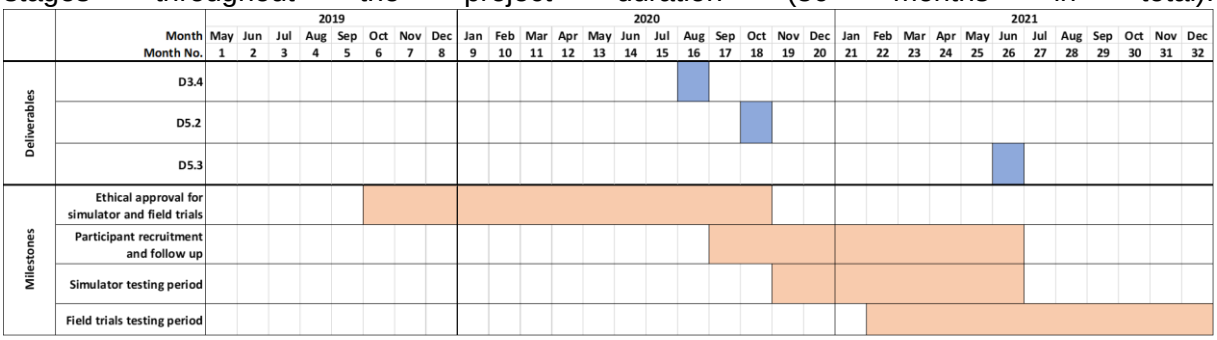


Figure 2 provides an overview of the key deliverable completion dates and timescales for key activities within *i*-DREAMS in relation to the simulator and field trials.

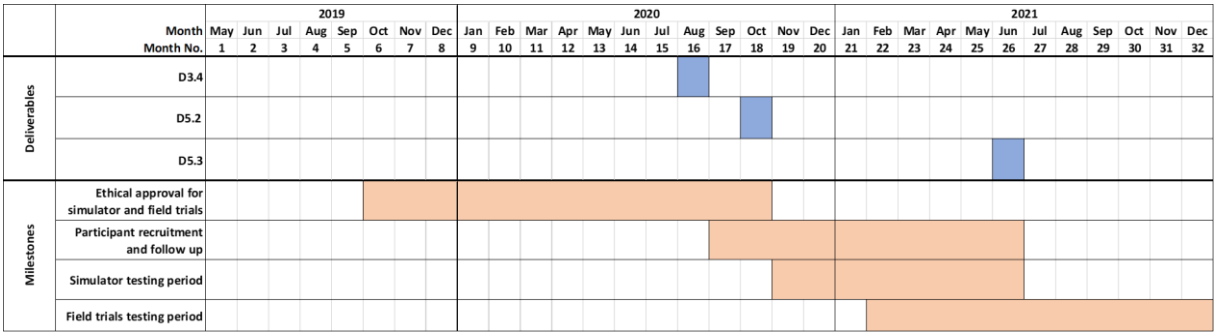


Figure 2: Overview of key deliverable completion dates and activities in relation to the simulator and field trials

Note. Multiple trials will be conducted during the simulator and field trial testing period.

The planning of the simulator trials is more advanced compared to the field trials, which is reflected in this deliverable. Further technical detail of the simulator trials will be provided in deliverable (D)5.2, 'Description of the driving simulator experiment for identifying Safety Tolerance Zones and performance of in-vehicle interventions'. In comparison, the field trials are currently being planned and will be updated as a result of the simulator trials and equipment finalisation. This will be reported in D5.3, 'Description of on-road driving trials for identifying Safety Tolerance Zones and the performance of in-vehicle interventions.'

1.3 Deliverable overview, objectives and report structure

i-DREAMS is divided into five broad technical work areas: State of the art (monitoring and interventions), Methodological development, Technology development, Trials, and Analysis. The work presented in this deliverable expands the methodological development in preparation for the simulator and field trials. The *i*-DREAMS project aims to use simulator and field operational trials to test the concept of a STZ and trial the *i*-DREAMS platform. As these trials will occur across five different countries in four transport modes (shown in Figure 3), it is important that a standard protocol is developed to ensure consistency in testing.

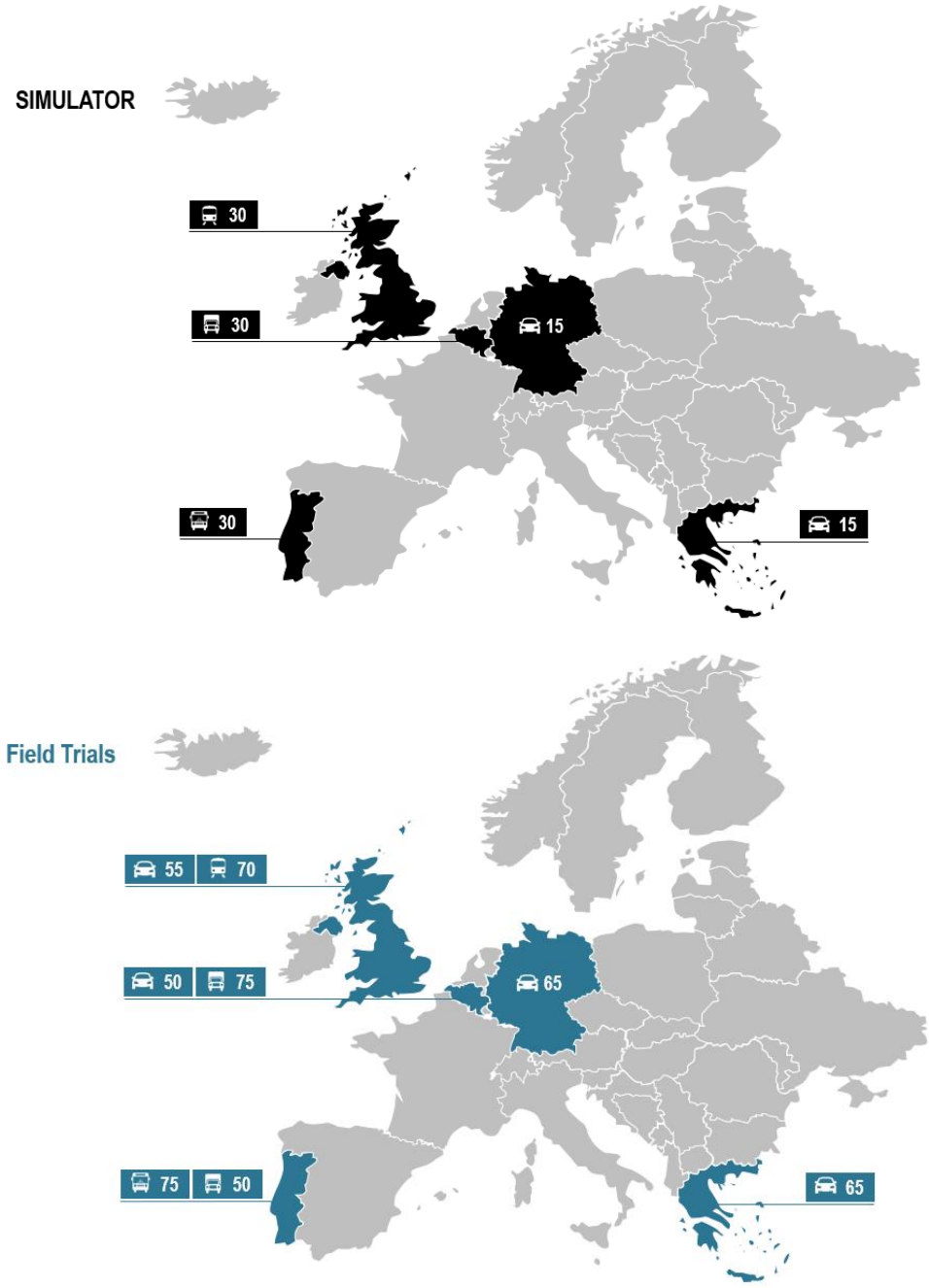


Figure 3: Maps highlighting the location and target participant numbers for the i-DREAMS simulator and field trials

The main aim of this deliverable is to inform the planning, development and finalisation of the simulator and field trials which will be conducted as part of work package (WP) 5 and analysed in WP6, including best practice and recommendations towards the experimental protocol, specific to the context of the *i*-DREAMS project. The general parameters and environment for testing will be discussed, and the high-risk scenarios under which the *i*-DREAMS platform will be tested, will be defined. Information and content from D5.1, 'Simulator and field study organisation and support' (Hancox et al., 2020), will be updated in this deliverable. An expanded and detailed methodology for the simulator and field trials will be presented in subsequent deliverables D5.2 and D5.3.

This deliverable contains eight chapters, including the introduction. Chapter 2 will focus on the considerations for the simulator trials, providing recommendations for protocols for the trials. The guidance suggested will be a broad approach, which will be further defined in later

deliverables. An overview of design principles is provided, including defining quantifiable outcomes, sample size and power calculation, design, scenario and drive details, simulator sickness and confounding effects. A generic experimental design and overview of the trials is also provided alongside detail about the simulators and data collection parameters. The chapter concludes with a checklist of considerations for the simulator trials. As trials are being conducted across five countries and four transport modes it is important to develop protocols and checklists to ensure consistency in approach.

Chapter 3 focuses on the development of risk scenarios which will be used as part of the simulator trials, to test the *i*-DREAMS platform. The target risks, events, environments and conditions will be described, before outlining the features of the high-risk scenarios that will be used per transport mode.

The considerations for the field trials are detailed in chapter 4. Similar to the simulator considerations, an overview of guidance and recommendations will be provided, which will be further developed in future deliverables. The field trials are defined in the context of the *i*-DREAMS project, and information is provided in relation to learnings from previous field and naturalist driving trials. Data collection measures are briefly highlighted, and a brief outline of timelines is reported, with a detailed example of a timeline for passenger cars. This can then be amended for other modes. Conducting simulator and field trials contains many phases and steps, and therefore it is important to develop a realistic timeline which includes as much information as possible, to help in the planning and conducting of the trials. Similar to the simulator trials, a checklist is provided detailing considerations for each of the steps involved in conducting the field trials.

Chapter 5 aims to detail participant recruitment, providing guidance and recommendations for sampling considerations, recruitment, participant screening and participant retention. The selection and recruitment of participants is one of the most important aspects in planning a study and it is acknowledged that recruitment can be a difficult and lengthy process. Therefore, it is vital that aspects such as these are taken into consideration and implemented as part of the research trials.

It is also important that data is collected from participants relating to characteristics, background, and opinions, to help inform the analysis, interpretation and reporting of the results of the trials. Chapter 6 therefore provides a brief overview of two supplementary data questionnaires which have been developed for use by all partners when conducting the simulator and field trials. Several competency tests are also included, to be completed by participants at the start of trials.

Chapter 7 provides an update in relation to ethical and legal considerations for conducting the simulator and field trials. This information was originally detailed in D5.1 (Hancox et al., 2020), and therefore this chapter aims to summarise any additional information relevant to the on-going development of the simulator and field trials.

Finally, chapter 8 summarises the key points of this deliverable and outlines the next steps for conducting the trials and future deliverables.

1.4 The COVID-19 pandemic

At the time of writing this deliverable, the COVID-19 pandemic is ongoing. Therefore, it is important to recognise that this situation may have potential implications for the *i*-DREAMS project. It is possible there will be delays to the beginning of simulator trials and potential restrictions in terms of testing with human participants and social distancing measures. This may be in the form of delays in ethical approval for work with human participants, restrictions in visiting external simulator sites, or delays in recruitment. Additional risk assessments will likely be required to ensure that the experiments and trials are conducted in a safe manner.

The pandemic may also impact data collection, with restrictions in travel (for both researchers and participants) and potential change in travel behaviour in all transport modes (e.g., individuals using their vehicle or public transport less due to lockdowns or working from home). Participants may also be more hesitant to participate in experiments and field trials due to the risk of COVID-19, which may impact recruitment. The plans and timelines listed here do not currently take into account potential delays of the pandemic, as currently the full extent of its impact cannot be known. Instead, what is presented here is the planned case intended by the project. It may be, as a result of this situation, there are changes made to the plans and protocols outlined in this deliverable, for example the introduction of controlled trials, extended risk assessments and ethics submissions, movement on trial start and end dates etc. This will be updated in future deliverables.

2 Considerations for simulator trials

The following chapter aims to provide recommendations and considerations for testing protocols for the simulator trials. The recommendations and guidance suggested here is in parts a broad approach, which will be further refined in a future deliverable – D5.2. As trials are being conducted across several locations, it is important to develop protocols and checklists to ensure consistency in approach where possible.

The general purposes of the driving simulator trials in the *i*-DREAMS project are:

- To test driving behaviour and validate the STZ mathematical model.
- To test the monitoring equipment and intervention technologies ability to observe the STZ.
- To obtain user acceptance feedback about these technologies.

Although the simulator trials will primarily serve as pilot studies with the aim of testing the *i*-DREAMS platform rather than full experimental studies, it is still of great importance to systematically design the trials to avoid experimental errors, which can cause delays or biases in the full implementation of the project. Therefore, this chapter aims to elaborate on the design of driving simulator trials and to provide the (scientific) basis for their implementation in other work packages. To achieve this aim, an overview of design principles for driving simulator experiments is first presented based on the 'Handbook of driving simulation for engineering, medicine, and psychology' (Fisher et al., 2011). The experimental design of the *i*-DREAMS driving simulator trials is then presented at a generic level, and the specific data that could be collected by *i*-DREAMS driving simulators are then discussed. Finally, a checklist of experimental design considerations is included, to be used while implementing simulator trials later in the project.

2.1 Overview of design principles for driving simulator experiments

Designing a driving simulator experiment is not a trivial task. The principles governing the experimental design arise from various sources such as technological factors (e.g. characteristics of simulator devices), organisational factors (e.g. recruiting strategies), human factors (e.g. simulator sickness and carryover effects), statistical and analytical factors (e.g. confounders, sample size and statistical power) and so forth. Fisher et al. (2011) describe the principles of driving simulator experimental design in several stages which can be summarised into four general categories:

1. Identifying research questions
2. Translating research questions into quantifiable outcomes and predictors
3. Formulating hypotheses linking those outcomes and predictors
4. Designing experiments to test the formulated hypotheses

The following provides an overview of the generic design principles relevant to the simulator trials. It is, however, important to note that this overview aims to provide guidelines for designing driving simulator experiments in *i*-DREAMS. More detailed description and exhaustive guidelines for implementation will be provided in forthcoming deliverables (D5.2).

2.1.1 Definition of quantifiable outcomes, predictors, and hypotheses

Following the identification of research questions, the second step in designing a driving simulator experiment is to translate the research questions into quantifiable outcomes and predictors and to formulate certain hypotheses linking those outcomes and predictors. The outcomes in a driving simulator experiment may be categorical (e.g. three discrete levels of

STZ, abnormal/normal driving, hands on/off the wheel, initiating/not initiating a warning) or may be continuous (e.g. headway distance, speed, acceleration, deceleration). Furthermore, these outcomes may be objective if they are derived (directly or indirectly) from devices mounted on the simulator or may be subjective if they are extracted from self-reported questionnaires. The predictors, on the other hand, may be individual specific characteristics (e.g. demographics, attitudes, health status) or may be experimental factors such as road layout, environmental conditions, and interventions.

Whether a factor is an outcome or a predictor highly depends on the research questions and objectives of the experiment. Sometimes the outcome variable may be used as intermediate predictor of another outcome variable. For example, the Karolinska Sleepiness Score (KSS[2], see Annex C), which is a subjective indicator of sleepiness (a lower level outcome) may be used as the predictor of lane departure warning (a higher-level outcome). As a result, it is also important to define certain hypotheses that link the outcomes and predictors with each other. The study hypothesis is usually formulated in terms of a null hypothesis (H_0) and an alternative hypothesis (H_1) and the aim is to reject that null hypothesis using the data from driving simulators. For example, Ting et al. (2008) investigated whether driving more than 80 minutes could be an indicator of fatigue for truck and bus drivers. In this study abnormal driving (binary) was the outcome and driving hours (continuous) was the predictor. A typical hypothesis for linking fatigue and abnormal driving may be formulated as:

H_0: Driving more than 80 minutes continuously without a break is not related to abnormal driving for trucks and buses

H_1: Driving more than 80 minutes continuously without a break is related to abnormal driving for trucks and buses

The aim is to reject the null hypothesis and to statistically show that driving more than 80 minutes is related to abnormal driving. It should be noted, however, that some research questions (and objectives) may not necessarily require defining outcomes, predictors and/or hypothesis. For example, testing in-vehicle technologies and obtaining participants' feedback about user acceptance of those technologies may not require statistical testing and so definition of outcomes, predictors and/or hypotheses is not relevant for these research questions and objectives.

2.1.2 Sample size and power calculations

Choosing the sample size in driving simulator experiments is another critical aspect of the experiment design. The sample size is directly related to the statistical power of the experiment, that is, how strongly the null hypothesis can be rejected assuming that the alternative hypothesis is true (Wang et al, 2019). This depends on the hypothesis and in turn on the type of the statistical test being used. For example, a one sample t-test is used for determining whether the mean of a continuous variable (e.g. headway, acceleration) in a large sample is equal to a hypothesised value (e.g. 2.5 seconds) (Washington et al., 2011). The statistical power in this test can be stated as:

$$\Phi\left[\frac{\bar{X}-\mu}{\sigma\sqrt{N}} - \Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right] \qquad \text{Equation 1}$$

[2] The KSS is a 9-point subjective scale ranging from 1 = extremely alert to 9 = extremely sleepy (Åkerstedt & Gillberg, 1990).

Where $\Phi(.)$ is the cumulative distribution function of the standard normal distribution, $\bar{X}$ is the mean of the variable in the sample, μ is the hypothesised value of the mean, σ is the standard deviation of the variable in the sample, α is the statistical significance, and N is the sample size.

A two-sample t-test, on the other hand, is used for testing whether the mean of a continuous variable in one sample is equal to the mean of the same variable in another sample (Washington et al., 2011). This is particularly useful to test whether an intervention has been effective or not. The statistical power in this test can then be expressed as:

$$\Phi\left[\frac{\bar{X}_1-\bar{X}_2}{\sigma\sqrt{\frac{1}{N_1}+\frac{1}{N_2}}}-\Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right] \quad \text{Equation 2}$$

Where $\bar{X}_1$ and $\bar{X}_2$ are the means of the continuous variable in the two samples, N_1 and N_2 are the sample sizes of the two samples and the rest of the notations are as previously stated.

There are many other types of statistical tests for hypothesis testing in experimental studies. For example, the Pearson Chi-squared test is used for testing whether there is an association between individuals across levels of a categorical variable (e.g. normal/abnormal driving). The statistical power calculations, however, are more complicated (Dupont & Plummer, 1990) and so the power is usually calculated using common statistical software packages such as STATA (Statacorp, 2013). Nonetheless, the statistical power depends on three general aspects of the experiment: sample information (mean and standard deviation in the above examples), sample size and the required statistical significance. It is therefore evident that calculating the sample size requires setting up the other two aspects and so selecting a sample size could be an iterative process where the starting point could be of historical normative values, studies from other participant populations, and small pilot studies.

2.1.3 Full factorial or fractional factorial design

In contrast to one-factor-at-a-time (OFAT) experiments where the aim is to investigate the relationship between one outcome and one predictor (referred to as factor in this context) at a time, factorial experiments aim to investigate the relationship between one (or more) outcomes with multiple predictors at the same time. As a result, the factorial design has several advantages over the OFAT design:

- It can investigate the differential effects of one predictor across different levels of other predictors.
- It is more efficient than OFAT designs because it investigates the effects of multiple predictors with no additional cost.
- It leads to conclusions across wider range of experimental conditions. Factorial designs can take the form of full factorial or fractional factorial.

A full factorial design takes into account all combinations of predictors at their discrete possible values or "levels". As a result, the size of combinations in a full factorial design with *N* predictors is equal to $L_1 \times L_2 \times L_3 \times ... \times L_N$ where L_i is the number of levels of predictor *i*. For example, an experiment with two predictors each with two levels (e.g. rural/urban roads and hand-held mobile phone use/no mobile phone use) will have four (2×2) combinations. As expected, the size of full factorial design experiments increases exponentially with a high number of predictors which makes the experiment impractical and cumbersome.

Among all combinations of a full factorial design, many are redundant and may not add new information to the experiment. An alternative design is a fractional factorial design (Fisher et al., 2011; Box & Hunter, 1961), which takes into account only a part (fraction) of all combinations of predictors at their levels in the full factorial design. The important question is then which combinations can be included (and how) and which combinations cannot be included so that the fractional factorial set is still properly designed. The answer to this question is that the combinations that can be included in the fractional factorial design should be balanced and orthogonal (Mukerjee, 1980; Kacker et al., 1991). In other words, observations in the sample should be evenly distributed (balanced) across combinations and the effects of any factor should balance out (sum to zero) across the effects of the other factors (orthogonal).

Accordingly, the size of a fractional factorial design can be expressed as: L^{K-P}[3] where *L* is the number of levels of factors, *K* is the total number of factors and *P* is the number of factor generators which are the assignments as to which effects or interactions are not orthogonal, i.e., cannot be estimated independently of each other. For example, in a full factorial design with three factors e.g. fatigue, speeding, and forward collision avoidance, each with two levels e.g. with and without, and one generator, the size of the full factorial design is eight whereas the size of the fractional factorial design is four (2^{3-1}) which is substantially less than the size of the full factorial design. These four combinations in the fractional factorial design may be:

1. With fatigue, with speeding and with forward collision avoidance
2. With fatigue, without speeding and without forward collision avoidance
3. Without fatigue, without speeding, and with forward collision avoidance
4. Without fatigue, with speeding, and without forward collision avoidance

However, it is important to note that there may be more than one orthogonal combination. The number of generators is set by the designer and is usually based on special requirements of the study (e.g. limitation of resources or sample size).

2.1.4 Within-participant or between-participant design

Another important consideration when designing the driving simulator experiments is to define whether one participant drives different conditions (e.g. with and without warnings) and the outcome variables are compared within participants, or all participants are split randomly and some participants drive one condition (e.g. with warning) and the rest of the participants drive another condition (e.g. without warning) and the outcome variables are compared between participants (Fisher et al., 2011). The former design is referred to as within-participant and the latter design is referred to as between-participant.

The main advantage of the within-participant design over the between-participant design is that it has high statistical power because each participant serves as their own control. The statistical power for within-participant designs are high enough even if the entire sample is not used. However, the within-participant design has a few disadvantages over the between-participant design:

- Some variables are, by definition, within-participant e.g. gender. It may also not be practical or ethical to change the levels of a variable (e.g. weight) for a participant during the experiment.

[3] This formula assumes that the number of levels is uniform across predictors. 2-level fractional factorial designs are the most common fractional factorial designs in engineering and behavioural research. The fractional factorial designs for higher level factors can be derived using the same logic for the uniform 2-level designs. Interested readers are referred to Chen et al., (1993) for more details about higher level fractional factorial designs.

- It may be subject to contamination (e.g. carryover effects, learning effect) which influences the conclusions.
- It is often more difficult to implement because external devices should be mounted and dismounted from the simulator during the same drive.

2.1.5 Assignment of scenarios to drives

Many driving simulator experiments consist of multiple scenarios each of which may have a different outcome(s), predictor(s) and hypotheses. An immediate question which arises during the experimental design phase is whether to allocate each scenario to a distinct drive or to include multiple scenarios at different instances of the same drive. This decision creates a trade-off between efficiency and practical difficulty of the experiments. The experimental design with a single scenario in one drive is simpler to implement (the devices and technologies may remain on the driving simulator until the end of one drive). In addition, including only one scenario per drive reduces the likelihood of contamination and learning effects. In contrast, including multiple scenarios in one drive is more efficient and may reduce the overall number of trials, particularly in big studies. Including multiple scenarios in one drive also increases the within-participant variability and consequently increases the statistical power of the study. As such, there is no rule of thumb for choosing whether to include single or multiple scenarios in one drive. A pilot study may be helpful in making this decision.

2.1.6 Order of drives

Order and learning effects are two important concerns that should be accounted for in experimental design. Order effect is referred to the differences in participants driving behaviour that are the result of the order of events and scenarios that are presented to them (Shaughnessy et al., 2000). Order effects are especially important in within-participant designs where participants drive all conditions. Learning effect, on the other hand, is referred to as the change in driving behaviour caused by repetition of the same event/scenario in the trial (Fisher et al., 2011). Participants may improve their behaviour as a result of such repetition. Because of these two types of effects, the order of drives should be random across participants and across time. Participants should be assigned with an identification number and selected based on a randomised selection of those numbers. Similarly, the drives with different scenarios should be randomised in terms of the time of implementation otherwise the results may be biased. For example, implementing all drives with a particular technology on one day and implementing all drives without that technology on another day may influence the results as there may be several factors (e.g. temperature, noise, external weather conditions, etc.) that could change during this time difference. However, randomising all the scenario drives a participant completes may not be possible if baseline data needs to be collected.

2.1.7 Simulation sickness and duration of drives

Many participants in driving simulator experiments report feeling ill while using the driving simulator device (Casali, 1986). This ill feeling which has been reported in both fixed and motion-based driving simulators is referred to as simulation sickness (Draper et al., 2001; Draper et al., 1997; Ehrlich, 1997). Simulation sickness can result in severe symptoms in participants including eye strain, headache, postural instability, sweating, disorientation, vertigo, pallor, nausea, and vomiting. It can also severely influence the behaviour and performance of participants and thus can lead to invalid results. Participants may lose their motivation and ability to concentrate, avoid tasks that are found disturbing, or even modify their

behaviour to reduce sickness symptoms. As a result, simulation sickness must be considered and accounted for when designing the experiments.

From the design perspective, it is recommended that the scenarios have minimal rapid change in direction and acceleration. For example, wider curves and fewer roadside objects may help reducing simulator sickness among participants. The total duration of the simulation should not exceed two hours and the duration in each drive should not exceed one hour. The duration of drives with more demanding scenarios should be shorter than the duration of regular drives. Although there are no set rules for the duration of drives, the general practice is to set the duration between 5 - 25 minutes and have 10 minutes breaks in between. It has been shown that simulator sickness increases with the drive duration in one trial but decreases with successive trials in multiple sessions (Kennedy et al., 2000). As such, designing a few practice drives prior to the main drive may help reduce the simulator sickness effects. However, practice drives may result in adaptation (or learning effects) which is a type of contamination and may influence the results. Overall, higher fidelity of the driving simulators to the real-world environment substantially contributes to the mitigation of simulator sickness.

Simulation sickness has also been shown to correlate with individual characteristics such as health status, age, gender, concentration levels, ethnicity, experience with the real-world task and experience with a simulator (Kolasinski et al., 1995). As a result, screening participants during the trials can help avoid simulation sickness in individuals who are particularly susceptible to it such as those with fatigue or sleep loss, upset stomach, head colds, ear infections, ear blockages, pregnancy, upper respiratory illness, or those or who have recently taken medications or alcohol.

2.1.8 Confounding effects and effect modification

A confounding effect in driving simulator experiments is referred to as the circumstances in which the association between an outcome and a predictor is due to a third external factor, a named confounder. For example, the association between abnormal driving and lane deviation may be primarily due to long driving hours. Fisher et al. (2011) defines certain characteristics for a variable to be considered as a confounder:

- The confounder must be associated with the outcome (i.e. dependent variable).
- The association between the confounder and the outcome must be the same across all levels of predictors.
- The outcome and the predictors must not influence the confounder.

The third property of the confounder makes it distinctly different from intermediate factors (which are also influenced by predictors). Nonetheless, neglecting the confounding effects in the experimental design may have consequences such as corresponding outcomes with incorrect sources of predictors, and perhaps more importantly, not being able to replicate the findings.

Random distribution of participants into experimental groups is an approach that can account for confounding effects as it assures even distribution of measured and even unmeasured factors across individuals. However, potential differences in experimental groups can still occur to some extent in confounding effects, particularly in small samples. Alternatively, participants may be randomly distributed into experimental groups based on certain attributes (e.g. gender and driving experience). This technique, which is referred to as matching, ensures that certain attributes of the participants are evenly distributed across experimental groups and addresses the confounding effect.

Effect modification is another consideration to be made during the design phase. It is referred to as the circumstances in which the relationship between an outcome and a predictor changes

with a third external factor, named effect modifier. For example, driving more than 8 hours may be associated with abnormal driving among truck drivers. However, this association may be significantly influenced by the time of the day, in that driving for fewer hours during the night may be associated with abnormal driving. As a result, time of the day can be the effect modifier in the relationship between driving hours and abnormal driving. As shown in this example, the effect modifier (i.e. time of the day) plays an important role in making inferences about experiment findings, although the main interest is to investigate the association between the outcome and the predictors. As such and in contrast to the confounding effect, the common interest in experimental studies is to consider effect modification and explain the results accordingly.

Finding confounders and effect modifiers may be difficult during the design phase and prior to the actual implementation of experiments. Thus, it may be more helpful to hypothesise a few confounders and effect modifiers and to test these effects during the experiments. Nevertheless, confounding effect and effect modification may be addressed in the analysis phase, if they cannot be addressed in the design phase.

2.1.9 Summary of design principles

This section provided an overview of the design principles that should be considered for simulator trials. The overview aimed to provide generic guidelines for designing driving simulator experiments serving as a basis for specific experimental design in *i*-DREAMS. These principles include (1) definition of outcomes, predictors and hypothesis, (2) sample size and power, (3) eligibility criteria, (4) full/fractional factorial design, (5) within/between subject design, (6) assignment of scenarios to drives, (7) order of drives, (8) simulation sickness and duration of drives, (9) confounding effects, and effect modification. These principles will be tailored in part for the *i*-DREAMS project in the following section.

2.2 Designing simulator experiments for *i*-DREAMS

To aid in the design of high-risk scenarios which would be used to test the *i*-DREAMS platform per mode, partners' input for driving simulator scenarios was collected in three stages prior to designing the simulator experiments. These inputs provided an initial insight in the risk factors that are of interest for each partner and revealed the environmental conditions, types and number of events that each partner had in mind for the simulator trials. An overview and description of the high-risk scenarios for the simulator trials is provided in chapter 3 of this deliverable.

2.2.1 Generic experimental design

The aim of the following section is to provide a tentative generic design, that could be the basis for testing the main risk factors for all *i*-DREAMS transport modes and could be adjustable to further needs of specific modes and specific research objectives of *i*-DREAMS partners. This generic design is presented in line with the design principles stated at the beginning of this chapter.

Considering the scope of simulator trials in *i*-DREAMS and the design principles described above, the following design features are opted for:

- The outcomes, predictor and hypotheses in *i*-DREAMS are defined according to the main objectives of driving simulator trials in this project and the corresponding research questions developed for these trials. The primary outcomes are defined as the real-time interventions based on STZ thresholds and the predictors are defined as risk

factors associated with the STZ including fatigue[4], sleepiness, speeding, forward collision avoidance, lane discipline, overtaking, vulnerable road user collision, number of harsh accelerations\decelerations and steering. Some of these risk factors (i.e. sleepiness, speeding) will have a real-time intervention in *i*-DREAMS, while others will be only used for post-trip interventions (e.g. distraction). The hypotheses are defined as whether the STZ can be detected and real-time interventions can be triggered using the above risk factors.

- The sample size for simulator trials are pre-defined based on limitations and resources, and mainly because the primary objective of the simulator trials is to test the *i*-DREAMS technology and real-time interventions. As a result, the statistical power of the trials are also affected by this.
- The eligibility criteria are set in *i*-DREAMS with the aim of recruiting a representative sample. Participant recruitment will be discussed in chapter 5 of this deliverable.
- The experimental design will be a fractional factorial design where only a subset of all scenarios will be selected. This is due to the large number of risk factors resulting in an abundance of combinations for experimental trials in a full factorial design. The choice of the fractional factorial design is further motivated by the fact that the simulator trials primarily serve as a pilot study rather than a full experimental study in this project.
- The statistical significance level will be set at 0.05 (5%).
- The experimental design will be a within-participant design because the sample size in simulator trials is limited (30 participants per transport mode). Since triggering real-time warnings by the *i*-DREAMS technology is achieved from the same gateway for all risk scenarios, with this design there is no need to dismount and change the *i*-DREAMS technology for investigating the with/without conditions for different risk events and thus multiple risk events can be included in the same scenario. In addition, including multiple risk events in one scenario is more efficient and reduces the overall number of scenarios and trials. Although it is noted that this approach presents some limitation for fatigue testing, as experiencing risk events with greater frequency that would be expected in normal driving may have alerting effects.
- The experiment will include multiple risk events in one drive to increase the within-participant variability and consequently increase the statistical power of the study.
- The order of scenarios and events are randomised among the participants and during the trials.
- Due to the small sample size and the high number of risk events in *i*-DREAMS, the duration of the simulator trials are initially defined based on the upper allowable limits (two hours in total, with each trial up to one hour and a 10-minute break in between), based on the recommendation from Fisher et al., (2011). This may be amended as the finalisation of the simulator planning is completed. Therefore, the maximum number of risk events can be included in each scenario while simulator sickness is prevented. In addition, several practice drives are included prior to the intervention scenario in order to familiarise the participants with the simulator device and to reduce the simulator sickness effect.

[4] It is important to distinguish between fatigue and sleepiness. Although likely that the two states are interlinked, the causal factors contributing to the driver state may differ. Sleepiness is defined as the physiological urge to fall asleep, which results from sleep loss and circadian time of day. Due to the body's circadian rhythms, there are certain times of the day where an individual would experience decreased alertness, such as during the night/early morning, and early afternoon. Fatigue can be defined as the inability to continue with a task that has been continuing for too long and can be influenced by monotony, workload (underload and overload) and task duration.

- To test the confounding effects and effect modification, an additional scenario will be included in the experimental design in which environmental conditions will serve as a condition for driving behaviour.

Taking the above experimental design considerations into account, one to two primary risk factors are selected to be explored during three scenarios for each partner simulator trial. The number of risk factors is considered adequate for a one-hour session, split into two scenarios (with and without interventions) as well as a baseline trial beforehand, taking into account that:

- Each risk factor should be captured by several separate events, to ensure adequate validity of the observations per risk factor.
- Several 'neutral' events should be used, creating a realistic driving scenario and minimising confounding effects (e.g. order / learning effects).

In principle, partner trials should focus on one to two risk factors with real-time interventions, with one scenario including fixed timing warnings, and another scenario including variable timing warnings. The intervention scenario with variable timing warnings could include a condition (e.g., fatigue / sleepiness, distraction or bad weather), which will be used to adapt the timings of the warnings related to the primary risk factors, for example, the warning for forward collision avoidance is given sooner in bad weather. However, it should be noted that fatigue may need separate consideration in the design. Fatigue is associated with monotony and can be evident following a long monotonous drive. Past studies have shown that participants in driving simulators are usually fatigued after 20 to 90 minutes of monotonous driving (Desai et al, 2007; Merat & Jamson, 2013; Philip et al., 2005; Rossi et al., 2011; Saxby et al., 2007; Ting et al., 2008; Zhao et al., 2012). In *i*-DREAMS, fatigue can be indicated by the number of hours driven, under the assumption that long and monotonous driving may induce fatigue directly, or fatigue through sleepiness (indirectly).

2.2.2 Overview of trials

The schematic of the generic simulator trial design is presented in **Error! Reference source not found.**

Table 1: Generic experimental design for simulator experiments on i-DREAMS risk factors

#Session	# Scenario	Description	Duration
Briefing	Completion of questionnaires		
Practice drive	Practice drive 1	No events	5 minutes
	Practice drive 2	With basic tasks / events	5-10 minutes
Session 1	Scenario 1 Baseline driving	1-2 risk factors (multiple events) No intervention	20 minutes
	Scenario 2 Interventions	1-2 risk factors (multiple events) With interventions (fixed timing)	20 minutes

Break	Completion of questionnaires		10 minutes
Session 2	Scenario 3 Including a condition	1-2 risk factors (multiple events With interventions (variable timing, based on conditions such as fatigue, distraction and bad weather)	20 minutes
End	Completion of questionnaires		

The simulator trials will begin with briefing about the trials, signing the legal and ethical documents (consent form etc.) and completing the participant entry questionnaire (Annex H). Several practice drives will then be used to familiarise the participants with the simulator. It is proposed to have a practice drive without any events (~ 5 minutes) and another with some basic events such as steering along curves, maintaining the gap between a car coming from right shoulder, adapting to speed limit change and traffic change to provide more experience with the simulator (expected at ~10 minutes). Drivers will be asked to drive as they normally would, and to make a full stop to ensure they can deaccelerate to 0 km/h. For rail drivers who use the simulator for training purposes, it may be that only one practice drive is required to re-familiarise themselves with the simulator. The intervention drives will then follow using a series of high-risk scenarios. In total the trials will consist of three 20 minute drives, including a baseline monitoring scenario followed by two intervention scenarios, one with fixed timing warnings and one with variable timing warnings and the inclusion of a condition. There will be a break between the two intervention scenarios. If for any logistical reason the break is extended, for example session 1 and session 2 conducted on different days, or a break is required between scenarios, a practice drive will be completed if needed to ensure participants are re-familiarised. A customised design for each partner trial will be developed to accommodate primary risk factors and specific transport mode factors. In addition, the order of sessions, scenarios and events within trials should be randomised. Due to the small sample size, this will be further analysed once the overall design of the experiment is finalised. Further information relating to the specific risk factors per mode is provided in section 3.2 of this deliverable, and more detailed information about the simulator trials will be provided in a future deliverable (D5.2).

2.2.3 Environmental conditions

Environmental conditions of the scenarios within the simulator trials depend on the transport mode. These conditions may include the location type, the time of the day and the weather conditions simulated for the scenarios. For passenger cars, trucks and buses, four locations types are considered: divided three-lane (each direction) highway with 130 km/h speed limit[5], rural undivided two-lane road with 90 km/h speed limit, urban single-lane road with 30 km/h speed limit, and unsignalised intersections (urban and rural). For rail, the locations include mixed traffic (urban) and segregated (suburban) rail segments with differential speed limits, stations (one with doors opening at the right-hand side and one at the left-hand side) and rail crossings.

[5] The speed limits mentioned in this document are based on Belgium speed limits. Equivalent speed limits on similar road layouts should be used for the countries involved in simulator experiments.

2.2.4 Number and type of events

The number of events to be included in the trials may be fixed to two to three events per risk factor in each scenario. As mentioned above, this is based on design principles in that, on the one hand the driving behaviour should not be random (thus the need to have more than one event) and on the other hand, the learning effect should be prevented (thus the need to not have excess events). The type of events, however, depends on the risk factors to be explored in the trials and scenarios, and the risk factors to be selected (and their corresponding type of events) are considered customisable depending on partners needs and interests. The type of events also depends on the transport mode. Although the generic design in principle aims to cover the same risk factors across all modes, the same risk factors may need different events depending on the transport mode.

2.3 Specifications of *i*-DREAMS simulators

There will be several simulators used for the simulator trials in *i*-DREAMS including: car simulators in Germany and Greece to be used for passenger car simulator trials; large vehicle simulators in Belgium and Portugal to be used for the trucks and bus simulator trials; and rail simulators in the UK. The exact specifications of these simulator trials are presented in other deliverables (see Annex 3 and Annex 4 in D5.1, Hancox et al., 2020, and D5.2). To recap, a summary of these simulators and their specifications are presented in Table 2.

Table 2: i-DREAMS driving simulators and their specifications

Driving simulator	Transport mode	Country	Type	Number of participants	Software
DSS	Passenger cars	Germany	Fixed-based	15	STISIM Drive 3
FOERST	Passenger cars	Greece	Fixed-based	15	F10 Driving software
DSS	Trucks	Belgium	Fixed-based	30	STISIM Drive 3
DSS	Buses	Portugal	Fixed-based	30	STISIM Drive 3
TBD	Rail	UK	Fixed-based	30	TBD

Table 3 below provides an overview of the data collection measures which will be used per mode during the simulator trials.

Table 3: Overview of data collection measures per transport mode for the simulator trials

Car	**Truck**	**Bus**	**Rail**
Simulator data Mobileye Wristband/wearable CardioGateway – OBU/OBDII Questionnaire data	Simulator data Mobileye CardioWheel CardioGateway – OBU/OBDII Questionnaire data	Simulator data Mobileye CardioWheel CardioGateway – OBU/OBDII Questionnaire data	Simulator data Mobileye Wristband/wearable CardioGateway – OBU/OBDII Questionnaire data
Optional considerations: Eye tracking Video recording	Optional considerations: Eye tracking Video recording	Optional considerations: Eye tracking Video recording	Optional considerations: Eye tracking Video recording

2.4 Data collection parameters

The data that will be collected from simulator experiments in *i*-DREAMS come from various sources such as the driving simulator, *i*-DREAMS technologies (e.g., CardioWheel, Mobileye), participants entry questionnaire, technology acceptance questionnaire and fatigue/sleepiness questionnaires. The data collected may also vary depending on transport mode. An exhaustive list of all parameters to be collected from driving simulators are presented in D5.1 in Annex 5 and Annex 6 (Hancox et al., 2020) and will be confirmed in future deliverables.

In addition, the following data and warnings will be collected from the *i*-DREAMS instrumentation:

- I-DREAMS real-time interventions implemented on CardioID Gateway: Headway Warning (HW), Illegal overtaking warning (IOW), Fatigue Warning (FW), Overspeeding Warning (OSW)
- Mobileye: Forward Collision Warning (FCW), Lane Departure Warning (LDW), Pedestrian Collision Warning (PCW), Wiper indicator, Risky times (Day/Night/Dusk), Left Turn Indicator
- CardioWheel/wristband/wearable: (variability of) heart rate

2.5 Checklist of considerations for simulator trials

The simulator trials in *i*-DREAMS will be implemented across five different countries, a substantial task. As such, a checklist of simulator experimental design considerations for trial partners is helpful to ensure that the experiment trials are consistent across modes and countries. Although some of the checklist items may need to be tailored for different simulator experiments (depending on the transport mode or country), the overall checklist rather serves as a broad benchmark for implementation of simulator trials.

Checklist for the planning phase of simulator trials

Summary of actions to perform:

- ***Create study plan***
  - General time plan and deadlines for the different simulator trial phases per country.
  - Define eligibility criteria.

- ***Overview of simulator trial experimental design considerations***
    - Translation of research questions (objectives) into quantifiable outcomes and predictors.
    - Generation of hypothesis correlating outcomes and predictors.
    - Identification of confounders and effect modifiers among predictors.
    - Sample size and statistical power calculations.
    - Identification of the design type (full/fractional factorial) and the number of trials to be implemented.
    - Identification of within-participant or between-participant design.
    - Generation of risk scenarios, simulation driving environment, and risky events per trial (per mode).
    - Defining the duration of the trials based on simulation sickness considerations.
    - Randomisation of the order of the drives (across time and per person).
    - Identification of participant selection/inclusion criteria that will be used.

- ***Prepare recruitment***
    - Create information materials in the local language where simulator trials are implemented:
        - Project video, flyer, information letter, presentation about the purpose of the simulator trials per transport mode.
    - Define recruitment strategy/channels:
        - The strategy should be tailored to type of participants and should be available in the local language of the field trial location. Possible methods are: own recruitment database, personal references, web-based recruitment, driver clubs, newspaper advert, flyers, social media recruitment agency, vehicle fleets, organising recruitment events.
    - Create a dropout management strategy.

- ***Legal and ethical aspects***
    - Obtain permission from relevant ethics committee.
    - Consultation with unions (professional drivers).
    - Create participant agreement/consent form according to national regulations:
        - This should contain the incentive payment, data protection aspects, liability issues etc.
    - Create an incentive strategy.

- ***Technical and operational aspects***
    - Book the simulator if using a shared facility.
    - Create a plan for data storage.
    - Assign simulator trial responsibilities:
        - Persons in charge for dealing with legal, participant or simulator equipment issues during the simulator trials.
    - Create documents in local language:
        - Participant related: briefing presentation, entry, exit and recruitment questionnaires, participant consent forms, contact information (helpline)
    - Prepare installation/de-installation of data collection unit in simulator (if applicable):
        - Technicians are trained, equipment is available, spare parts are available, data storage is arranged, and installation location is determined.

Checklist for the recruitment phase of simulator trials

Summary of actions to perform:

- Start recruitment based on the selected requirement channels.
- Select potential participants based on participant selection criteria defined in the study plan, using the recruitment survey.
- Create a backup-plan in case a simulator trial cannot meet its recruitment criteria.

Checklist for the start of simulator trials

Summary of actions to perform:

- ***Check prerequisites for simulator trials***
  - Simulator trial responsibilities and teams are identified.
  - Necessary forms, documents, strategies are ready (all in the local language).
- ***Participants briefing/reception***
  - Participants are briefed about the simulator trials:
    - An overview of the study, the equipment, the planned execution of the trial, the legal and ethical framework, simulator trial partner and participant engagements, rights and obligations, content of contractual documents, incentives payment principle and organisation as well as the support and communication means.
  - Participants also sign the legal and ethical documents (consent form etc.) and complete the entry questionnaire.
  - Participants are familiarised with the sleepiness concept and the scaling of the KSS score.
- ***Driving simulator instrumentation***
  - Check the simulator instrument is working properly.
  - Check the warning strategies are working properly.
  - Check that the data is accurately recording.

Checklist for during the simulator trials

Summary of actions to perform:

- ***Participant handling and support***
  - Assistance is in place in order to answer participant questions, deal with complaints or arrange a meeting to solve equipment issues.
  - Emergency kits are in place in order to deal with participants simulator sickness or any other safety issues (kits could contain cleaning supplies, instructions for emergency protocols, basic first aid, etc).
  - Manage the incentive payments.
- ***Fatigue/sleepiness questionnaire***
  - Participants fill in sleepiness questionnaire before and after each trial.
- ***Participant handling and support***
  - Assistance and refreshment in place for the break sessions.
  - Monitor for simulator sickness and end trial if needed.
- ***Dropout management***
  - Select participants from the reserve pool in case initial participants no longer wish to participate.

Checklist for the end of simulator trials

Summary of actions to perform:

- ***User acceptance questionnaire***

    - Participants fill in user acceptance questionnaire regarding the driving simulator and *i*-DREAMS technologies.
- ***De-installation of data collection unit***
    - De-installation of the simulator instrument and transfer the simulator instrument to another country (if applicable).

An example list of simulator trial considerations with the relevant questions to ask at each of the phases of the simulator trials can be found in Annex A.

3 Risk Scenarios

This chapter aims to describe the development of the high-risk scenarios which will be replicated in the simulator trials to test the *i*-DREAMS system. Additional risk factors may be investigated for the field trials, and this will be detailed further in a future deliverable (D5.3). A scenario describes the traffic situations that a driver will encounter when driving in the simulator. Several risk scenarios and events will be developed per mode for the different driving simulators. The content of the scenarios will depend on the transport mode under investigation, for example, the target risks and traffic environments differ per transport mode. In addition to the main intervention scenarios, several practice scenarios will be developed with the aim of familiarising participants with the simulator.

3.1 Development of risk scenarios

In order to harmonise the approach across partners, a three-step process was followed to develop the risk scenarios. In step one, general information such as the research (sub)goals were collected in order to provide an overview of what could be investigated. The conclusion of this first phase was that there are two main research goals related to the driving simulator experiments (independent of the transport mode under investigation):

1. To test whether the STZ is valid/reliable (e.g., accuracy of input from monitoring devices)
2. To investigate how to give appropriate real-time feedback (e.g., message, display, timing)

In the second step, information was gathered exploring how the research goals could be investigated. More specifically, information about risk factors (e.g., following distance, illegal overtaking, speeding, and sleepiness), number of scenario(s), duration of scenario(s), procedure, weather conditions (e.g., rain), and data (e.g., time headway) were collected. After gathering information, bilateral meetings took place between partners in order to discuss the proposed scenarios. During these meetings, it was agreed that, from the available list of performance objectives (see Figure 18 in D3.3, Brijs et al., 2020), at least four objectives would be addressed in the simulator experiments, with some of these shared across partners working on a certain mode (e.g., both NTUA and TUM work on cars and will look into forward collision avoidance), and others specific for a partner (e.g., NTUA will also work on illegal overtaking, while TUM will also work on vulnerable road user (VRU) collisions). In the third step, detailed information about the road environment, number of events, and type of events were collected. See section 3.2 for a detailed description of the high-risk scenarios per transport mode.

3.1.1 Target risks

Overview

The content of the simulator scenarios will be focused around certain target risks. While the specific target risks for car, bus and truck may vary, on-road vehicles share similarities. However, rail transportation has different operations and therefore in part, different risks, which need to be considered. As road and rail are different sectors, it is important to consider risks and crash statistics separately for each mode in the first instance. This will ensure that any mode specific target risks are captured in the planning of scenarios.

Crash statistics – road vehicles

In 2016, road traffic crashes resulted in 25,651 fatalities in European Union, of which 47% involved a car, 2% a truck (over 3.5 tonnes) and less than 1% involved a bus or coach (ECa, 2018). Around a fifth of the total number of fatalities were a result of a crash at a junction and approximately a third were as a result of single vehicle crashes (ECb, 2018).

From a safety perspective, the prevention of the most harmful crashes in terms of injury severity is usually the priority. The risk of these crashes resulting in injury varies according to several factors. Junction crashes tend to be harmful for vehicles such as cars if they are hit in the side as there is less protection to the occupants than in a head on collision. Any collision between a motorised vehicle and a vulnerable road user is likely to result in injury. Also, the vehicle mass is a factor. A heavy vehicle is more likely to cause more severe injury to the occupants of a lighter vehicle or a vulnerable road user, although the heavier the vehicle, the less risk to the occupants (Evans, 1990). In addition, some injuries that are considered less severe can have a long-term impact. For example, 'whiplash' type (neck/back) injuries are a common injury and are often associated with less severe crashes, particularly rear crashes (Thatcham, 2016). The majority of this type of injury are short term, but in some cases (Estimated as 10% in Sweden by Kraftt, 2002, cited in Thatcham, 2016) severe 'whiplash' can affect the individual for a year or more.

As the orientation of the collision can be associated with injury risk, *i*-DREAMS has adopted the ISO 6813:1998 definitions of collision impact type for the vehicles road users and obstacles involved:

- Collison:
    - Frontal (collision to the front of the vehicle, including 'head on' collisions with another vehicle).
    - Side (involving a side impact to at least one vehicle, which may involve the front of one vehicle impacting the side of another).
    - Rear (involves a rear impact to at least one vehicle, including when one vehicle as run into the rear of another).
    - The ISO definitions refer to collisions with an object or another vehicle and *i*-DREAMS also uses the term VRU to describe a collision with a pedestrian or cyclist[6].
- Non-collision:
    - Overturn (where the vehicle rolls at least 90 degrees).

Crash statistics - rail

Data collected by the European Railway Agency (ERA), reported by Eurostat (2020), shows that in 2018, 1721 'significant' railway crashes were reported in the EU-28 countries. These resulted in 885 fatalities and a further 760 people were seriously injured. This includes level crossing users, railway passengers and employees and 'unauthorised persons', but not suicides. Out of the fatalities, 69% were 'accidents to persons by rolling stock in motion', usually unauthorised individuals hit on the track and a further 29% were as a result of a level-crossing crashes. Collisions and derailments were rare and resulted in 11 and 3 fatalities respectively. Suicides on the railway are a particular problem with 2637 reported cases additional to the accident fatalities in 2018. It is believed that any tram crashes would be reported in these figures, however it is possible that collisions with motorised vehicles in areas of mixed traffic are also reported in national road vehicle crash statistics.

[6] *i*-DREAMS definition of VRU differs from the standard definition

The European Union Agency for Railways have documented a taxonomy for 'common occurrence reporting' (EU Agency for Railways, 2016). This covers wide range of reportable accidents, incidences and near misses including collisions, derailments, track and infrastructure faults and incidents involving people on the line (collision, trespass). The taxonomy lists the following accident categories:

- Collison:
    - Collision of train with rail vehicle (front to front, front to end, side).
    - Collision of train with obstacle within the clearance gauge (fixed or temporary on or near track; overhead contact lines).
    - Level crossing accident (crossing vehicle, user (e.g. pedestrian) or object).
    - Accident involving rolling stock in motion (person hit, fall from railway vehicle, fall or hit by object when travelling on railway vehicle).
- Non-collision:
    - Derailment of train.
    - Fire in rolling stock.
    - Other (e.g., Electrocution).

The majority of these map onto the ISO road collision descriptions. Therefore if 'fire' and 'other' are excluded as being out of scope for *i*-DREAMS, the ISO definitions can be used with the addition of 'derailment' and 'passenger injury' to describe both collision and non-collision impact type for all the *i*-DREAMS modes.

Risk and crash causation

The most effective way of reducing the risk of injury is by reducing the risk of the crash occurring in the first place. The *i*-DREAMS system seeks to prevent crashes occurring by warning the driver in time for them to take action to avoid or at least mitigate a crash.

Accident causation models (Talbot et al., 2013) suggest that a 'critical' event or manoeuvre (that which leads directly to a crash, e.g. commencing an overtake manoeuvre) is influenced by contributory factors which in themselves may not directly lead to a crash but make the likelihood of a crash occurring more risky (e.g. fatigue).

A mapping exercise was undertaken to link crash type with specific driver manoeuvres/actions and additional factors that are known contributors to crashes. No new crash analyses were undertaken – instead the knowledge gained in other projects over many years (crash investigation, manoeuvre classifications, contributory factor classification) was utilised. Key sources were the European Road Safety Decision Support System (SafetyCube, 2018); the DaCoTA on-line manual for in-depth road accident investigators (DaCoTA, 2012), the Driver Reliability and Error Analysis Method manual (DREAM) v 3.2 (Ljung Aust et al, 2012) and the Initiative for the Global Harmonisation of Accident Data (iGLAD, 2019). This was then supplemented with rail specific factors that have been identified as having the potential to lead to injury (Sources: discussions with *i*-DREAMS rail operators, UK Office for Road and Rail website [https://orr.gov.uk/], EU Agency for railways, 2016).

Table 4 summarises the crash types, manoeuvres/actions and contributory factors identified. See Annex B for full detail, including the relationship between ‘crash type’ and the *i*-DREAMS collision impact types (safety outcomes).

Table 4: Summary of crash type, manoeuvres and contributory factors

Crash Type	Specific manoeuvre/action	Additional factors
VRU (Pedestrian or Cyclist) Stationary object (on road/track) Single vehicle Head on/oncoming traffic Rear end collision/same direction Junction accident (no turning) Junction accident (turning) Rollover (overturn) /Derailment Injury to passenger (public transport)	Continue straight ahead Turn across traffic Turn with traffic Leave lane - change lane Leave lane - overtake Leave lane - unintentional Speed - excessive/inappropriate Harsh - acceleration/deceleration Headway (close following) SPAD/SPAS (train/tram) Wrong side door opening (train/tram) Trapping passenger in door & drag Red light running Using road lane dedicated to another road user	Drink driving Distraction/Inattention Fatigue/sleepiness poor visibility - darkness poor weather conditions (strong wind/rain/snow) sight distance Vehicle blind spot Disregard of right of way Misjudgement (self, others, situation) observation errors Sensation seeking Young driver (18-24) Elderly (65+)

The next step was to compare the identified driver manoeuvre/actions and additional factors with the variables that could be measured with the monitoring module of the *i*-DREAMS platform. Table 5 lists those that can be addressed in *i*-DREAMS alongside the safety outcomes targeted. It is estimated that the *i*-DREAMS platform will have a high or medium impact on the safety outcomes in italics and underlined.

Table 5: Safety outcomes, manoeuvre/action and additional factors addressed in i-DREAMS

Note. Safety outcomes in italics, underlined = high/medium impact

Safety outcome (*i*-DREAMS collision impact type)	Specific manoeuvre/action – addressed in *i*-DREAMS	Additional factors – addressed in *i*-DREAMS
Frontal crashes *Vehicle to Vehicle* Vehicle to obstacle *Vehicle to VRU* Side crashes Vehicle to Vehicle Vehicle to obstacle Vehicle to VRU *Rear crashes* *Vehicle to Vehicle* Vehicle to obstacle	Continue straight ahead Leave lane - change lane Leave lane – overtake (illegal) Leave lane - unintentional Speed - excessive Harsh - acceleration/deceleration Headway (close following) SPAD/SPAS (train/tram)[1]	Distraction/Inattention[2] Fatigue/sleepiness Poor visibility - darkness Vehicle blind spot[3] Disregard of right of way Misjudgement (self, others, situation) Observation errors Sensation seeking Young driver (18-24) Elderly (65+)

Vehicle to VRU *Rollover/Derailment* *Injury to passenger*		

[1] Addressed in simulator studies only

[2] Mobile phone in hand (car only)

[3] Tram only

Several target risks will be incorporated into the scenarios; however, the risks depend on the transport mode under investigation. There are not only large differences between the transport categories (i.e., road transport vs. rail transport), but there are also large differences within a transport category (e.g., within road transport: difference between cars and heavy vehicles). With the help of desk research and stakeholder input (see D9.1 Giorgiutti et al., 2019 and D3.1 Talbot et al., 2020), the most prominent accident types and hazardous situations were found that should be replicated in virtual scenarios.

Since speed is continuously logged by all the simulators, each partner will also be able to investigate speeding behaviour (define as above the limit or inappropriate for the context). However, only rail transport will specifically focus on this risk factor, in relation to speeding behaviour and choice under or around the speed 'limit'.

The following target risks will be investigated:

- Cars: forward collision avoidance, illegal overtaking and VRU detection, with distraction as a condition to examine interventions for forward collision avoidance and VRU collision avoidance.
- Heavy vehicles:
    - Truck: forward collision avoidance, with sleepiness as a condition in order to examine interventions for forward collision avoidance.
    - Bus:
        - Coaches: forward collision avoidance and illegal overtaking, with distraction as a condition in order to examine interventions for forward collision avoidance and illegal overtaking.
        - City buses: forward collision avoidance and VRU detection, with distraction as a condition in order to examine interventions for forward collision avoidance and VRU detection.
- Rail transport:
        - Tram: VRU detection, with fatigue/sleepiness as a condition in order to examine interventions and event detection. Speed behaviour will also be examined but it has not yet been determined whether the *i*-DREAMS system can provide warning for speeding in trams.
        - Train: speed and signal passed at danger (SPAD), with fatigue/sleepiness as a condition in order to examine interventions for speed and SPADs. Moreover, since there are already some safety systems integrated within a train, the use of safety systems will also be explored.

3.1.2 Scenario environments

Several traffic environments will be incorporated into the scenarios. Again, the environments depend on the transport mode under investigation. Whereas the targeted risks for trucks and

longer haul coaches typically prevail on highways and rural areas, for cars and city buses these typically occur in urban and rural areas. In addition, most environments will contain daytime driving under normal weather conditions. Some high-risk scenarios for passenger cars will contain night-time driving and rainy/cloudy weather conditions in order to increase task demand. For example, due to rain, there is a significantly increased risk for road accidents (Focant et al., 2016). Nearly all events will occur on a straight road in order to reduce the risk of simulation sickness.

3.1.3 Scenarios

For the car, truck and bus trials, two practice scenarios will be used for participants to become familiarised with the simulator:

1. The first practice scenario will not contain traffic situations. In this way, participants become acquainted with driving through a scenario (e.g., visual environment, use of the mock-up).
2. The second practice scenario will contain traffic situations (e.g. intersection with a stop sign) requiring the execution of simple manoeuvres in order to become more acquainted with the driving simulator (e.g., use of pedals, steering wheel to manage safety margins while driving).

As the rail simulators that will be used will be those that are routinely used for training purposes, the drivers will already be familiar and therefore the first level of familiarisation will not be necessary. A practice will be needed, but this will be more of a re-familiarisation as the rail drivers will have used the simulator before.

In addition, for all modes, each trial will have at least three scenarios within it, (see Table 1):

1. Monitoring scenario: a scenario in order to monitor driving behaviour to provide baseline measurement (i.e., without the use of interventions).
2. Intervention scenario: a scenario in order to influence driving behaviour (i.e., with the use of interventions). During the intervention scenario, there will be a focus on fixed timing thresholds (and/or message and/or display).
3. Intervention scenario: a scenario in order to influence driving behaviour (i.e., with the use of interventions). During this intervention scenario, there will be a focus on variable timing thresholds (and/or message and/or display), with the inclusion of a condition (e.g. fatigue/ sleepiness, distraction, bad weather).

Regarding the timing, multistage warnings in alignment with the different stages of the Safety Tolerance Zone (STZ) will be tested (e.g., early and late warnings). Research has indicated that early warnings could be beneficial, for example during a first stage in order to inform the driver, and during a second stage in order to pre-warn the driver (Winkler, Werneke & Vollrath, 2016). In addition to a multi-staged timing strategy with fixed threshold levels, situation-adaptive timing strategies (i.e., variable threshold levels) will also be investigated. For example, threshold levels that are based on a multi-factorial real-time assessment of coping capacity and task load. In this way, warnings for a specific performance objective (e.g., forward collision avoidance) are triggered at different dynamically changing thresholds. For example, if higher levels of sleepiness are being detected, this implies that warnings (e.g., for forward collision avoidance) should be triggered sooner. In order to trigger fatigue and possibly sleepiness among professional drivers, fatigue trials could be conducted in the simulator at the end of a working day.

Although the environment and events are the same, the order of environments and events will be different in the test scenarios. There may be variation in the duration of time between scenarios, for example it is a possibility that professional drivers will drive through the exercise

scenarios and scenario 1 and 2 on a free day or before the start of their working day, and scenario 3 after a different working day.

Further information regarding the intervention trials will be provided in D5.2. 'Description of the driving simulator experiment for identifying safety tolerance zones and the performance of in-vehicle interventions'.

3.2 High risk scenarios per mode

Events

In order to investigate risk factors, the scenarios will include certain (critical) risk events that are associated with real world crashes or violations (e.g., circumstances associated with another driver in the form of a rear-end collision or head-on collision) if the driver does not undertake an action (e.g., release accelerator and/or press brake pedal and/or make a steering manoeuvre). In addition to risky events, masking events will also be included, i.e., events that also trigger a reaction from the participant, but do not contain manoeuvres we are interested in for analysis purposes, in order to mask the true purpose of the experiment. In addition, filler pieces will be included, i.e., pieces that do not trigger a reaction from the participant, in order to have enough data to make conclusions about 'driving behaviour under safe driving conditions', and to provide a baseline measurement as a result. A proposal for events will be described within this section, however a final selection of events will be described in detail within D5.2 ''Description of the driving simulator experiment for identifying safety tolerance zones and the performance of in-vehicle interventions'.

Data

Within all high-risk scenarios the same parameters will be saved with the simulator: average speed, (standard deviation of) lateral acceleration ((SD)LA), (standard deviation of) lateral position ((SD)LP), steering variability, edge line crossings, detection time (accelerator release), reaction time (press brake pedal), signal use, time headway (and distance headway), violations (e.g., speeding), crashes, and surrogate safety measures such as TTC.

However, dependent on the mode and risk factor under investigation, the focus will be on a selection of these parameters.

Procedure

Roughly the same procedure will be used among all transport modes. The following steps will be completed by all participants:

- Researcher gives a general introduction to the participant about the experiment.
- Participant signs an informed consent and are informed about data protection and privacy issues.
- Researcher explains the scales within questionnaire(s) to the participant
- Participant completes questionnaire(s), (e.g., demographic information such as gender, age, driving experience, sleepiness scales - KSS).
- Researcher explains the use of the driving simulator to the participant.
- Participant drives through the two practice scenarios.
- Participant drives through the monitoring scenario in the driving simulator.
- Participant completes questionnaire(s), (e.g., KSS).

- Researcher explains the functionalities of the warning device to the participant.
- Participant drives through the first intervention scenario in the driving simulator.
- Participant completes questionnaire(s), (e.g., technology acceptance questionnaire with items derived from Osswald et al., 2012 and Ghazizadeh et al., 2012, see Annex I, KSS).
- Participant drives through the second intervention scenario in the driving simulator.
- Participant completes questionnaire(s), (e.g., technology acceptance questionnaire with items derived from Osswald et al., 2012 and Ghazizadeh et al., 2012, (see Annex I), KSS).

3.2.1 Car

Both TUM (Germany) and NTUA (Greece) will focus on passenger cars for the simulator trials. They will use different simulators; while TUM uses a STISIM simulator, NTUA will use a FOERST Driving Simulator FPF simulator.

Risk factor(s)

For car drivers, the test scenarios will focus on forward collision avoidance (TUM and NTUA), VRU detection (TUM) and illegal overtaking (NTUA). In addition, distraction (TUM) and bad weather conditions (NTUA) will be used as a condition in order to examine interventions for forward collision avoidance, VRU detection and illegal overtaking.

Environment(s)

The scenarios will include urban, rural and highway environments.

Event(s)

The type of event depends on this risk factor under investigation and differs between environments.

In order to investigate forward collision avoidance, there will be a lead vehicle in front of the driver. In this way, following behaviour (under safe driving conditions) can be measured. In order to investigate behaviour in case of a risky event, the lead car will brake and, as a result, the driver also needs to brake. A possible implementation goes as follows: a bus/car is driving with low speed in front of the car, while the available gap in the opposite traffic is not long enough for an overtaking manoeuvre. The car has to follow the bus/car for a specific distance, until the vehicle in front suddenly brakes (Abou-Zeid et al., 2011).

In order to investigate VRU detection, a VRU will be included within the scenario. A VRU will consist of a pedestrian and/or a cyclist. A possible implementation goes as follows: at a mid-block crossing, a pedestrian, initially obstructed from the driver's view by a bus, attempts to cross the road while the car is approaching (Oza et al., 2005).

In order to investigate illegal overtaking, risky events will be included whereby an illegal overtaking manoeuvre is provoked. A possible implementation goes as follows: a car suddenly driving out of a parking position, with the result that the leading vehicle needs to make an illegal overtaking or a harsh brake in order to avoid a potential crash risk (Yadav & Velaga, 2020).

Data

The simulator parameters for cars will focus specifically on:

- Time headway and distance headway (forward collision avoidance).
- Detection time[7], reaction time[8], steering variability (VRU detection).
- Average speed, (SD)LA, (SD)LP, steering variability, signal use (illegal overtaking).

3.2.2 Heavy vehicles (trucks and buses)

The STISIM simulator will be used by both UHasselt (Belgium) and BARRA (Portugal) to investigate heavy vehicles. UHasselt will focus on trucks, BARRA will focus buses, which includes both coaches and city buses.

Truck

Risk factor(s)

The test scenarios will focus on forward collision avoidance, with sleepiness as an additional condition.

Environment(s)

As drivers of trucks mainly drive outside city centres, the scenarios will include rural and highway environments.

Event(s)

Since the focus is on forward collision avoidance, during the whole scenario there will be a lead vehicle in front of the driver. In this way, the behaviour of the participant (under safe driving conditions) can be measured. In order to investigate forward collision avoidance in case of a risky event, the lead vehicle will brake and as a result, the driver also needs to brake in order to avoid a crash.

The type of event is related to forward collision avoidance and differs between the environments. Possible implementations are as follows: a car that was overtaking the driver and the lead vehicle, suddenly merges into the lane in front of the lead vehicle, or, a car coming from the hard shoulder, suddenly merges into the lane in front of the lead vehicle.

Data

The simulator parameters for trucks will focus specifically on:

- Time headway and distance headway (forward collision avoidance).
- Detection time, reaction time, SDLP, steering variability (sleepiness).

Sleepiness will be measured by using the CardioWheel that uses an electrocardiogram (ECG) reading. Alongside this measure, participants will complete the KSS to indicate their level of sleepiness before, during and after each drive. An overall sleepiness score will be derived from CardioWheel in order to compare with the KSS assessment.

[7] Detection time defined as time for a participant to release the accelerator.
[8] Reaction time defined as the time for a participant to press the brake.

Bus (coaches)

Risk factor(s)

Safety critical events involving coaches are associated with forward collision avoidance and illegal overtaking, therefore the test scenarios will focus on these risk factors. In addition, distraction will be used as a condition in order to examine interventions for forward collision avoidance and illegal overtaking, within the capabilities of the *i*-DREAMS platform.

Environment(s)

As coaches drive for longer distances between cities or international travelling compared to city buses, they mainly drive outside city centres. As a result, the scenarios will include rural and highway environments.

Event(s)

The type of event is related to forward collision avoidance and illegal overtaking and differs between the environments. Some suggestions in order to investigate forward collision avoidance and illegal overtaking include:

- Following slow vehicles in zones where overtaking is forbidden.
- Following a lead vehicle that stops without signalling or initiates a parking manoeuvre unannounced and unexpectedly.
- A lead vehicle that will turn left but hesitates due to traffic in the opposite direction and makes a harsh break.

Data

The simulator parameters for coaches will focus specifically on:

- Time headway and distance headway (forward collision avoidance).
- SDLA, signal use (illegal overtaking).
- Detection time, reaction time, SDLP, steering variability (distraction and compliance).

Bus (city buses)

Risk factor(s)

The test scenarios for city buses with focus on forward collision avoidance and VRU detection. In addition, distraction will be used as a condition in order to examine interventions for forward collision avoidance and VRU detection.

Environment(s)

As drivers of city buses mainly drive inside city centres, the scenarios will include urban environments.

Event(s)

The type of event is related to forward collision avoidance and VRU detection. Suggestions in order to investigate this include:

- Following a leading vehicle when approaching junctions, traffic lights, etc. where the leading vehicle breaks unexpectedly or “unnecessarily”.

- Following a leading vehicle that stops in the right lane without signalling or initiates a parking manoeuvre unannounced and unexpectedly.

Data

The simulator parameters for city buses will focus specifically on:

- Time headway and distance headway (forward collision avoidance).
- Detection time, reaction time (VRU detection).
- Detection time, reaction time, SDLP, steering variability (distraction).

3.2.3 Rail transport (train and tram)

Simulators for rail transport will be used by Loughborough University. It is the intention that two simulators be used, one for trams and one for trains. The simulators are privately owned and used by the rail companies as part of their standard training provision.

Although trams and trains are both forms of rail transport, there are some notable differences between the two. The main difference is that trams drive in a mixed mode environment, whereas trains do not. Tram driving relies on line of sight, whereas trains cannot stop within driver line of sight due to speed. Therefore, different simulators and scenarios will be used.

Trams

Risk factor(s)

For tram drivers, the test scenarios will focus on VRU detection and speed. In addition, fatigue and sleepiness will be used as a condition in order to examine interventions for these risk factors.

Environment(s)

The routes which tram drivers drive are replicated within the simulator. The track route will include urban mixed traffic area and suburban segregated track including the natural transition between the two. The standard routes are suburban/segregated – urban/mixed – suburban/segregated. Specific speeds are set for a station and road crossings and single-track segregated section.

Event(s)

Suggestions in order to investigate VRU detection and speed in trams include:

- A signal set to stop requiring the tram to stop.
- Pedestrian and/or cyclists getting very near the track in urban section.
- Pedestrian or cyclist crossing in front of a tram.

Data

The simulator parameters for trams will focus specifically on:

- Average speed, speeding events (speeding, acceleration/ deceleration).
- Detection time, reaction time (VRU detection and braking).

Sleepiness will be measured using a wearable in the form of a wrist band. Participants will also complete the KSS in order to indicate their level of sleepiness before, during and after each drive.

Trains

Risk factor(s)

For train drivers, the test scenarios will focus on speed and SPADs. As there are already some safety systems integrated within a train, the interaction with and perception of current safety systems will also be explored. This will inform optimal integration of the *i*-DREAMS system within the train cab. It is possible that additional simulator trials will be undertaken to establish this. In addition, fatigue and sleepiness will be used as a condition in order to examine interventions for these risk factors.

Environment(s)

The routes which train drivers drive are replicated within the simulator. The simulator trial will use sections of these routes that include a high-speed section with a minimum of two station stops per scenario with equal distance between stops. Several signals should be on the route with some set to 'safe' and some set to 'danger'.

Event(s)

Suggestions in order to investigate speed and SPADs in trains include:

- Stopping at a station.
- Signals set at danger/warning.
- Changes in sections of track and therefore changes to speed limits.

The use of safety systems will be investigated by observing the drivers' interaction with those fitted on the train as standard.

Data

The simulator parameters for trains will focus specifically on:

- Speed (absolute, compared to speed limit, variability), acceleration/deceleration, emergency brake use, signal status (risk factors).
- Safety system alert and driver response, video of driver use of controls/safety systems inside the simulator (use of safety systems).

Sleepiness will be measured using a wearable in the form of a wrist band. Participants will also complete the KSS in order to indicate their level of sleepiness before, during and after each drive.

3.3 Summary of risk scenarios

This chapter provided an overview of the high-risk scenarios that will be used per mode in the simulator trials. Further detail will be provided in D5.2. Table 6 below summarises the key information for the scenarios per mode.

Table 6: Summary of high-risk scenarios per transport mode

		Partners						
		TUM	**NTUA**	**LOUGH**		**UHASSELT**	**BARRA**	
	Transport mode	Passenger Car	Passenger Car	Tram	Train	Truck	Coach	City Bus
	No. of participants	15	15	30		30	30	
Risk Factors	**Forward collision avoidance**	×	×			×	×	×
	Illegal overtaking		×				×	
	Speeding			×	×			
	Use of safety devices			×	×			
	VRU collision avoidance	×		×				×
Conditions	**Bad weather**		×					
	Distraction	×					×	×
	Fatigue/ sleepiness			×	×	×		
	Location	Rural Urban Highway	Rural Urban Highway	Urban and suburban with differential speed limits.	A route with high speed section with 2 equally distanced station stops and signals along the route	Rural Highway	Rural Highway	Urban
	Specific simulator parameters	Time headway, distance headway, average speed, SDLA, SDLP, steering variability, signal use, detection and reaction time.	Time headway, distance, average speed, SDLA, SDLP, steering variability, signal use, detection and reaction time.	Average speed, speeding events (speeding, acceleration/ deceleration), detection and reaction time.	Speed (absolute, compared to speed limit, variability, acceleration/ deceleration), emergency brake, signal status, use of safety systems.	Time headway, distance headway, detection and reaction time, SDLP, steering variability.	Time headway, distance headway, SDLA, signal use, detection and reaction time, SDLP, steering variability.	Time headway, distance headway, detection and reaction time, SDLP, steering variability.

4 Considerations for field trials

The following chapter aims to briefly overview the aim and scope of the field trials and provide recommendations and guidance in relation to the field trials protocol. A brief outline of timelines is also provided, including a detailed example of a timetable for the passenger car field trials. Other transport modes can use this as a guide and alter accordingly. The chapter culminates in a general considerations checklist to help in the development of the field trials as part of the *i*-DREAMS project.

The recommendations and guidance suggested here is in parts a broad approach, which will be further detailed in a future deliverable, D5.3. The information and considerations have been developed using information from the FESTA handbook (2018), with guidance summarised in D5.1 (Hancox et al., 2020), and key learnings from previous Field Operational Trials (FOTs) and Naturalistic Driving (ND) studies, including UDRIVE, Euro-FOT and PROLOGUE, which were also described in D5.1 section 2.8. It should be noted that in relation to rail, if field trials cannot be conducted with trains, additional trials will be conducted in the simulator. It is intended that for trams, both simulator and field trials will be conducted.

4.1 Definition

When studying human behaviour in the context of transport safety, there is a variety of methods available. One method is conducting research in a 'real life' context, rather than conducting research in controlled laboratory or simulated conditions. The purpose of the *i*-DREAMS field trials is to instrument vehicles across five vehicle types and four modes, which will then continue to operate as usual, all the time collecting data. The field trials have two stages. The first is a baseline data collection phase. This will then be followed by an intervention stage where alerts and feedback will be given. Therefore, the field trials are a type of FOT, rather than an ND study.

The aim of an FOT is to evaluate technology and measures on a larger scale. The FESTA handbook defines FOTs as "*a study undertaken to evaluate a function, or functions, under normal operating conditions in environments typically encountered by the host vehicle(s) using quasi-experimental methods".* As the *i*-DREAMS platform will be installed in the vehicles, monitoring driver behaviour and providing alerts and interventions when triggered, the proposed field trials are 'intervening' rather than just observing driver behaviour, with the equipment being used in a naturalistic manner. The benefit of utilising FOTs is that implementing technology allows for the relatively unobtrusive and continuous recording of driver behaviour, environmental and vehicle parameters, as well as being able to observe/record the driver under usual driving conditions. It is highly likely that drivers will be aware that they are being observed through the technology measures, which could influence driving behaviours. However, by conducting the field trials over an extended period of time drivers may get used to the equipment and return to normal driving.

4.2 Aim and scope of *i*-DREAMS field trials

The aim of the field trials are to assess the effect of the interventions, developed as part of the *i*-DREAMS system, for both real time and post-trip warnings. As shown in Figure 3 in the introduction, the field trials are to be conducted across Europe in five testing sites, which will focus on particular transport modes. Overall, the experimental testing will take place over four stages, approximately 12 months in duration:

- Stage 1 – simulator trials
- Stage 2 – pilot testing (field trials)

- Stage 3 – baseline measurement (field trials)
- Stage 4 – testing of interventions (field trials)

Following testing of the *i*-DREAMS platform in the simulator trials, the system will be installed in the four transport modes. Vehicle instrumentation will take place prior to stage 2. For all modes, the same drivers will be engaged in the baseline and intervention stages, (3 and 4), however, for passenger cars at least, different participants will be used in both the simulator and the pilot on-road testing so as not to influence the results. Five vehicles per trial will be equipped with the *i*-DREAMS technology for the pilot testing, in order to record measurements of the equipment and interventions prior to the experiment starting and check that everything is working as it should. During the baseline stage, no interventions will be implemented, however driving performance will be recorded and the *i*-DREAMS technology will be in use but without alerts. The interventions used in stage 4 will be in-vehicle real time and post trip interventions. No intervention will occur in the 'avoidable crash phase' of the STZ for safety and liability. Due to equipment and fitting capacity, participants may be divided into two groups, particularly for passenger cars, so therefore stage 3 and stage 4 would occur twice but with different participants over the testing period, (as shown in Figure 4, not including installation/de-installation time). For the later parts of stage 4 participants will receive post trip feedback through the post-trip app and/ or the gamified web platform.

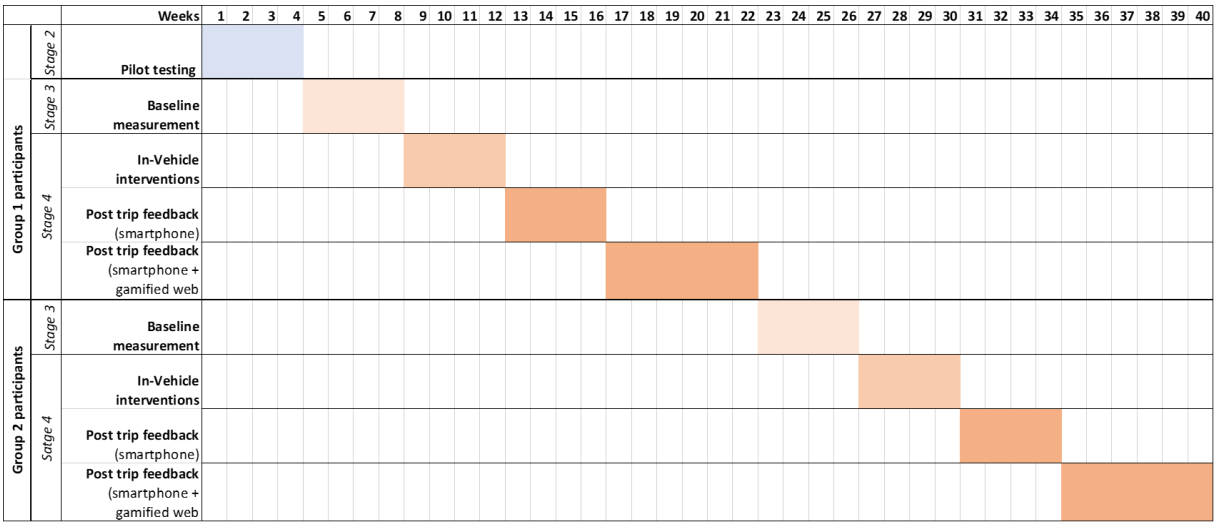


Figure 4: Overview of the stages of field trials in weeks with two participant groups

The ultimate goal of the field trials is to successfully capture the necessary indicators, performance metrics and intervention characteristics that can assist in validating of the STZ for each mode, and to select the most successful in-vehicle interventions.

4.3 Recommendations for conducting field trials

It is important when planning trials to consider lessons learnt and specific points of attention from previous projects. In this instance, learnings from FESTA, UDRIVE (Martin et al., 2017) and PROLOGUE (Sagberg et al., 2011; Van Schagen et al., 2011) will be taken into consideration when planning and conducting the *i*-DREAMS field trials. D5.1 (Hancox et al., 2020) contained overviews of relevant information from these projects. The specific sections are referenced below with any additional points of consideration.

Plan of approach

A key aspect of a successful field trial is a realistic and detailed plan of approach. D5.1 included modifications of the FESTA checklists in Annex 1, tailored specifically to the *i*-DREAMS project. Developing checklists alongside detailed plans will assist in avoiding delays, limiting overspending and saving resources and ensure none of the stages of the trials are overlooked. A pilot plan can describe all procedures, necessary forms, participant-related and vehicle-related documents, instruction manuals and guidelines to instrument vehicles, contact participants etc. Before the start of the actual field trials, the pilot plan can be adjusted accordingly in case any issues were encountered during the pilot phase.

Participant recruitment

The recruitment process takes a long time and therefore should be well planned in order to be successful (Martin et al., 2017; Sagberg et al., 2011; Van Schagen et al., 2011). Section 2.8 of D5.1 details learnings from previous FOT and ND studies, which mention aspects of participant recruitment (Hancox et al., 2020). In addition:

- The recruitment process should start early in the field trial process, to allow time to recruit adequate numbers and to provide more time in case delays arise. Furthermore, it is recommended that all procedures, documents, information materials, legal and ethical aspects are ready and translated into the local language of the field trial location before starting the recruitment process. This is necessary to avoid delays (i.e. postponed start of the piloting and field trials) which can lead to participant dropouts.
- While recruiting, potential participants should be asked to complete a screening questionnaire to ensure that the defined participant selection criteria per field trial location are met.
- The duration of the field trial (several months) followed by the fear that their vehicle might be damaged due to the installation of the equipment are important barriers for participation. This can be overcome by selecting sufficient and efficient recruitment channels in advance and be transparent about the field trial which can make people more receptive to participate.
- Participants should be selected that are within a maximum one-hour travel radius of the field trial base. At larger distances, it becomes quite cumbersome to solve technical problems concerning the data collection system.
- It is essential to keep potential participants informed of the progress of the field trials in order to keep them engaged.

Recruitment of professional drivers

The participant recruitment for professional drivers can be difficult because there are different stakeholders involved that need to agree to participate:

- The main contact person of the fleet, the company management, the union and the professional driver themselves have to agree to join the field trial. Unions should be approached from the start and should be informed about all aspects of the field trial in order to avoid delays; unions need to approve changes in the worker's working environment (such the installation of monitoring equipment).
- To encourage participation, the value of safe driving conditions and contribution to safe traffic, positive company image, etc. can be an incentive for companies to participate.

- It is recommended that fleet owners inform the field trial responsible about their driving schedules so that it is known when a driver change takes place. This will also help with driver identification.
- If exit and entry questionnaires are used, they need to be adjusted for professional drivers as their driving experience and behaviour differs significantly from non-professional drivers.
- Professional drivers might be more willing to participate if they also receive an incentive. However, this is something that the fleet manager should decide.

Further information about the *i*-DREAMS recruitment strategy can be found in section 5.2.1 of this deliverable.

Participant dropout and incentives

In relation to participant dropout and incentives, in addition to points raised in section 2.8 of D5.1 (Hancox et al., 2020), the following actions are recommended:

- Keep participants well-informed about the field trials and stress that their contribution is important.
- Comply with the starting and end dates communicated to participants. This can be done by developing a realistic and detailed plan of action for the experiment. By means of this plan of action all necessary steps and issues prior and during the experiment are identified with the aim of avoiding delays, which result in participant dropouts
- Be transparent about the experimental study conditions during the recruitment and participant reception briefing.
- Create a reserve pool of participants during the recruitment. These participants can then easily replace the initial participant that may drop out during the experiment

In defining the right incentive strategy for field trials, the following aspects should be taken into account:

- The incentive strategy (amount, type of payment and payment periods) must be specified in the participant agreement/consent form in order to avoid discussion afterwards.
- The incentive needs to be high enough - if the incentive is not high enough, for example, (monetary) benefit is not in line (lower than) with the duration of the experiment, it will not motivate potential participants.
- Incremental incentive payments are recommended to reduce the dropout rate encourage participants to be committed to stay in the trials until completion.
- A dropout budget could be implemented in order to recruit back-up participants during all field trial stages. This dropout budget ensures that participation is still appealing to the back-up participants even if they enrol in the later stages of the trials.
- The incentives need to be managed locally by the partner in each country responsible for conducting the field trial experiments as the legal aspects for receiving incentives differ from country to country.
    - Depending on the national legislation (income tax regulations), it might be necessary to pay the incentive by vouchers.
    - Participants should be informed in advance if the received incentives need to be reported in their income tax declaration. This should be mentioned in the participant agreement/consent form.

Additional information relating to participant retention and incentives is provided in section 5.3 of this deliverable.

Vehicle instrumentation

Certain aspects should also be considered regarding the equipment that will be installed in the vehicles. The aspects recommended are:

- All equipment should be checked before installation.
- Spare parts should be available in case of equipment failure.
- The planning and organisation of equipment installation should be careful considered, ensuring there are enough personnel to handle the vehicles and that a limited number of vehicles are installed/deinstalled at once to help with coping capacity.

Participant handling and support

A good participant handling and support strategy during the field trials is essential to avoid dropouts. Elements to take into account are:

- A clear procedure to handle participant complaints.
    - For this, a helpline by means of e-mail address and telephone number will be developed. This helpline should be monitored regularly so that participant issues and complaints can be dealt with as soon as possible (e.g., within two working days).
    - Furthermore, researchers can be assigned to exclusively deal with solving participant issues. The assigned person can differ according to the specific issues (general issue, ethical/legal issue, problems with the data collection equipment etc.).
- It is recommended to have insurance in order to compensate the participants for damages caused to the vehicle by the field trial equipment.
- In order to limit the burden for participants, technicians should be available who can go to the participants' home or work place to fix possible issues with the data collection equipment.
- It is important to maintain informal contacts with participants.
    - In case of suspected failure in data logging, participants can be contacted to check if the equipment still works.
    - Participants should be instructed to contact the researchers in case of specific circumstances such as damage to the vehicle or equipment, not using the vehicle for long time due to illness or holidays, change in driving patterns due to job change, etc.

Ethical and legal issues

An overview of FESTA recommendations were provided in section 2.1 of D5.1 (Hancox et al., 2020). According to previous European trials (Ströbitzer et al., 2013; Van Schagen et al., 2011) it is recommended that legal and ethical issues are considered, approved and put in place in advance in order to avoid delays during the recruitment phase or a postponed start of the actual field trials. The legal and ethical issues that should be considered are:

- Approval of the competent national authorities for data protection (when necessary/applicable).
- Participant consent forms.
    - The participant consent form should contain a passage detailing that the data of participants who have not signed the participant consent form (i.e. second driver of a vehicle) will not be collected during the study.
- Liability issues (insurance etc.).

An update on the ethical and legal considerations is provided in chapter 7 of this deliverable.

4.4 Data collection

Due to differences between modes, their operation, technological capabilities and vehicle design, the data collection methods and measures may differ among the field trials. Table 7 below provides an overview of the data collection technologies which will be used during the field trials, per mode:

Table 7: Overview of data collection technologies per mode for field trials

Car	**Truck**	**Bus**	**Rail**
Mobileye	Mobileye	Mobileye	Mobileye
Wristband/wearable	CardioWheel	CardioWheel	Wristband/wearable
Dash cameras	Dash cameras	Dash cameras	Dash cameras
CardioGateway – GPS, OBU/OBDII	CardioGateway – GPS, OBU/OBDII	CardioGateway – GPS, OBU/OBDII	CardioGateway – GPS, OBU/OBDII
Post-trip feedback app	Post-trip feedback app	Post-trip feedback app	Post-trip feedback app
Questionnaire data	Questionnaire data	Questionnaire data	Questionnaire data

It is important to recognise that data handling (from data collection in vehicles to final analysis), data quality assurance and tool preparation are significant steps within data collection and require adequate planning. In relation to how this will be addressed in *i*-DREAMS, more detail will be provided in D3.5, 'Standard protocol for handling big data'. D3.5 will also provide details of the data acquisition system which will be used in the *i*-DREAMS field trials.

4.5 Detailed car field trial timetable example

Conducting field trials contains many phases and steps, and therefore it is important to develop a realistic and detailed timeline which includes as much information as possible, to help in the planning and conducting of the trials. Figure 5 below is an example of a timetable for conducting the field trials in cars, including approximate timescales for installation/de-installation. This timetable can then be updated when necessary and modified for other modes. Prior to the start of the timetable, ethics applications, protocol developments and recruitment would need to take place.

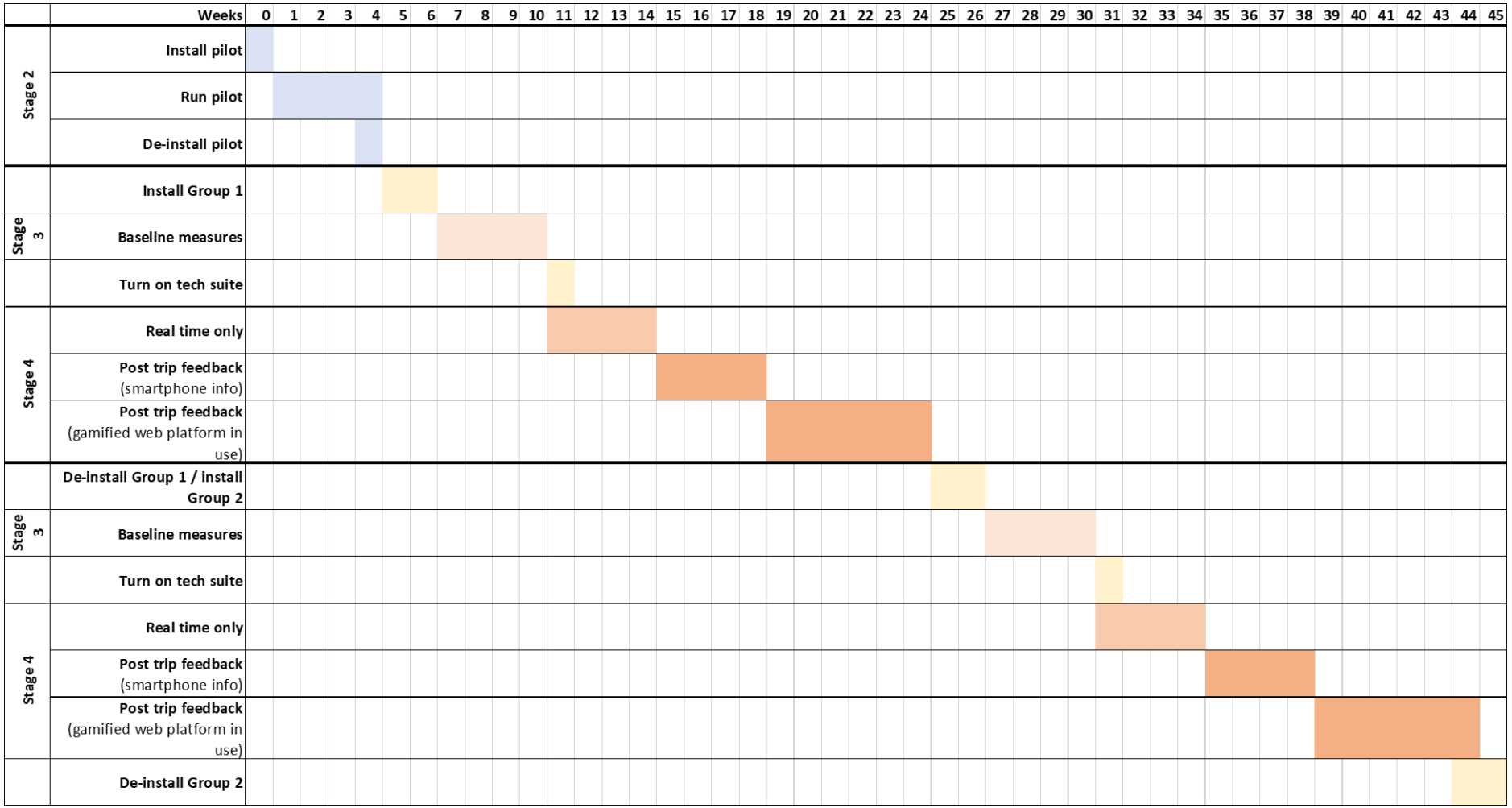


Figure 5: Example timeline for conducting field trials in cars

Note. It may be possible that de-installation of Group 1/ installation of Group 2 starts earlier than shown due to the current plan only allowing for de-installation of Group 1 once all of the Group have finished. In reality, those first equipped can be de-installed slightly sooner allowing for installation of Group 2 to begin earlier. Installation could also take longer than stated due to reliance on participant availability, therefore additional contingency may be required.

4.6 Checklist for conducting field trials

As described in D5.1 (Hancox et al., 2020), the FESTA handbook provides guidance in relation to conducting FOTs. One important point advises that checklists are useful considerations for running and conducting trials. These can be useful reference documents and can ensure continuity between testing across different sites, something which will be particularly important in relation to *i*-DREAMS. It may be that some aspects of the checklist need adapting or adjusting depending on different modes, however the aim here is to provide a broad checklist of considerations for the field trials. The presented checklist is based on lessons learnt from PROLOGUE (Backer-Grøndahl et al., 2011; Groenewoud et al., 2010; Sagberg et al., 2011; Van Schagen et al., 2011) and UDRIVE (Castermans, 2017; Castermans et al., 2017; Lai et al., 2013; Lai, et al., 2013; Martin et al., 2017; Quintero et al., 2016; Ströbitzer et al., 2013).

Checklist for the planning phase of field trials

Summary of actions to perform:

- ***Create study plan***
  - General time plan and deadlines for the different field trial phases per location.
  - Overview of the field trial locations and sample size.
  - Identification of participant selection/inclusion criteria that will be used.
  - Identification of vehicle selection/inclusion criteria that will be used.

- ***Prepare recruitment***
  - Create information materials in local language of the field trial locations:
    - Project video, flyer, information letter, presentation about the purpose of the field trials tailored to nature of participants (private versus professional drivers).
  - Create participant recruitment survey based on the participant selection and vehicle selection criteria defined in the study plan.
  - Create a website for participant recruitment in local language of the field trial locations:
    - This website contains all additional information that possible participants might inquire about. This website can also include the participant recruitment survey.
  - Define recruitment strategy/channels:
    - The strategy should be tailored to type of participants and should be available in the local language of the field trial location. Possible methods are: own recruitment database, personal references, web-based recruitment, driver clubs, newspaper advert, flyers, social media recruitment agency, vehicle fleets, organising recruitment events.
  - Create dropout management strategy:
    - This may include keeping a reserve list of participants who are interested in participating, in case of drop outs. Participant details will be held securely.

- ***Legal and ethical aspects***
  - Create the participant agreement/consent form according to national regulations:
    - This should contain the incentive payment, data protection aspects, liability issues etc.
  - Create an incentive strategy.
  - Arrange insurance in case of vehicle or equipment damage.

  - Receive data collection approval by the competent national/local authority.
  - Create a strategy that details what will happen if a participant drops out and would like their data removing.
  - Create a strategy that details the procedure if an individual is involved in an accident or incident.

- ***Technical and operational aspects***
  - Assign field trial location responsibilities:
    - Persons in charge for dealing with legal, participant or equipment issues during the field trials.
  - Create documents in local language:
    - Participant related: briefing presentation, entry, exit and recruitment questionnaires, participant consent forms, contact information (helpline).
    - Vehicle related: vehicle condition report to enter the vehicle condition (scuffs, dents, broken, cracked, etc.) on installation, vehicle registration form, vehicle adaptation document, instrumentation agreement, garage information notice (instructions to disconnect / reconnect the system if necessary in case of maintenance), as well as contact information for the corresponding installation team.
    - Field trial itself: user manuals and installation guides, participant liaison strategy, incentive strategy, data collection approval, online data monitoring tool, field trial plan (checklist) adjusted to lessons learnt from the pilot.
  - Create service procedures for participant handling and support:
    - Procedure to handle participant complaints/questions, guidelines for when participants need to contact the researchers.
  - Prepare installation/de-installation of data collection unit in vehicles:
    - Technicians are trained, equipment is available, spare parts are available, data storage is arranged, and installation location is determined.
  - Book facilities for participant briefing.

Checklist for the recruitment phase of field trials

Summary of actions to perform:

- Start recruitment based on the selected requirement channels.
- Select potential participants based on participant selection criteria defined in the study plan. Selection is based on completed recruitment survey.
- Create a backup-plan in case a field trial location cannot meet its recruitment criteria.

Checklist for the start of field trials

Summary of actions to perform:

- ***Check prerequisites for field trials***
  - Ensure field trial location responsibilities and teams are identified.
  - Ensure all relevant staff trained in terms of data protection and privacy issues.
  - Check the necessary forms, documents, strategies are ready (all in the local language):
    - Participant-related documents, documents for the field trial itself, vehicle related documents etc.
  - Ensure the vehicles and participants are selected.

- Check that suitable facilities to receive participants are prepared.

- ***Participants briefing/reception***
  - Participants are briefed about the field trials:
    - An overview of the study, the equipment, the planned execution of the trial, the legal and ethical framework, field trial partner and participant engagements, rights and obligations, content of contractual documents, incentives payment principle and organisation as well as the support and communication means.
  - Participants also sign the legal and ethical documents (consent form etc.) and complete the entry questionnaire.
  - Participant briefing on post-trip applications.

- ***Vehicle reception and instrumentation***
  - Prior to installation the vehicle is registered and checked for damages, damages are noted on the vehicle condition report, photos are taken of the outside and inside of the vehicle.
  - The equipment is installed in the vehicle and the participant receives the garage information notice (instructions to disconnect / reconnect the system if necessary, in case of maintenance).
  - After, the vehicle is checked again for damages. Damages are noted on the vehicle condition report, photos are taken of the vehicle.

Checklist for during the field trials

Summary of actions to perform:

- ***Participant handling and support***
  - Operate the helpline in order to answer participant questions, deal with complaints or arrange a meeting to solve equipment issues.
  - Manage the incentive payments.

- ***Dropout management***
  - Select participants from the reserve pool in case initial participants no longer wish to participate.

Checklist for at the end of field trials

Summary of actions to perform:

- ***De-installation of data collection unit***
  - Contact participants to schedule removal of equipment.
  - Meet the participant and its vehicle, check the vehicle for damages, fill in vehicle condition report.
  - De-installation of the data collection unit.
  - Give vehicle back to the participant, do a new check for damages and fill in a new vehicle condition report.

- ***Participant de-briefing***
  - Organise a meeting with all participants to record impressions of the trials.
  - User acceptance questionnaire to be completed.

An example list of considerations with relevant questions to ask at each of the phases of the field trials can be found in Annex D.

5 Participant recruitment

The following sections describe aspects of participant recruitment that need to be considered as part of the *i*-DREAMS project simulator and field trials. Overviews include sampling considerations, recruitment strategies, participant screening and retention. It is the intention that recruitment for the simulator trials will follow the criteria outlined in this chapter where possible. Further detail on the sample size and composition for the simulator experiments will be included in D5.2.

5.1 Sampling strategies

5.1.1 Probability sampling versus nonprobability sampling

The information in this section has been informed by Gravetter & Forzano (2006). Essentially, there are two types of sampling strategies:

- Probability sampling: the entire population is known, each individual in the population has a specifiable probability of selection and the sampling occurs by a random process based on probabilities.
- Nonprobability sampling: the population is not completely known, individual probabilities cannot be known, and the sampling method is based on factors such as common sense or ease, with an effort to maintain representativeness and avoid bias.

As probability sampling requires thorough knowledge of the population, this sampling method is better in ensuring a representative sample. However, extensive knowledge of all the individuals in the population is very often unavailable to researchers, resulting in the use of nonprobability sampling in most behavioural science studies. This is also the case for the field and simulator trials in the *i*-DREAMS project.

Nonprobability sampling methods can be divided into convenience sampling and quota sampling. Of these two methods, convenience sampling (also known as accidental sampling) is mostly applied to conduct behavioural science studies. In convenience sampling, individual participants are selected based on their availability to participate and willingness to respond. As a result, the sample contains individual participants that are very eager to participate or are merely selected because they are available. This makes the convenience sampling approach an easy and inexpensive method to obtain a sample. However, a limitation of this approach is that the researcher has very little control over the representativeness of the sample, which almost definitely leads to the selection of a biased sample.

In order to control the composition of a convenience sample, quota sampling can be used. Quota sampling guarantees that subgroups are equally represented within a convenience sample. More specifically, the sample is obtained by identifying different subgroups that need to be included based on inclusion criteria and subsequently defining quotas for individuals to be selected through convenience from each subgroup. By setting quotas, the most important limitation of nonprobability convenience sampling is removed, since researchers regain control over the sample composition, which results in a more representative sample.

5.1.2 Participant selection criteria

The next step after choosing the most appropriate sampling approach for a study is to determine the participant selection criteria. The selection criteria and corresponding quota for each criterion represent the different aspects that should be considered in order to create a well-balanced and representative sample of participants.

Based on a review of PROLOGUE deliverables (Backer-Grøndahl Lotan, & Van Schagen, 2011; Groenewoud et al., 2010; Lai et al., 2013; Sagberg et al., 2011; Van Schagen et al., 2011), the following selection criteria may also be interesting for the *i*-DREAMS simulator and field trials:

- Participants: driving experience (minimum annual driving distance), age and gender of participants (a minimum of 40% per gender is recommended for cars[9] in order to avoid overly skewed gender factor), multi-driver access to vehicles, environmental exposure (mixed driving pattern across urban, rural and motorway environments).
- Vehicles: selection of different makes or types of cars/trucks/buses, manual and/or automated transmission. For buses: city traffic and coaches; for trucks: long-haul vehicles, city/local distribution (specific relevance for field trials).

5.1.3 Sampling strategy within *i*-DREAMS

Based on these insights, a non-probability quota sampling approach will be used to sample participants for the field and simulator trials within *i*-DREAMS. The following paragraphs provide an overview of the sampling strategy and selection criteria that will be used for the *i*-DREAMS simulator and field trials.

Trial location, format and sample size

In total over 600 participants, divided over five countries and four transport modes will participate in the simulator and field trials. The tables below have been adjusted from the proposal and reflect the figures in D5.1 (Hancox et al., 2020). Please note that for the United Kingdom, the division and type of transport modes indicated in Table 8 and

Table 9 differ from D5.1 as trams have been included in addition to trains. As a result, the number of participants per mode has also been adjusted to increase the sample size of the rail mode.

Table 8: Target participant numbers for simulator trial by location and vehicle type

	Belgium	Germany	Greece	Portugal	United Kingdom	Total per mode
Car		15	15			30
Bus				30		30
Truck	30					30
Rail (tram)					15	15
Rail (train)					15	15
Total per country	30	15	15	30	30	120

[9] This value will be adjusted for professional drivers to reflect the driving population.

Table 9: Target participant numbers for field trials by location and vehicle type

	Belgium	Germany	Greece	Portugal	United Kingdom	Total per mode
Car	50	65	65		55	235
Bus				75		75
Truck	75			50		125
Rail (tram)					45	45
Rail (train)					25*	25
Total per country	125	65	65	125	125	505

*For train operators, testing in real-life conditions is subject to proven safety case and Union agreement. Otherwise, implementation of interventions for this group will be in a simulator.

The experiments will include four stages with a total duration of 12 months, as described in section 4.2 of this deliverable. The pilot stage (stage 2) will include five participants per trial, and these will be conducted for cars in Germany, Greece and the UK, for buses in Portugal, for trucks in Belgium and for rail in the UK. These participants will not be included in the baseline and intervention phases (stage 3 and 4). For logistical reasons, two trial groups for the field trials will be used, particularly for passenger cars, meaning less equipment is required to be purchased than if participants were tested in one group, all participating at the same time. Due to restrictions with multi-access vehicles in trucks and buses, the target participant numbers for field trials are determined by the equipment available.

Participant selection criteria

The following participant selection criteria and quota will be applied in the *i*-DREAMS field trials and simulator experiments where possible.

Driving experience

In order to guarantee that enough data will be collected during the field trials, it is necessary that potential participants meet the criterion of a minimum annual driving distance. The following specifications are set:

- Car: a minimum annual mileage of 10,000km is recommended for the principal driver. This requirement does not apply to secondary drivers.
- All other modes: drivers who have at least 6-12 months driving experience. However, the participating fleets/companies will determine which drivers will participate in the trials.

Age

Age is a known factor that can influence driving behaviour. Therefore, four age groups are defined in order to guarantee a spread of the age distribution: 18-25, 26-45, 46-64, 65+. These age groups are similar to how age groups were defined in comparable projects, for example, in UDRIVE the age groups were 18-25, 26-45, 46-70.

The following specifications are set:

- Car: all trials with cars should comply with the four age categories.
- All other modes: no minimum requirement for age as the participating fleets/companies will determine which drivers will participate in the trials. However, the project aims to have all age groups represented in the sample if possible.

Gender

The following specifications are set for the drivers:

- Car: based on a recommendation of a previous study (Lai, et al., 2013; Martin et al., 2017), a minimum of 40% per gender is recommended in order to avoid an overly skewed gender factor. If possible equal division between genders is desired.
- All other modes: no minimum requirement for gender as the participating fleets/companies will determine which drivers will participate in the trials. However, the researchers aim to have both genders represented in the sample.

Multi-driver access

Recruitment of multi-drivers for cars and rail is favoured in order to collect as much data as possible during one trial group. Based on a recommendation of previous studies (Lai et al., 2013; Martin et al., 2017), the aim is to have at least 25% of cars in each country participating in the field trials to have multiple drivers. As the rail industry by nature is multi driver, the aim is to recruit as many drivers as possible for any one vehicle equipped who are willing to take part. This criterion is not applied to trucks and buses as it is expected that the vehicles are not multi-driver access and the drivers are less likely to share vehicles.

Environmental exposure

Participants in the field trials should have a mixed driving pattern across urban, rural and highway environments. Based on a recommendation of previous studies (Lai et al., 2013; Martin et al., 2017), it is decided that a minimum of 20% of exposure to the three road environments will be aimed for in car drivers. For trucks, buses, trams there is no minimum requirement for environmental exposure, as the participating fleets/companies will determine which drivers will participate in the trials, and drivers often operate in the same road environment (e.g. long haul drivers undertaking highway driving versus construction material transport driving short distances on urban and rural roads).

Summary of required participant characteristics

The required and desired participant characteristics per transport mode are summarised in Table 10.

Table 10: Minimum requirements of participant characteristics for field trials

	Car	**Bus**	**Rail**	**Truck**
Driving experience	10,000 km per year	Minimum 6 months experience	Minimum 6 months experience	Minimum 6 months experience
Age	18-25, 26-45, 46-64, 65+	N/A	N/A	N/A
Gender	40% per gender	N/A	N/A	N/A

Multi-driver	At least 25% of the cars in each country with minimum 2 drivers per car	N/A	At least 25% of the trains/trams with minimum 2 drivers per tram	N/A
Exposure	20% annual mileage in urban, rural and motorway environments	N/A	N/A	N/A

Vehicle selection criteria

For the field trials, specific car makes and models are evaluated to be more suitable to participate due to popularity (vehicle stock) and installation requirements of the *i*-DREAMS technology (analysis conducted by CardioID). Although other car makes and models are also likely to be able to participate in the field trials, the following are specifically suitable:

- Audi: A3 (2004-2007; 2010-2018), A4 (2009-2020)
- Ford: Fiesta (2018), Focus (2011-2016)
- Hyundai: Tucson (2016-2020)
- Mercedes: A-Class (2017, 2018)
- Mini cooper: Hatch (2009-2016)
- Nissan: Qashqai (2007-2018)
- Opel/Vauxhall: Astra (2008-2019), Corsa (2008-2018)
- Peugeot: 208 (2012), 308 (2014)
- Renault: Captur (2013-2015), Clio (2007-2012)
- Skoda: Octavia (2007-2019)
- Volkswagen: Golf (2000-2013; 2016-2019), Passat (2006-2018), Tiguan (2009-2018)

For buses, trucks, and rail, no specific requirements regarding vehicle make and model apply as the participating fleets/companies will determine which vehicles will participate in the trials.

5.2 Recruitment strategies

Recruitment can be a lengthy process and can often be underestimated (Martin et al., 2017). In order to avoid early participant drop-out or a lack of participants, it is necessary to develop an efficient recruitment strategy that can recruit enough interested participants when the actual recruitment takes place. However, it should be kept in mind that there is no right recruitment strategy. In general, several steps can define the recruitment process, as detailed in Figure 6. Advertising and promotion of the study needs to occur, to generate participant interest and begin recruitment. Inclusion/exclusion criteria should be defined, which will be used for the screening of all potential participants. Screening could be in the form of a questionnaire, which could be web based or delivered over the phone. Following this, more targeted recruitment may need to take place, to ensure an adequate sample. It is important to keep in mind that interest in participating does not mean that participants are recruited. The number of prospective participants that could drop out at this stage should not be underestimated. The time between interest, screening and enrolment should be kept to a minimum to help with retainment.

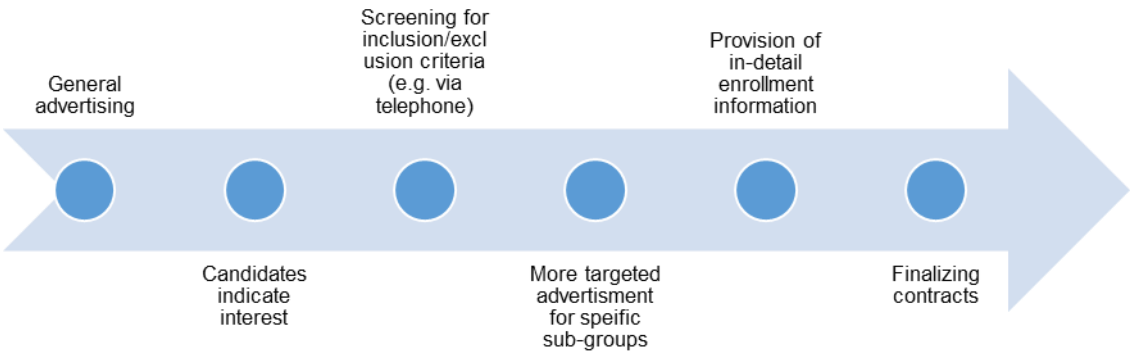


Figure 6: Flow of recruitment process

An important factor is that the recruitment strategy and associated recruitment channels are tailored to the target group in question. The following recruitment strategies/channels have been successfully applied in the past to recruit participants for field and simulator experiments (Ströbitzer et al., 2013; Van Schagen et al., 2011):

- ***Own recruitment database***: Databases or lists of possible participants from previous experiments can be used as a starting point for recruitment.
- ***Personal references:*** Possible participants can also be recruited by contacting personal contacts of the researchers such as relatives, acquaintances, friends, colleagues, etc. When using this approach, it is necessary to inform the employees of the project partners about the recruitment and participation conditions so that they can support the recruitment process.
- ***Web-based recruitment***: An essential prerequisite for web-based recruitment is that researchers should know in advance which websites are often visited by the target group. Therefore, the first step before using this recruitment channel is to make an analysis of potential websites for each target group that should participate in the experiments. It should also be considered that this form of recruitment is not always free of charge. Furthermore, web-based recruitment by means of advertisements through websites and social media channels should be supported by a local recruitment website. This website needs to provide all necessary information that interested participants might ask for. It is also convenient if this website includes a web-based questionnaire in order to screen and collect relevant information from possible participants, which can then be used to make the final participant selection.
- ***Motorist clubs***: Driver and vehicle organisations operate as a platform to exchange information and interests of their members. In that respect, representatives of local driver or vehicle organisations can also be approached in order to assist in the recruitment process.
- ***Newspaper advert***: Newspaper advertisements can also be used to recruit participants. As these advertisements are quite expensive it is highly recommended to in advance make an analysis of the target group (demographic, geographic) and scope of the newspaper. Another aspect that should be considered is that designing an advert also takes time.

- ***Flyers***: Flyers can also be developed and used for recruitment purposes.
- ***Social media***: Social media may help to distribute advertisements to a broader audience; however, this may also come with certain biases. Various media for recruitment should be used.
- ***Recruitment agency***: Recruitment agencies can also be hired to recruit participants. This expensive recruitment strategy is very useful to recruit very specific participants (e.g. elderly participants).
- ***Recruitment events****:* Recruitment events or information meetings about the experiments can also be organised in order to answer questions and reassure and convince potential participants to engage in the experiments.
- ***Vehicle fleets***: Contacting fleet operators is a useful way to recruit potential participants for field trials as this makes it easier to quickly find participants that fit the criteria. However, attention should be paid that the sample is not biased.

A point to note is that forms of recruitment that rely on volunteers may be subject to self-selection bias, which may lead to the sample not being representative or exaggerating certain findings. It may be that those who volunteer for a study have different characteristics than those who do not, and those characteristics could influence the results. There is also the issue of inherent bias, whereby underlying factors or assumptions due to the nature of the situation, may skew results or findings. Factors such as these need to be taken into consideration when analysing, concluding and reporting results.

5.2.1 Recruitment strategy within *i*-DREAMS

The sample and legal and ethical requirements are different in each country. Therefore, the recruitment channels to reach each target group will also differ. Consequently, each partner will be responsible for developing a tailored recruitment strategy that best fits the needs of their country and sample in order to recruit the desired number of participants for the simulator and field trials. Based on the analysis above, own recruitment databases, personal references and web-based recruitment are recommended strategies for the simulator trials. For the recruitment of the field trials, personal references, web-based recruitment, driver clubs and vehicle fleets (especially for the professional drivers) appear to be viable recruitment strategies. Furthermore, participants will be recruited from the partners' organisations based on appropriate yet non-discriminatory inclusion criteria (see section 5.1.2 participant selection criteria). However, as previously stated, this may vary depending on each partner and country, for example, ethical committees may prefer for recruitment to occur outside of personal contacts. Although a range of channels will be used to recruit, the aim is for a large sample across transport modes. Therefore, there may be limitations in terms of choice of participants and final sample.

5.3 Participant screening

Screening is an important step to help ensure that that the participant sample matches the selection criteria. Typically, participants are asked to answer a series of questions which determine whether they are eligible to participate. Within the *i*-DREAMS project, it is proposed that a recruitment website will be developed, which contains all the necessary information for interested participants, and will include a web-based questionnaire which will collect relevant information from possible participants and can be used as a screening tool. However, it may be that additional screening measures will need to be applied, which are briefly outlined below.

5.3.1 Simulator sickness

As previously mentioned in section 2.1.7 of this deliverable, simulation sickness is an important consideration when conducting simulator trials. Therefore, participants will be screened for sickness throughout the simulator trials, and the trials will be stopped if symptoms of simulation sickness are apparent, or the participant reports feeling unwell.

5.3.2 Sleepiness and fatigue

Within the *i*-DREAMS project, the driver mental state is an important consideration and potential source of emerging risk, with interventions targeted at specific triggers. D2.1 (Kaiser et al., 2020) provided a review relating to measuring driver's mental state, including attention and distraction, fatigue and sleepiness, emotions and stress. As sleepiness and fatigue are important risk factors for driving, and of interest to the *i*-DREAMS project, it is important to collect data relating to these factors. The standardised and validated questionnaires listed below can be used, both to collect data during simulator experiments and field trials relating to sleepiness and fatigue, as well as for screening purposes.

Sleepiness

Epworth Sleepiness Scale (ESS)

The ESS (Johns, 1991) is a short questionnaire which aims to subjectively determine daytime sleepiness. Eight daytime scenarios are presented, and the participant scores the likelihood of falling asleep or dozing in each situation (0-3). Answers are totalled to provide a global score ranging from 0-24, with higher scores indicating higher levels of daytime sleepiness. The ESS is included in Annex E. The ESS could be used to screen participants for excessive daytime sleepiness and could also be used during the simulator and field trials as a single measure of daytime sleepiness, incorporated into the participant entry questionnaire (Annex H).

Pittsburgh Sleep Quality Index (PSQI)

The PSQI (Buysse et al., 1989) is a self-report questionnaire which assess sleep quality over the preceding month. The questionnaire relates to subjective sleep quality, efficiency, latency, duration, disturbances, daytime dysfunctions and use of medications. Participants are asked to provide answers on a Likert scale (0-3), which are analysed to provide a global score. A score of > 5 indicates poor sleep quality. The PSQI is included in Annex F. The PSQI could be used to screen participants for poor sleep quality.

Fatigue

As a general note, many scales and questionnaires which aim to measure fatigue are designed to measure chronic fatigue, or fatigue related to health conditions, rather than mental fatigue.

Fatigue Questionnaire

The Fatigue Questionnaire (Chalder et al., 1993) aims to measure the severity of physical and mental fatigue, primarily in individuals with Chronic Fatigue Syndrome. The questionnaire consists of 11 items related to physical (items 1-7) and mental (items 8-11) fatigue. However, scores can also be calculated separately. Higher scores indicate more fatigue. The Fatigue Questionnaire is included in Annex G. The questionnaire could be used as a screening tool for increased levels of fatigue and could also be used during the simulator and field trials as a measure of fatigue.

5.4 Participant retention

Participant dropouts are unavoidable and increase with the duration of the experiment. According to Thiese (2014), a drop-out rate of 20% of the participants can be expected for observational and interventional studies. In order to minimise dropouts, a dropout management strategy should be developed. A good dropout management strategy should consider points raised in section 4.3 of this deliverable and should be combined with an incentive strategy to keep participants motivated and engaged with the experiment. An incentive is especially important for experiments with a long duration. As stated in section 4.3, incentive strategies based on incremental payments are the best approach to reduce the dropout rate for experiments with a long duration and encourage participants to engage with the experiment until completion (Martin et al., 2017). With incremental payments, the incentive is usually paid at three times: start, middle and end of the experiment. In order to keep participants motivated during the whole experimental study period, a larger amount of money is allocated to the final payment compared to the initial and middle payments (Martin et al., 2017). Furthermore, incentives do not always have to be a monetary benefit. For short experimental studies, a gift voucher or certificate is enough to stimulate participation.

5.4.1 Participant retention strategy within *i*-DREAMS

Given that a dropout of participants is expected, the aim is to recruit 120 individuals for the simulator trials and 505 individuals for the field trials for further analyses. The individuals who participate in the simulator trials will not be eligible to participate in the field trials. In order to minimise dropouts, a participant management strategy based on the identified recommendations from previous studies will be developed for the simulator and field trial experiments. This will include a reserve list of participants who are interested in participating, to be used as back participants if individuals drop out.

For the simulator trials, drop out is likely to occur due to simulator sickness or withdrawal. For the field trials, it is assumed that dropout will be low during the pilot and baseline phases but may increase during the intervention phase. Therefore, it is proposed that if participants drop out in the first three weeks of the intervention phase, then they will be replaced (where possible). A potentially useful criterion to qualify participants as a ‘dropout’, could be a mode-specific combined time & distance criterion (e.g. for cars: three weeks + 300 kilometres driven, in the assumption that three weeks of active participation in the field trials allows sufficient data collection for statistical analysis). The fact that a three-week time period allows feedback-based interventions to generate impact has been demonstrated in several studies before. Indeed, previous work where naturalistic driving data was collected for participants using feedback intervention approaches, have shown that the impact on driving behaviour is largest in the short-term, without further drastic changes in terms of intervention impact in the longer term. Put differently, feedback interventions seem to induce impact on driver behaviour in the first three to four weeks (e.g., Toledo et al., 2008).

The incentive strategy is part of the participant management strategy which aims to further reduce the dropout rate. The incentives will be managed locally by the partner in each country responsible for conducting the simulator and field trial experiments, as the legal aspects for receiving incentives differ from country to country. However, in order to ensure some form of uniformity the following guidelines are defined for the field trial experiments:

- Monetary incentives should be provided for private car drivers.
- Drivers of professional vehicles (trucks, buses and rail) participating in the study will not receive an incentive from the *i*-DREAMS consortium as it is the truck/bus/rail company that will decide if their drivers participate or not. However, they will be required to go above and beyond their normal work activities. Therefore, the feasibility

of incentives for professional drivers is being investigated and would be dependent on company policy. The participation of these companies is based on prestige and creating a positive company image by participating in a project focusing on increasing road safety.

- The incentive strategy (amount, type of payment and payment periods) is specified in the participant agreement.
- The incentive budget of € 250 is fixed per car regardless of the number of drivers and will be paid incrementally. The participant will receive € 50 at the start, € 75 in the middle and € 125 at the end of the field trial. If participant's drop out, they will not be provided with further payment, however they will not be required to return previous payments.

Participants of the simulator trials for passenger cars will also receive an incentive in the form of a gift voucher, as their participation is limited to just one drive in the driving simulator. For professional drivers, this is dependent on specific recruitment strategy and company policy. Participants who take part in the pilot field trials will not receive an incentive.

6 Supplementary data collection

As part of the trials it will be important to collect certain information from participants which will aid in the analysis, interpretation and reporting of the results. This chapter briefly highlights two supplementary questionnaires which will be used as part of the trials, the participant entry questionnaire and the technology acceptance questionnaire, as well as several tests which could be used to test participant competency.

The recruited participants will be a diverse group of drivers, differing not only in nationality but a range of characteristics relevant for safe driving and interacting with the *i*-DREAMS intervention system. It is crucial to collect additional information from participants in order to consider these varying characteristics during the analysis and reporting of the results. This information will ultimately contribute to improving the *i*-DREAMS platform by either refining the STZ calculation, allowing for validation of inter-individual differences in the real-time measures or by facilitating the customisation of interventions. This therefore applies to all stages of the trials. Apart from the more obvious socio-demographic and basic driving variables such as age, gender, driving experience and attainment of the driving license, etc., certain additional topics should be covered, including competencies, personality traits, habitual driving behaviour, and health conditions and factors. While factors such as age or years of experience can simply be queried, latent constructs such as sensation seeking (personality) for example are inferred by applying validated, standardised scales which result in a score. Both, however, can be administered by having participants complete a questionnaire. Gaining information on certain competences or cognitive abilities requires testing the participants, which will be detailed in section 6.1.2 of this deliverable. For more details on the suggested questionnaires, scales and tests as well as for the reasoning behind suggesting collecting this type of information, see Kaiser et al., (2020).

6.1.1 Participant entry questionnaire

The full draft of the participant entry questionnaire can be found in Annex H and is to be completed at the start of the trials. It is formulated for car drivers and will require language adaptations and alterations for other modes. Table 11 below summarises the recommended information to be collected from participants.

Table 11: Recommendation of information to be collected by means of a questionnaire

Note. SD=Socio-demographic and related data, PT=Personality trait, DB= (habitual and past) Driving behaviour and driving record, HI=Health information.

	Variable, construct	Measurement tool	No. of items	Comments & recommendation
SD	Age	-	1	Query only if not available from recruitment process
SD	Gender	-	1	Query only if not available from recruitment process
SD	Attainment of driver license	-	1	- Query only if not available from recruitment process - Attainment of each type of licence for all groups
SD	Occupation	-	1	Query only if not available from recruitment process
HI	Shift working	-	1	
SD	Education	-	1	Query only if not available from recruitment process

SD	Professional driving	-	1	Query only if not available from recruitment process
SD	Yearly kilometrage	-	1	Query only if not available from recruitment process
SD	Frequency of driving	-	1	Query only if not available from recruitment process
SD	Driving record (accident involvement, offences)	-	2-4	Query only if not available from recruitment process
SD	Nationality	-	1	Query only if not available from recruitment process
SD	Cultural identity	SSVS (Short Schwartz's Value Survey)	10	- Lindeman & Verkasalo (2005) - Language: other language versions might already be available
DB	Speeding	ESRA2 questionnaire (adapted)	3	Meesmann et al. (2019)
DB	Forward collision avoidance	ESRA1 questionnaire (adapted)	1	Torfs et al. (2016)
DB	Fatigued driving	ESRA1/ESRA2 questionnaire (adapted)	2	Torfs et al. (2016), Meesmann et al. (2019)
DB	Distracted driving	ESRA2 questionnaire (adapted)	3	Meesmann et al. (2019)
DB	Aggressive driving	ESRA1 questionnaire (adapted)	3	- Torfs et al. (2016) - Language: other language versions available
DB	Avoidant behaviour		4	-
DB	Driving style		1	-
PT	Sensation seeking personality	BSSS (Brief Sensation Seeking Scale)	8	- Hoyle et al. (2002) - Language: other language versions might already be available
PT	Anger proneness	DAS (short form)	14	- Yasak & Esiyok (2009) - Language: other language versions might already be available
	Daytime sleepiness	ESS (Epworth Sleepiness Scale)	8	- Johns (1991) - Language: other language versions might already be available - Annex F
HI	Sleep quality	PSQI (Pittsburgh Sleep Quality Index	9	- Buysse et al., (1989) - Language: other language versions might already be available - Annex G
HI	Sleep quality, sleep apnea	Berlin Questionnaire ©	5-10	- Thurtell et al (2011) - Language: other language versions might already be available
HI	Neurological, musculoskeletal, cardio-vascular diseases	-	3	- -
HI	Hearing	-	1	-
HI	Sight	-	1	
HI	Medication relevant to driving	-	1	- -

HI	Medical condition relevant to driving			-

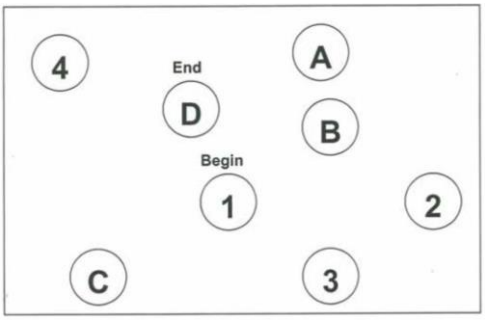
Aspects to be considered include:

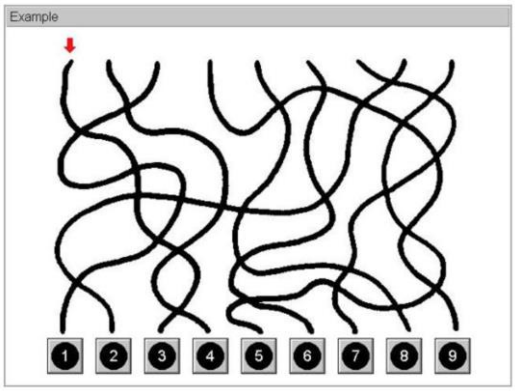
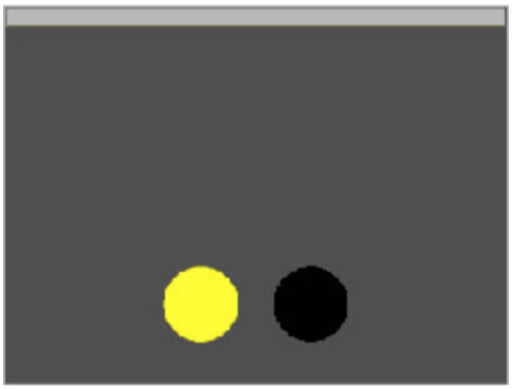
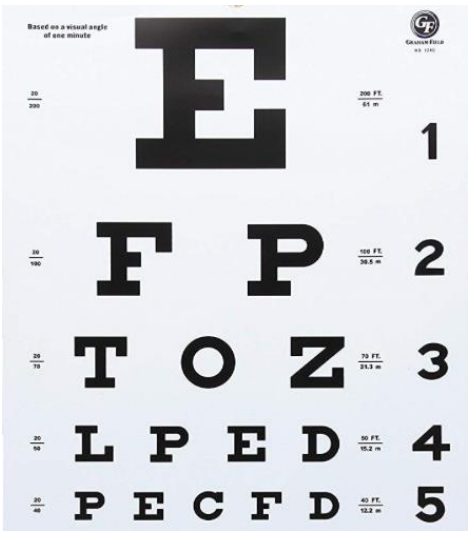
- Some of the information suggested in Table 11 may already be available from the recruitment process (age, gender etc.). Since the questionnaire is already extensive and participants will have to fill in many forms, it is important to avoid asking for information twice.
- The sequence as displayed in Table 11 is not finalised and therefore subject to change, however, the single items within a scale should remain contiguous since repeated changes of subjects may appear arbitrary to the participants.
- Some of the suggested scales have already been translated to other languages than English and corresponding research may be available. If research also provides measures of reliability and validity, the translations of those studies should be given priority over loose translation by the *i*-DREAMS partners.
- In case of aggregating the values of single items to the level of a scale, attention should be paid to the polarity of items since positively and negatively formulated items may aggregate to the same value. Furthermore, the overall direction of a scale has to be considered. High values may not always express the desirable behaviour/answer.
- As can be seen in the draft questionnaire in Annex H, the number of answer options can vary between the questions or scales. The advantage of maintaining this for the established scales (such as the ESS Annex E, or PSQI Annex F, for example) is that the validity and reliability scores as reported by the corresponding publications can be assumed.

6.1.2 Participant competency testing

Objectivity and validity are arguments for competency testing, compared to self-report data. The use of such tests is usually a trade-off between collecting interesting and relevant data that are not often considered in trials, and time restrictions and efficiency. Multiple additional questionnaires and pre-trial tests may appear off-putting to the participant and result in higher instances of dropouts. However, it is also important to ensure that participants are competently able to participate in the simulator and field trials. Table 12 contains a selection of recommended competency and capacity tests which could be used as part of the trials.

Table 12: Recommendation of information to be collected by means of a competency testing

Variable, construct	Measurement tool	Comments	Demonstration figures
Attention, executive control	Trail making test (Part B)	- 75 seconds (on average) - Language free (only to be adapted for Greek participants) - Test sheets can be printed out - No additional costs - Standardised instructions are to be accounted for	 http://www.nmr.mgh.harvard.edu/~bradd/Trail_Making_Test.pdf

		- See for demonstration figure for example - See e.g. Bowie & Harvey (2006) for instructions	
Visual orientation, selective attention	LVT (Visual Pursuit Test)	- 5-25 minutes - Available in all *i*-DREAMS languages - License costs have to be accounted for - Standardised instructions come with test license - Can be run on any standard computer - See Biehl (1996) for more information	 https://marketplace.schuhfried.com/en/LVT
Reactivity	RT (Reaction Test)	- 5-10 minutes - Available in all *i*-DREAMS languages - License costs have to be accounted for - Standardised instructions come with test license - Can be run on any standard computer	 https://lafayetteinstrumenteurope.com/product_detail.asp?ItemID=355
Visual acuity	Snellen E Chart	- 5 minutes - Available with Latin and Greek letters - Low cost (€10-20 pre piece) - Standardised instructions are to be accounted for	 www.amazon.com

Aspects to be considered:

- Competence or capacity testing requires standardised instructions throughout the different testing sites for the participants. A short training session for partners is advised to ensure consistency.
- Participants should be advised to arrive well rested.
- For simulator trials, a subset of competency testing could be conducted at the beginning of the trials.

6.1.3 Acceptance of *i*-DREAMS technology

Key to the success of the *i*-DREAMS platform is that drivers find the technology beneficial for their driving and safety. If drivers do not accept the interventions, whether in the form of information or suggestions and prompts, the technology will not increase the safety of drivers. The change (or absence of change) in driver behaviour in response to the interventions will be an indication of acceptance. However, this will not provide information on how the drivers feel about the *i*-DREAMS technology. Hence, the subjective assessment of drivers will be valuable additional information to keep improving the system.

Much of the respecting research has centred around the Technology Acceptance Model (TAM, Davis, 1989), which attempts to explain intention to use novel information technology. The principal predictors of intention to use are:

- Perceived ease of use.
- Perceived usefulness.

TAM has been adapted and used for in-vehicle monitoring and intervention technology, as well as advanced driver assistant systems (ADAS). Over time, many modifications of the TAM have been proposed, with additional factors dependent on the specific technology investigated. The Unified Model of Driver Acceptance (UMDA, Rahman et al., 2018), which is described in section 5.1 of D3.3 (Brijs et al., 2020), is viewed as a synthesis of the literature, integrating several individual theories, including TAM, the Theory of Planned Behaviour and the Unified Theory of Acceptance and Use of Technology. The most important additions to the model are trust, endorsement, compatibility and affordability.

For on-board monitoring systems in trucks, perceived usefulness resulted as the strongest predictor of intended use, which is in line with UMDA, although trust was also an important factor (Ghazizadeh et al., 2012). Osswald et al. (2012) proposed a Car Technology Acceptance Model (CTAM), which is based on the Unified Theory of Acceptance and Use of Technology (UTAUT). Their adapted and evaluated model highlights the importance of including the determinants anxiety and perceived safety.

Research of technology acceptance in the driving context mainly addresses real-time information and intervention systems as well as ADAS. Acceptance of post-trip intervention technology such as phone or web applications is not studied very well. However, TAM has also been applied to predict acceptance and use regarding health technology (e.g. Tao et al., 2020).

The items in Annex I are suggested to evaluate the *i*-DREAMS participants' acceptance of the technology. The items were adapted from Osswald et al. (2012) and Ghazizadeh et al. (2012) with the aim to better account for the *i*-DREAMS context. Since not all the items are applicable for the real-time and the post-trip intervention, an indication of which intervention questions apply to is provided. The technology acceptance questionnaires can be distributed at the end of the first intervention scenario and again following the second intervention scenario to explore how acceptance values change over time and with longer term use of the *i*-DREAMS technologies.

7 Ethical and legal considerations

The following section aims to provide an update on the ethical and legal considerations relevant to the *i*-DREAMS simulator and field trials. An overview of the ethical and legal issues was previously described in section 7 of D5.1 (Hancox et al., 2020). It is important that for all partners involved in the collection, handling and processing of data, the relevant data processing to personal data, and relevant data protection measures are applied, in accordance with General Data Protection Regulation (2016/679) and *i*-DREAMS privacy policy.

7.1 Ethical considerations

It is important that ethical considerations are considered when conducting simulator and field trials, and that appropriate ethical approval is received before trials are conducted. Each of the partners involved in the trials are required to obtain their institutions own ethical approval, which will vary from country to country. Below is an update for the ethics applications and approval status for each of the countries where trials will be conducted.

UK: Loughborough University still plans to submit the ethics application in two separate rounds, as recommended by the departmental ethics advisor, first for the simulator trials, and second for the field trials. The main reason for this is that the field trials may require full ethical approval which consists of submitting a full research proposal to the University ethics committee, rather than completing the standard checklist. The ethics advisor also advised to submit ethics applications once all the details of the trials had been finalised. However, during the COVID-19 pandemic, Loughborough University paused approvals on submissions involving human participants and therefore the ethics proposals have not yet been submitted to the University ethics committee.

BE: Research ethics approval for the simulator and field trials was provided by the Hasselt University Social-Societal Ethics Committee (SSEC) on 16th October, 2019 with reference REC/SMEC/JA/189-132. Considering the COVID-19 pandemic, no re-evaluation is needed for UHasselt. However, separate operational procedures to deal with participants in the driving simulator have been submitted, which include procedures on how to deal with social distancing and hygiene when working with participants. The board of directors have reviewed and accepted these procedures.

DE: The ethics application for the simulator study was submitted to the Ethikkomission der Technischen Universität München ethical committee on 17th February 2020. Subsequently, feedback and amendments were received. A revised ethical application was submitted and approved on 30th June 2020, reference number 78/20 S-KH. Once the details have been finalised, the ethics application for the field trials will be submitted. However, post COVID-19 implications may require additional considerations and risk assessments in relation to working with human participants.

EL: Ethical approval has been provided for the simulator and field trials by the National Technical University of Athens (NTUA) Ethics Committee of Research, on 14th April 2020, approval number 11771/10.03.2020. It is not predicted that further approval will be needed following the COVID-19 pandemic, however, further considerations and risk assessments may need developing for both stages of the trials.

PT: As no local research institution is involved in the Portuguese trial, the procedure to submit the project proposal for evaluation by a research ethics committee is less straightforward. One option would be to submit the ethics approval to the Clinical Research Ethics Committee (CREC). However, this would require detailed finalisation of the trials. Therefore, alternative approaches are being investigated. These will likely require a certain degree of involvement by a local university or research institute. Although the current pandemic may have an unexpected impact, it is thought that the ethics approval submission will be completed within the timeline initially determined at the beginning of the project.

7.2 Legal considerations

Legal issues and considerations were previously outlined in D5.1, identifying rules and regulations for each transport type in each country where the trials will operate. The FESTA handbook also highlights important legal considerations for trials, including:

- The participant has adequate insurance to be driving their vehicle especially when modifications have occurred due to the trial. This mainly relates to private car drivers where personal insurance needs to be checked to ensure that cover is still valid after the *i*-DREAMS system is fitted.
- A participant agreement is developed to formalise the relationship between the participant and trial partner or organisation. This should include: obligations, liabilities, insurance issues, information on the logging of personal data requiring informed consent, which parties will use the data, and data sharing after the project including the use of personal data (personal data will be anonymised and only used in the anonymised form after the project). Agreements such as this may need to be considered for each country separately.
- A protocol is developed for what happens in the event of a crash in terms of liability/ excess payment, speeding tickets, responsibility in the event of vehicle damage, and who is allowed to drive e.g. other household members.
- Protocols are established and information is provided to detail what happens to the data once the study finishes and who can access it.
- Privacy issues related to camera use (privacy, the recognisability of other road users and their registration numbers) are outlined.

The information below provides a brief update of any legal considerations that were detailed in D5.1 (Hancox et al., 2020).

General legal considerations

- No additional update

Steering wheel and heart rate monitor

- No additional update

Dash camera

- The dash camera will be permanently switched on however, will only record/save a specific situation when an event is detected and will blur faces/license plates so will be compliant with various regulations and data protection mechanisms.
- However, judiciary can request to view footage from the camera in the event of a crash, it should be noted that there may be situations where an event is not detected by

Mobileye either (either if the driver is too slow or there is not harsh braking/ acceleration) and therefore the video may not be recorded.

Mobileye warning system

- No additional update

Mobile phone application

- No additional update

OBD-II port interrogation

- No additional update

Insurance issues

- **UK:** Additional in-depth discussions still required with the Insurance Officer to ensure adequate cover from all fronts.
- **BE:** AXA Belgium has confirmed that as insurance company they fully support initiatives such as i-DREAMS to improve road safety and that under no circumstances the use in a vehicle insured by AXA Belgium of telematics devices, such as the i-DREAMS system, can justify the termination, nullification or admendment of an AXA car insurance contract concluded by i-DREAMS project participants. In case of an accident, the presence of telematics will not be used by AXA Belgium as a (unfavourable for the customer) motive to interfere in the claims management or nullify/amend the coverage detailed in the contract, for instance, decreasing the due allowance. UHasselt have also subscribed to a public liability insurance.
- **DE:** TUM is consulting with the legal office regarding public liability insurance. A first consultation revealed that TUM being a Bavarian University, Bavaria (in Germany) would usually be liable. In case the risk is assessed to be high, permission for liability insurance can be granted. This is under discussion.
- **EL:** Discussions with an insurance company relating to the procedure for field trials have taken place. No additional foreseeable issues other than those described from other partners are to be expected.
- **PT:** An in-depth assessment has been conducted by an insurance mediator to ensure that the installation and use of all components of the *i*-DREAMS system are in compliance with national and European legal provisions. The insurance mediator did not raise any additional questions and therefore no limitations regarding insurance are expected.

Implications for the study from legal considerations

Overall, the legal implications for the study outlined in D5.1 were:

UK:

- No foreseeable legal barriers to technology fitment or use.
- A recommendation that the creation of a project fact sheet detailing equipment, who to contact etc. to keep in the glovebox in case a participant is stopped and needs to explain the data.

- That equipment will require professional fitting. The dashcam and Mobileye must be placed so they do not obstruct vision within the 'swept area[10]' of the windscreen.
- A project wide data policy needs to be considered for if a dangerous driving is witnessed on the videos (there is no legal but perhaps moral obligation to hand over to authorities depending on frequency and severity).
- A project wide procedure is required for the request for footage by judiciaries.
- An explanation needs to be provided to the user about safe use of the installed equipment, especially when the vehicle is moving (i.e. systems do not replace driver's responsibility to observe the road and react accordingly, the driver should not rely too heavily on the system warnings, the *i*-DREAMS technology is only 'assistive').
- Any use in the rail sector is likely to require detailed risk assessments, control procedures put in place to minimise risk and union approval.

BE:

- No foreseeable legal barriers to technology fitment or use
- A recommendation that the creation of a project fact sheet detailing equipment, who to contact etc. to keep in the glovebox in case a participant is stopped and needs to explain the data.
- That equipment will require professional fitting. The dashcam and Mobileye must be placed so they do not obstruct vision within the 'swept area, CardioWheel must not be movable on the wheel (firmly attached) and no trailing wires to block drivers' movements.
- A project wide data policy needs to be considered for if a dangerous driving is witnessed on the videos (there is no legal but perhaps moral obligation to hand over to authorities depending on frequency and severity).
- A project wide procedure is required for the request for footage by judiciaries.
- An explanation needs to be provided to the user about safe use of the installed equipment, especially when the vehicle is moving (i.e. systems do not replace driver's responsibility to observe the road and react accordingly, the driver should not rely too heavily on the system warnings, the *i*-DREAMS technology is only 'assistive').

DE:

- Same as outlined above for UK and BE.

EL:

- Same as outlined above for UK and BE.
- No foreseeable legal barriers to technology fitment, however there is a need for professional fitting of most equipment

PT:

- Same as outlined above for UK and BE.
- To avoid hindering the voluntary recruitment process, the procedure for handling the detection and recording of illegal behaviours and dangerous driving should be transparent and the participants should be given information about applicable procedure (e.g. no action, communication between fleet manager/HR department and driver, handing over the data to competent authorities, etc.).

[10] Area cleared by windscreen wipers.

Driving abroad

In relation to participants driving abroad during the field trials, it will be asked of passenger car drivers to inform researchers of holidays or additional journeys which are not part of everyday driving. As the *i*-DREAMS technology is considered to be a standard type of ADAS, and will mainly involve a dash camera and Mobileye which are commercially and widely available, it is not known of any legal restrictions in member states of the EU which would prevent the use of the technology. As for professional drivers, they may typically make international trips as part of their standard journeys, and therefore will not be excluded from participating or prevented from making these trips during participation.

7.3 GDPR compliance

Certain aspects of the project will involve data protection and privacy issues. The trials outlined in this deliverable will result in data collection, including certain personal information. WP10 details the ethics requirements that the project must comply with, with all legal and ethical issues relevant to the project being identified in D10.1 (Cuenen & Ross, 2019). D1.2 (Brijs et al., 2019) specifies the data management plan, outlining procedures to ensure compliance with ethical considerations. The data handling lifecycle, including handling of data after completion of the project, collection and processing, sharing open access data and how data will be preserved is also described. Data security and protection, including GDPR compliance, personal data and anonymisation is detailed in section 5 of D1.2 (Brijs et al., 2019).

8 Summary and next steps

The main aim of this deliverable is to inform the planning and development of the simulator and field trials, which will be conducted as part of WP5. The purpose was to include best practice recommendations towards experimental protocols, specific to the context of *i*-DREAMS and the outline the development of high-risk scenarios which will be used to test the *i*-DREAMS platform. This deliverable builds on information provided in D5.1 (Hancox et al., 2020), and will be further expanded in future deliverables (D5.2 and D5.3) to provide detailed methodologies of both the simulator and field trials. As trials will be conducted across five countries and four transport modes, it is important to outline and develop protocols and checklists to ensure consistency in approach where possible.

As *i*-DREAMS is an ongoing project, decisions are made, and work is finalised at different stages. As such, the simulator trials are more developed compared to the field trials, which is reflected in this document. As one of the aims of the simulator trials is to test the *i*-DREAMS platform, the field trials will be further developed following the simulator trials and equipment finalisation.

It is crucial when designing simulator and field trials that aspects of experimental design, participant recruitment, timelines, ethical and legal considerations, procedures and protocols are considered. During the preparation of this deliverable, aspects relating to these factors have been researched and collated, and documentation of previous ND studies and FOTs have been analysed in order to identify all necessary steps and activities, to help prevent delays to the operational phase of the trials.

In relation to experimental design principles that were outlined in chapter 2, it was decided that the simulator trials would:

- Include a fractional factorial design where only a subset of all scenarios will be selected.
- Be a within-participant design.
- Include at least three scenarios, containing 1-2 risk factors. The trials will consist of a baseline scenario with no intervention, an intervention scenario with fixed timing warnings, and an intervention scenario with an added condition to produce variable timing warnings.
- Include several practice drives to familiarise participants to the simulator and reduce the chance of simulator sickness.
- Include multiple risk events in one scenario, increasing the within participant variability, statistical power of the study and efficiency of the study as well as reducing the overall number of trials.
- Include several separate events to capture each risk factor to ensure adequate validity of the observations.

The experimental designs provided in chapter 2, will provide a baseline for the simulator trials, these will be further developed and personalised for each transport mode and partners' area of interest. This will be used alongside the checklist of consideration, developed as part of this deliverable.

Chapter 3 detailed the development of the risk scenarios. It is important that these scenarios reflect realistic risks and are tailored to the specific transport modes. Although there may be similarities between the on-road vehicles, there are also differences in terms of their operations and target risks, and this should be reflected in the development of the scenarios. A series of risk factors, environments, events and data are to be used for the scenarios, specifically designed for each transport mode. The outlines provided here are to be further developed and finalised in preparation for the simulator trials, with more detail being provided in D5.2.

Similar to the considerations for the simulator trials, chapter 4 outlined considerations for the field trials. The aim of the field trials are to assess the effect of the interventions, developed as part of the *i*-DREAMS system, for both real time and post-trip warnings. Vehicles will be instrumented across several modes, which will then continue to operate as usual collecting data. Five vehicles per mode will be instrumented as part of the pilot trials. Then participants will be recruited to take part in the following two stages which include the baseline monitoring stage (with no intervention) and the testing of the intervention stage. The ultimate goal of the field trials is to successfully capture the necessary indicators, performance metrics and intervention characteristics that can assist in validating the STZ for each mode, and to select the most successful in-vehicle interventions.

It is important when designing trials to consider learnings from previously conducted FOTs and ND studies, summarised as part of this deliverable, to help avoid similar issues that may have been encountered. Key aspects of successful trials include a realistic and detailed plan of approach, a carefully considered recruitment strategy including incentive and drop-out plans, detailed vehicle instrumentation timetables and plans, efficient participant handling and support, and consideration of all necessary legal and ethical issues. Developing realistic timelines are also a critical step for both simulator and field trials. Broad timelines have been provided in previous deliverables, and chapter 4 of this deliverable includes an example of how this can be further developed for passenger car field trials. Timelines can also be developed alongside the checklist of considerations, to ensure that all stages and steps of the trials process are considered. Contingency should also be built into the timeline where possible.

By reviewing literature related to participant recruitment in previous studies, recommendations have been noted in relation to recruitment, sampling, screening and retention in chapter 5. It is acknowledged that recruitment is a lengthy process, and that certain barriers need to be addressed in order to have an efficient recruitment strategy, for example a balance between sampling strategies and target numbers, clear selection criteria and screening, and a participant management strategy focusing on incentives, drop-outs and retention. It is hoped that by taking these factors into consideration that adequate sample sizes will be achieved for both the simulator and field trials.

It is also important to collect certain information relating to participant characteristics, background, and opinions, to help inform the analysis, interpretation and reporting of the results of the trials. Chapter 6 briefly outlines elements of supplementary data collection, the participant entry questionnaire and the technology acceptance questionnaire, as well as several competency tests. It is vital that information such as this is captured consistently across all trials and transport modes, and the development of standardised questionnaires within this deliverable to help to ensure this.

Finally, it is important to gather all relevant information relating to legal and ethical issues prior to the start of the trials. The information provided in chapter 7 of this deliverable aims to summarise detail from D5.1 (Hancox et al., 2020), and provide additional update in preparation for the simulator and field trials. This information should be updated and reviewed whenever major decisions are made or finalised as part of the development of both the simulator and field trials.

8.1 Next steps

The information provided here will be developed further into a detailed methodology for the simulator and field trials, which will be described in D5.2, ‘Description of the driving simulator experiment for identifying Safety Tolerance Zones and performance of in-vehicle interventions’, and D5.3, ‘Description of on-road driving trials for identifying Safety Tolerance Zones and the performance of in-vehicle interventions.’ In terms of preparing for the trials, it is

important that the stages outlined in the checklists presented here are followed, ensuring that ethical and legal issues are resolved and in place for the start of participant recruitment, as well as the necessary protocols, procedures and screening questionnaires. The scenarios outlined as part of this deliverable will also need to be finalised for the simulator trials to ensure that the risks are specifically tailored to each transport mode, and that the *i*-DREAMS platform has been tested prior to the field trials. Realistic timelines will need to be developed specific to each of the trials conducted in the simulator and field trials. These can be developed alongside the checklists to ensure none of the stages are missed and that everything is in place and has been considered prior to the start of the trials.

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Annex A: Simulator trials considerations checklist

Consideration	Questions to ask
Pre-study	• Is there a timeline in place detailing the stages of the study and important milestones? • Have equipment needs and availability been checked? • Is ethical approval in place? • Have risk assessments been conducted? • Are there data protection protocols for the handling of personal information and confidentiality issues? • Are the research questions correctly translated into outcomes and predictors? • Are the target risk scenarios correctly defined to hypothesize the relationship between outcomes and predictors? • Are the target risk scenarios adjusted with respect to confounders and effect modifiers? • Are the target risks aligned with the result of the stakeholders' survey and the collection of crash statistics? • Will there be any mode specific issues or considerations to take into account? • Are there any issues with the technology recordings? • Is a data output received? • Do the data outputs go to the correct place / is the data being saved? • Will time be needed between the practice, baseline and intervention sessions to modify any equipment or settings?
Participants	• Are there GDPR protocols in place, including if a participant drops out and wants to remove their data? • What sample size will be required? • How will participants be recruited? Are there contingency plans or alternative sampling strategies in case recruitment numbers are not reached? • Is there an eligibility criteria? Are there any demographic targets in terms of age, gender etc? Define eligibility criteria. • How will participants be screened? • Will participant incentives be required? • What will happen if participants drop out and there are partial/incomplete data sets? • Are there information sheets and consent forms in place? Will repeat visit forms be required? • Will a participant agreement document be used? • Has a participant information pack been created, providing participants with contact information for emergencies, or a project fact sheet in case stopped and need to explain equipment?

Trial considerations	• Have the trials been correctly designed in terms of balance and orthogonality? • Will all participants drive all trials, or will participants be split into two categories so the trials are different per category? • Are risk scenarios and risky events randomised per trial? • Are additional neutral events included in the scenarios to prevent learning effects? • Is there a protocol in place in case participants suffer from simulator sickness? • How will the fatigue trials work for professional drivers? • Will there be any issues with collecting data across different countries? How do we ensure continuity? • IS there a plan for where to store the data? • How will we ensure information is translated properly to ensure the same level of understanding in each country? • What data collection measures will be used, including any additional questionnaires? • If using a shared facility, will the simulator need to be booked?
Practice drives	• How many practice drives are needed? • How long should the practice drives last? • How many (and which) risky events are needed to ensure drivers are fully familiar with the simulator during the practice drives? • Is the participant experiencing simulator sickness?
Baseline trials	• What baseline measures (risk scenarios) will be collected and recorded? • How long should the baseline simulator trials last? • How many events should be simulated per risk factor? • Are there other measures to be collected as part of baseline trials e.g. questionnaires etc? • Is data accurately recording? • Is the participant experiencing simulator sickness?
Intervention trials	• How long should the intervention trials last? • How many events with intervention should be simulated per risk factor? • How will the interventions be measured and tested? What will the data output be? • Is the technology working? • Are there other measures to be collected as part of the intervention trials, e.g. questionnaires before and after the intervention trial, user acceptance? • Is data accurately recording? • Is the participant experiencing simulator sickness?

Fatigue trials	• How long should the fatigue trial last to ensure drivers are fatigued? • Will drivers participate in the fatigue trials on the same day or on another day? • What is the protocol for professional drivers to drive the fatigue trial after their shift? • Are there assistance and first aid kits in place for fatigue trials? • Is data accurately recording? • Is the participant experiencing simulator sickness?
Post study	• How long will de-installation take? • What will happen to the simulator after the trials? • Will participant de-briefing take place face-to face/phone/via a questionnaire? Have de-brief forms been created?

Annex B: Crash type, manoeuvres and contributory factors

The following table has been informed by

- European Road Safety Decision Support System, SafetyCube (2018), in particular the risk factors associated with the specified accident scenarios.
- DaCoTA on-line manual for in-depth road accident investigators, DaCoTA (2012), in particular the GDV accident classification codes.
- Driver Reliability and Error Analysis Method manual (DREAM) v 3.2 (Ljung Aust et al., 2012).
- Eurostat (2020) and the European Union Agency for Railways (2016).

Crash type	*i*-DREAMS Safety Outcome	Specific manoeuvre/action	Additional factors
VRU (Pedestrian or Cyclist)	Frontal crashes - Vehicle to VRU Side crashes - Vehicle to VRU Rear crashes - Vehicle to VRU	Continue straight ahead Turn across traffic Turn with traffic Leave lane - change lane Leave lane - overtake Leave lane - unintentional Speed - excessive/inappropriate Harsh acceleration/deceleration Using road lane dedicated to other road user Red light running	Drink driving Distraction/Inattention Fatigue/sleepiness Poor visibility - darkness Poor weather conditions (strong wind/rain/snow) Sight distance Vehicle blind spot Disregard of right of way Misjudgement (self, others, situation) Observation errors
Stationary object (on road/track)	Frontal crashes - Vehicle to obstacle	Continue straight ahead Turn across traffic Turn with traffic Leave lane - overtake Leave lane - unintentional Speed - excessive/inappropriate Headway (close following)	Drink driving Distraction/Inattention Fatigue/sleepiness Poor visibility - darkness Poor weather conditions (strong wind/rain/snow) Sight distance Observation errors

		Harsh braking Harsh accelerating	
Single vehicle	Frontal crashes - Vehicle to obstacle Side crashes - Vehicle to obstacle Rear crashes - Vehicle to obstacle	Leave lane - unintentional Speed - excessive/inappropriate Harsh braking Harsh accelerating	Drink driving Distraction/Inattention Fatigue/sleepiness Poor visibility - darkness Poor weather conditions (strong wind/rain/snow) Misjudgement (self, others, situation) Sensation seeking Young driver (18-24)
Head on/oncoming traffic	Frontal crashes - Vehicle to Vehicle Side crashes - Vehicle to vehicle	Turn across traffic Leave lane - overtake Leave lane - unintentional SPAD/SPAS Wrong way driving	Drink driving Distraction/Inattention Fatigue/sleepiness Risky overtaking Misjudgement (self, others, situation) Sensation seeking
Rear end collision/same direction	Rear crashes - Vehicle to Vehicle	Continue straight ahead Turn with traffic Speed - excessive/inappropriate Headway (close following) Harsh braking Harsh accelerating SPAD/SPAS Speed (excessive/inappropriate)	Drink driving Distraction/Inattention Fatigue/sleepiness Sight distance Misjudgement (self, others, situation) Observation errors
Junction accident (no turning)	Frontal crashes - Vehicle to Vehicle Side crashes - Vehicle to vehicle Rear crashes - Vehicle to Vehicle	Continue straight ahead Leave lane - overtake Speed - excessive/inappropriate Headway (close following) Harsh braking Harsh accelerating	Drink driving Distraction/Inattention Fatigue/sleepiness Poor visibility - darkness Poor weather conditions (strong wind/rain/snow) Sight distance

	Frontal crashes - Vehicle to VRU Side crashes - Vehicle to VRU	SPAD/SPAS Red light running	Misjudgement (self, others, situation) Observation errors
Junction accident (turning)	Frontal crashes - Vehicle to Vehicle Side crashes - Vehicle to vehicle Rear crashes - Vehicle to Vehicle Frontal crashes - Vehicle to VRU Side crashes - Vehicle to VRU	Turn across traffic Turn with traffic Speed - excessive/inappropriate Headway (close following) Harsh braking Harsh accelerating SPAD/SPAS Red light running	Drink driving Distraction/Inattention Fatigue/sleepiness Poor visibility - darkness Poor weather conditions (strong wind/rain/snow) Sight distance Misjudgement (self, others, situation) Observation errors Elderly (65+)
Rollover (overturn) /Derailment	Rollover (overturn) /Derailment	Leave lane - unintentional Speed - excessive/inappropriate Harsh braking Harsh accelerating	Drink driving Distraction/Inattention Fatigue/sleepiness Poor weather conditions (strong wind/rain/snow) Misjudgement (self, others, situation) Sensation seeking Young driver (18-24)
Injury to passenger	Injury to passenger (public transport)	Harsh braking Harsh accelerating Wrong side door opening (train/tram) Trapping passenger in door & drag	Drink driving Distraction/Inattention Fatigue/sleepiness Misjudgement (self, others, situation) Observation errors

Annex C: Karolinska Sleepiness Scale (KSS)

KSS value	Verbal description
1	Extremely alert
2	Very alert
3	Alert
4	Fairly alert
5	Neither alert nor sleepy
6	Some signs of sleepiness
7	Sleepy, but no effort to keep awake
8	Sleepy, some effort to keep awake
9	Very sleepy, great effort to keep awake, fighting sleep

Åkerstedt & Gillberg, 1990

Annex D: Field trials considerations checklist

Consideration	Questions to ask
Pre-study	• Is there a timeline in place detailing the stages of the study and important milestones? • Have equipment needs and availability been checked? • Are specialist fitters required to instrument the vehicles? How long will this take? • Is ethical approval in place? • Have risk assessments been conducted? • Are there data protection protocols for the handling of personal information and confidentiality issues? • Have insurance issues been considered?
Pilot on-road study	• How long will fitting the technology take? • Will there be any mode specific issues or considerations to take into account? • Are there any issues with the technology recordings? • Is a data output received? • Do the data outputs go to the correct place / is the data being saved? • Will time be needed between the pilot and baseline to modify any plans and adapt timelines?
Participants	• Are there GDPR protocols in place, including if a participant drops out and wants to remove their data? • What sample size will be required? • How will participants be recruited? Are there contingency plans or alternative sampling strategies in case recruitment numbers are not reached? • Is there an eligibility criteria? Are there any vehicle specific constraints that need to be considered? Are there any demographic targets in terms of age, gender etc? • How will participants be screened? • Will participant incentives be used? • What will happen if participants drop out and there are partial/incomplete data sets? • Are there information sheets and consent forms in place? Will repeat visit forms be required? • Is there a main contact for participants to keep in touch with during the trials? Who is organising the participants? • Will a participant agreement document be used? • Has a participant information pack been created, providing participants with contact information for emergencies, or a project fact sheet in case stopped and need to explain equipment?
Trial considerations	• Is there a protocol for if equipment is lost or damaged during trials?

	• Is there a protocol in place in case participants are involved in an accident or incident? • Depending on time of year, will weather be a factor? • Will there be any issues with collecting data across different countries? How will we ensure continuity? • How will we ensure information is translated properly to ensure the same level of understanding in each country? • What data collection measures will be used including any additional questionnaires? • Can data be collected from multiple drivers in one instrumented vehicle? • Where will data be stored?
Baseline trials	• Have risk assessments been conducted? • Is there a testing protocol in place? • What baseline measures will be collected and recorded? • How long are baseline measures being collected? (how many trips/days)? • Are there other measures to be collected as part of baseline trials e.g. questionnaires etc? • Is data recording accurately?
Intervention trials	• Have risk assessments been conducted? • Is there a testing protocol in place? • Will vehicles need to return to base for technology to be switched on manually or can this be done remotely? • How long will the intervention trials be? Is there a timeline? • Will there be specific non-safety critical scenarios to test? • How will the interventions be measured and tested? What will the data output be? • Is the technology working? • Are there other measures to be collected as part of the intervention trials, e.g. questionnaires before and after the intervention trial, user acceptance?
Post study	• How long will de-installation take? • What will happen to the technology after the trials? • Is the post-trip feedback protocol established? How will information be provided to the participants? • Will participant de-briefing take place face-to face/phone/via a questionnaire? Have de-brief forms been created?

Annex E: Epworth Sleepiness Scale

Epworth Sleepiness Scale (ESS)

Name: _____ Today's date: _____

Your age (Yrs): _____ Your sex (Male = M, Female = F): _____

How likely are you to doze off or fall asleep in the following situations, in comparison to feeling just tired?

This refers to your usual way of life in recent times.

Even if you have not done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the **most appropriate number** for each situation:

0 = would **never** doze
1 = **slight chance** of dozing
2 = **moderate chance** of dozing
3 = **high chance** of dozing

It is important that you answer each question as best as you can

Situation	**Chance of Dozing (0-3)**
Sitting and reading _____	
Watching TV _____	
Sitting still in a public place (e.g., a theatre, a cinema or a meeting) _____	
As a passenger in a car for an hour without a break _____	
Lying down to rest in the afternoon when circumstances allow _____	
Sitting and talking to someone _____	
Sitting quietly after a lunch without having drunk alcohol _____	
In a car or a bus while stopped for a few minutes in traffic _____	

THANK YOU FOR YOUR CO-OPERATION

Annex F: Pittsburgh Sleep Quality Index

Participant Initials ID# Date Time

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

f) Feel too cold

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

g) Feel too hot

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

h) Had bad dreams

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

i) Have pain

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

j) Other reason(s), please describe_____

_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

10. Do you have a bed partner or room mate?

No bed partner or room mate _____

Partner / room mate in other room _____

Partner in the same room, but not the same bed _____

Partner in the same bed _____

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Episodes of disorientation of confusion during sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Other restlessness while you sleep; please describe

_____

_____

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

Thank you

Annex G: The Fatigue Questionnaire

14-Item fatigue scale

Physical symptoms:

1. Do you have problems with tiredness?
2. Do you need to rest more?
3. Do you feel sleepy or drowsy?
4. Do you have problems starting things?
5. Are you lacking in energy?
6. Do you have less strength in your muscles?
7. Do you feel weak?

Mental symptoms:

8. Do you have difficulty concentrating?
9. Do you have problems thinking clearly?
10. Do you make slips of the tongue when speaking?
11. How is your memory?

Thank you

Chalder, T., Berelowitz, G., Pawlikowska, T., Watts, L., Wessely, S., Wright, D., & Wallace, E. P. (1993). Development of a fatigue scale. Journal of psychosomatic research, 37(2), 147-153.

Annex H: *i*-DREAMS participant entry questionnaire

Example participant questionnaire for entry into the trials - for car drivers

Participant ID: Date:

Many thanks for your willingness to contribute to this research by participating in the *i*-DREAMS trials. In order to meaningfully analyse the data, we will record from the vehicle, some additional information about your person is required. To this end it is important that you carefully answer all of the questions as best as you can. Some questions refer to driving and traffic, others refer to your person in general. At no time, there will be a connection made between the information you provide and your person. Thank you for your support!

Year of birth:

Gender: ❒ Female ❒ Male ❒ Other

Height:

Weight:

Nationality:

Year of attaining driver license (category B):

Are you holding any other driver license categories?

❒ yes, if yes, please detail:
❒ no

Highest level of education:

Current (main) occupation:

❒ Student
❒ Trainee
❒ Unskilled labourer
❒ Skilled worker / technician
❒ Executive employee
❒ Freelancer / self-employed
❒ Job applicant / seeker
❒ Parental / educational leave
❒ Stay at home caretaker
❒ Retiree
❒ Primary carer
❒ Other

Are you at least sometimes working in night shifts: ❒ Yes ❒ No

Do you drive on a regular basis during your work: ❒ Yes ❒ No

If yes, which type of vehicle are you driving for work:

❒ Car ❒ Light good vehicles ❒ Heavy good vehicle ❒ City Bus
❒ Coach ❒ Train ❒ Tram ❒ Other:

How many kilometres do you driver for work on average per year?
❒ up to 5,000 km
❒ 5 to 10,000 km
❒ 10 to 15,000 km
❒ 15 to 20,000 km
❒ more than 20,000 km

How many kilometres do you drive with your private car on average per year?

❒ up to 5,000 km
❒ 5 to 10,000 km
❒ 10 to 15,000 km
❒ 15 to 20,000 km
❒ more than 20,000 km

How often do you use your private car?

❒ (almost) daily ❒ A few times per week
❒ A few times per month ❒ A few times per year

Do you use your private car for work? ❒ Yes ❒ No

Do you currently use any Advanced Driver Assistant Systems (ADAS), for example lane detection warning?

❒ Yes. If yes, please detail which systems:

❒ No

Within the last three years, have you been involved in an accident with your private or professional vehicle where you were considered you to be at fault?

❒ Yes, once ❒ Yes, two times ❒ Yes, three or more times ❒ Never

If yes, how sever was this accident / were these accidents?

	Accident 1	Accident 2	Accident 3
Material damage only	❒	❒	❒
At least one person (including you) was mildly injured (no hospitalisation).	❒	❒	❒

At least one person (including you) was severely injured or killed.	❒	❒	❒

Within the last three years, have you been fined for a traffic offence?

❒ Yes ❒ No

If yes, for which offence have you been fined within the last three years? Multiple answers are possible.

❒ Speeding
❒ Forward collision avoidance (tailgating)
❒ Running a stop sign
❒ Not stopping at a pedestrian crossing
❒ Driving under the influence
❒ Running a traffic light
❒ Running a yielding sign
❒ Other:

Please rate the importance of the following values as a life-guiding principle for you. Use the 8-point scale in which:

- 0 indicates that the value is opposed to your principles and
- 8 indicates that the value is of supreme importance for you.

Power (social power, authority, wealth)	0	1	2	3	4	5	6	7	8
Achievement (success, capability, ambition, influence on people and events)	0	1	2	3	4	5	6	7	8
Hedonism (gratification of desires, enjoyment in life, self- indulgence)	0	1	2	3	4	5	6	7	8
Stimulation (daring, a varied and challenging life, an exciting life)	0	1	2	3	4	5	6	7	8
Self-direction (creativity, freedom, curiosity, independence, choosing one's own goals)	0	1	2	3	4	5	6	7	8
Universalism (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection)	0	1	2	3	4	5	6	7	8
Benevolence (helpfulness, honesty, forgiveness, loyalty, responsibility)	0	1	2	3	4	5	6	7	8
Tradition (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty)	0	1	2	3	4	5	6	7	8
Conformity (obedience, honoring parents and elders, self- discipline, politeness)	0	1	2	3	4	5	6	7	8
Security (national security, family security, social order, cleanliness, reciprocation of favors)	0	1	2	3	4	5	6	7	8

Please estimate: over the last year, how often did you as a car driver …

	never				(almost) always

… drive faster than the speed limit inside built-up areas?	1	2	3	4	5
… drive faster than the speed limit outside built-up areas (other than motorways/freeways)?	1	2	3	4	5
… drive faster than the speed limit on motorways/freeways?	1	2	3	4	5
… drive when you were so sleepy that you had trouble keeping your eyes open?	1	2	3	4	5
… realize that you were actually too tired to drive?					
… talk on a hand-held mobile phone while driving?	1	2	3	4	5
… talk on a hands-free mobile phone while driving?	1	2	3	4	5
… read a text message/email or check social media (e.g. Facebook, twitter, etc.) while driving?	1	2	3	4	5
… drive without respecting a safe distance to the car in front?	1	2	3	4	5
… driver aggressively?	1	2	3	4	5
… driver dangerously?	1	2	3	4	5

Please indicate to which extent you agree with the following statements.

	Strongly disagree	Disagree	Nether disagree nor agree	Agree	Strongly agree
I try to avoid driving in the dark.					
I try to avoid driving in urban areas.					
I try to avoid using highways / motorways.					
I try to avoid driving in bad weather.					

Please select with which of the following driving styles you identify the most.

❒ discreet, average driver
❒ less experienced, hesitant driver
❒ sportive, ambitioned driver
❒ risk-taking, offensive driver

Please indicate to which extent you agree with the following statements.

	Strongly disagree	Disagree	Nether disagree nor agree	Agree	Strongly agree
I would like to explore strange places.					
I get restless when I spend too much time at home.					
I like to do frightening things.					

I like wild parties.					
I would like to take off on a trip with no pre-planned routes or timetables.					
I prefer friends who are excitingly unpredictable.					
I would like to try bungee jumping.					
I would love to have new and exciting experiences, even if they are illegal.					

Please indicate how angry you would feel if you came across the following situations while driving.

	Not angry	Slightly angry	Angry	Very angry	Extremely angry
Someone is driving too slowly in the passing lane holding up traffic.					
Someone is weaving in and out of traffic.					
Someone is driving slower than reasonable for the traffic flow.					
A slow vehicle on a mountain road will not pull over and let people by.					
Someone runs a red light or stop sign.					
Someone coming toward you at night does not dim their headlights.					
At night someone is driving right behind you with bright lights on.					
Someone speeds up when you try to pass them.					
Someone is slow in parking and holding up traffic.					
Someone pulls right in front of you when there is no one behind you.					
Someone makes an obscene gesture toward you about your driving.					
Someone is driving way over the speed limit.					
Someone yells at you about your driving.					
A truck kicks up sand or gravel on the car you are driving.					

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?

This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you.

	Would never doze	Slight chance of dozing	Moderate chance of dozing	High chance of dozing
Sitting and reading				

Watching TV				
Sitting, inactive in a public place (e.g. a theatre or a meeting)				
As a passenger in a car for an hour without a break				
Lying down to rest in the afternoon when circumstances permit				
Sitting and talking to someone				
Sitting quietly after a lunch without alcohol				
In a car, while stopped for a few minutes in the traffic				

Do you snore? ❒ Yes ❒ No ❒ I don't know

If yes, your snoring is
- ❒ Slightly louder than breathing
- ❒ As loud as talking
- ❒ Louder than talking

If yes, how often do you snore?
- ❒ Almost every day
- ❒ 3-4 times per week
- ❒ 1-2 times per week
- ❒ 1-2 times per month
- ❒ Rarely or never

If yes, has your snoring ever bothered other people?
- ❒ Yes
- ❒ No
- ❒ I don't know

Has anyone noticed that you stop breathing during your sleep?
- ❒ Almost every day
- ❒ 3-4 times per week
- ❒ 1-2 times per week
- ❒ 1-2 times per month
- ❒ Rarely or never

How often do you feel tired or fatigued after your sleep?
- ❒ Almost every day
- ❒ 3-4 times per week
- ❒ 1-2 times per week
- ❒ 1-2 times per month
- ❒ Rarely or never

During your waking time, do you feel tired, fatigued or not up to par?
- ❒ Almost every day
- ❒ 3-4 times per week
- ❒ 1-2 times per week

❒ 1-2 times per month
❒ Rarely or never

Have you ever nodded off or fallen asleep while driving a vehicle?
❒ Yes ❒ No

If yes, how often does this occur?
❒ Almost every day
❒ 3-4 times per week
❒ 1-2 times per week
❒ 1-2 times per month
❒ Rarely or never

Do you have high blood pressure? ❒ yes ❒ no

Do you have any diseases of the following categories that you are aware of?
If yes, which ones?
❒ Neurological:
❒ Muscles, skeletal:
❒ Cardio-vascular:
❒ Vision:
❒ Hearing:
❒ No known diseases

Have you ever been diagnosed with a disorder or condition which affects your sleep, e.g. obstructive sleep apnoea?
❒ Yes. If yes, please detail which condition:
❒ No

Have you been diagnosed with any medical condition which may impact your driving?
❒ Yes. If yes, please detail:
❒ No

Do you currently take any medication which are known to influence driving?
❒ Yes. If yes, please detail:
❒ No

Thank you for supporting the *i*-DREAMS research by taking the time to answer the questions!

Annex I: Technology acceptance questionnaire

Technology acceptance questionnaire

Please think about the [in-vehicle information and prompts that were presented to you during driving] / [the intervention platform].

To which extent do you agree or disagree with the following statements (Strongly Disagree', 'Disagree', 'Slightly Disagree', 'Neutral', 'Slightly Agree', 'Agree' or 'Strongly Agree')

Construct / items	Real-time intervention	Post-trip intervention
Performance expectancy *		
The system is useful while driving.	x	
Using the system increases my driving performance.	x	x
If I use the system, I will reach my destination safely.	x	
Ease of use / effort expectancy		
My interaction with the system is clear and understandable. *		x
It was easy for me to become skillful at using the system. *		x
I find the system easy to use. *		x
Learning how to operate the system is easy for me. *		x
I think the i-DREAMS system is easy to use +	x	
I think the i-DREAMS system is easy to understand +	x	
I think the i-DREAMS system is annoying +	x	
Attitude towards using technology *		
Using the system is a good idea.	x	x
The system makes driving more interesting.	x	x
Interacting with the system is fun.		x
I like interacting with the system.		x
Social influence *		
I would be proud to show the system to people who are close to me.	x	x
People whose opinions are important to me would like the system too.	x	x
In general, people who I like would encourage me to use the system.	x	x
Facilitating conditions *		
While using the system I can maintain safe driving behavior.	x	
I have the knowledge necessary to use the system.		x
Self-efficacy * I could complete a task or activity using the system ...		

Construct / items	Real-time intervention	Post-trip intervention
... if there was no one around to tell me what to do.		x
... if I could call someone for help if I got stuck.		x
… if I had a lot of time.		x
… if I had just the built-in help facility for assistance.		x
Anxiety *		
I have concerns about using the system.	x	x
I think I could have an accident because of using the system.	x	
The system is somewhat frightening to me.	x	
I fear that I do not reach my destination because of the system.	x	
I am afraid that I do not understand the system.	x	x
I am confident that the system does not affect my driving in a negative way.	x	x
Perceived Safety *		
I believe that using the system information is dangerous.	x	
Using the system information requires increased attention.	x	
The system distracts me from driving.	x	
I feel save while using the system information.	x	
Using the system information decreases the accident risk.	x	x
I can use the system information without looking at it.	x	
Perceived Usefulness + I think using the i-DREAMS system ...		
... makes me a safer driver.	x	x
... makes it easier to drive.	x	x
... makes me more aware of my surroundings (other vehicles, lane position, etc.).	x	
... reduces distractions.	x	x
... improves my driving.	x	x
Trust +		
I trust the information I receive from the i-DREAMS system.	x	x
I think I can depend on the i-DREAMS system.	x	
I will feel more comfortable doing other things (e.g., adjusting the radio) with the i-DREAMS system.	x	
Behavioral Intention to Use +		
If I had a choice, I would continue to use the i-DREAMS system.	x	x
I would recommend the i-DREAMS system to other drivers.	x	x

* adapted from Osswald et al. (2012) and Ghazizadeh et al. (2012)