# 3.2 Toolbox of recommended data collection tools and monitoring methods and a conceptual definition of the Safety Tolerance Zone.

The Safety Tolerance Zone (STZ) is the core concept of the i-DREAMS project. This report conceptualizes the STZ in a practical way, which led to the theoretical framework for operational design described in D3.1. In WP4, this will then be further developed into a fully functional methodology to be implemented in the experimental set-ups. This means that three things come together in this report: the list of available technologies, the factors and indicators to be monitored ideally (described in D2.1) and the translation of the measurements into meaningful STZ levels that trigger interventions (described in D2.2). Furthermore, in this report we ultimately aim to provide a toolbox containing a list of feasible options with the most useful tools for data collection and monitoring, together with the suggestion of a mathematical framework to realise the STZ in real-life driving situations.

As for the most advanced measurement tools, several physiological and behavioural indicators, such as distraction/attention, fatigue, emotions or forward collision warning, are proposed for real-time processing, while performance measures, such as speeding, accelerating too fast, braking too hard or risky driving times, are also listed for post-trip processing.

Since several aspects related to the actual driving context (e.g. driver stress, time schedules, workload, frustration) may explain why drivers deviate from their "normal" driving style by accepting higher risks and engaging in more risky driving behaviour (e.g. speeding, accelerating too fast, dangerous overtaking), the identification and detection of abnormal driving practices becomes one of the most relevant aspects for the STZ estimation.

In this report recommendations are made for measurements of driver, vehicle and environment monitoring to estimate the STZ. Based on these recommendations, a list of thresholds for measurements to detect STZ levels and abnormal driving behaviour is provided. The main part of this deliverable is dedicated to the mathematical modelling of the STZ, where different methodological formulas are given to convert the available measurements into meaningful information about the level of driving safety. Finally, practical conclusions are drawn and recommendations are made for the next steps of the project.

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**The principle behind the STZ is that the system triggers warnings in real-time (and post-trip) in case danger is imminent. One of the aspects I read about in the report that determines whether or not an intervention is necessary, is the driver state. What exactly are you considering when you talk about driver state?**

EVA MICHELARAKI: *"There is no universal concept or standard definition of driver state. However, it is perceived as the current condition that can change continuously. When we talk about driver state, one can consider safety relevant cognitive aspects (like attention, fatigue, workload) and emotional aspects (such as arousal and stress), while complex interactions occur between those two categories. Emotions, for example, can shift a driver's attention and disrupt his focus."*


**How will you monitor this driver state in i-DREAMS?**

EVA MICHELARAKI: *"By measuring constituent constructs as opposed to measuring one aggregated mental state. To be able to provide appropriate and necessary real-time and post-trip interventions, we focus on distraction, fatigue and sleepiness. Reliability, intrusiveness and validity of the different measurement methods are a major concern. Therefore, multiple physiological/behavioural measurement methods are used."*

**What is the role of a driver's personal traits and characteristics in relation to his/her mental state while driving?**

EVA MICHELARAKI: *"Factors such as personality traits, driving experience or health status are known to affect driving safety, but they are relatively stable over time. As traits and driver characteristics are mostly "static", in terms of one-off measurements, traits and driver characteristics will not be considered for triggering interventions but may be used to influence the warning timing of particular interventions (e.g. age and gender are known to affect fatigue) and several constructs are also interesting to analyse later in relation to driving behaviour. The relevant constructs and variables pertain to the following categories: competences, personality traits, habitual behaviour, health condition and factors, socio-demographic factors. Most of the factors will simply be queried in a questionnaire (age, year of obtaining driving permit etc.)."*

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**Are there other things that will determine when a warning should be triggered to the driver, besides his/her mental state and personal characteristics?**

CHRISTOS KATRAKAZAS: *"Yes, definitely. There are several context (environment) variables known to impact task complexity, such as road layout, weather, traffic conditions as well as time of day. All these factors can be measured with equipment available to the consortium (e.g. with an intelligent camera). With regard to physiological and behavioural measures, the number and duration of eye fixations as well as cardiac measures are the most reliable indicators. While the latter is recorded by the CardioWheel or with a wristband, a supplementary vision-based recording device would improve reliability and validity. Although for financial reasons, the latter was not possible to include. In the report we have provided a detailed overview of available technologies (provided by our tech partners OSeven PC and CardioID)."*

**In the report detailed overviews are provided of available measurements in the different modes: cars, trucks, buses, trams and trains. What do all the measurements have in common?**

CHRISTOS KATRAKAZAS: *"Driver and vehicle monitoring equipment should require as less attentional or physical effort as possible to avoid drivers to be distracted or burdened. Measurement technology should preferably be powered by the vehicle and switched on and off automatically at the beginning and end of trips. The exchange of data (wired or wireless) between sensors and control units should take place without manual intervention of the driver. Monitoring technology must support the identification and prediction in real-time of risky events (e.g. dangerous headway) and must provide relevant data to trigger real-time in-vehicle safety related interventions (warnings), as well as feed post-trip interventions. Monitoring equipment should not interfere with normal operations while driving to avoid distraction, physical and visual obstruction which could lead to safety-related or ergonomic adverse outcomes. Monitoring equipment should enable faultless identification of the driver, especially when multiple drivers may operate the same vehicle. Monitoring equipment should also achieve high accuracy and low latency levels in terms of the real-time identification of relevant driver behavioural constructs, such as fatigue and distraction. Otherwise, the detection of such events may not allow for timely in-vehicle interventions. And lastly, expensive investments in driver monitoring technologies are unacceptable. The selection of driver monitoring technologies should find a good balance between effectiveness and cost, taking the commercial context into account after the project. Transport companies and public service operators work in a highly competitive market with low profit margins. For example, the large-scale adoption of after-market eye tracking technology, although potentially very effective to measure driver distraction and fatigue, is not acceptable in a practical (commercial) setting as long as these technologies require significant investments (in the order of several thousands of euros per vehicle)."*

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**What do all these principles imply for i-DREAMS?**

CHRISTOS KATRAKAZAS: *"It implies that we came to a final selection of the technology we use to monitor everything in the vehicles according to these principles. These technologies are described in the report. I think it will take us too far to go into everything in detail. Nevertheless, the challenge will mainly be in retrofitting the technologies in the different vehicles and the correct use of the technology."*

**Can you elaborate a bit more on these challenges?**

CHRISTOS KATRAKAZAS: *"Yes, I will try to illustrate what I mean precisely. CardioWheel for example can be installed as steering wheel cover or directly upholstering the steering wheel. Car owners prefer to keep the touch and feel of their luxury steering wheel, so adding a cover on top of the existing steering wheel is usually not accepted by car drivers. This is different for trucks and buses that usually have a less luxurious steering wheel, hence for CardioWheel trucks and buses were selected. Also, battery life can be an issue. And the overall quality of the CardioWheel data depends on the user cooperation since both hands are required to be on the wheel! Mobileye, one of the smart cameras we use, can be installed in almost all existing vehicles, but installation effort can differ significantly from vehicle to vehicle, specifically regarding the connection with vehicle CAN signals. We will restrict some vehicle models, if we are able to recruit a sufficient number of participants. Regarding the use of OBD-II monitoring devices, the compatibility is guaranteed with almost all light vehicles, but for trucks and buses, there are variations that may lead to the impossibility to read all the available information. Additionally, regarding the vehicles' warranty and the liability associated with the installation process, special care is being taken to devise a minimally invade installation procedure. Another crucial aspect is the proper determination of the driver identity… Well, I think I have made my point. The list of challenges is even a bit longer than what I have just explained, but we are prepared for each of the challenges on the list."*

**In the introduction section of the report, I could read that the main part of this paper is dedicated to the mathematical modelling of the STZ. We have not yet talked about this. What needs to be considered when modelling the STZ?**

EVA MICHELARAKI: *"Since the STZ triggers both real-time as well as post-trip interventions, we knew that we would have to consider both dynamic and static modelling approaches. Static modelling is more rigid than dynamic modelling as it is a time independent view of a system. It cannot be changed in real time and this is why it is referred to as static modelling. Dynamic modelling is flexible as it can change with time as it shows what an object does with many possibilities that might arise in time."*

**What mathematical models will you use to model the STZ?**

EVA MICHELARAKI: *"For modelling collision risks in real-time, Dynamic Bayesian Networks (or DBNs) and Long Short-Term Memory networks (or LSTMs) appear to be the most suitable. But for making post-trip evaluations, we turned to two other approaches: the Structural Equation Models (SEMs) and the Discrete Choice Models (DCMs). DBNs and LSTMs were chosen due to their efficiency and flexibility in real-time predictions, whereas SEMs and DCMs were chosen as they can enable explanatory analysis on precursors of the STZ levels. Although a dynamic DCM can be formulated, real-time efficiency might arise as a problem and in that case, DCMs are going to be implemented statically. We will use both dynamic (online) and static (offline) prediction techniques: to enable for flexibility with regards to the technical implementation of*

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*the model and to exploit the online/offline characteristics for the activation of real-time/post-trip interventions. For all the proposed approaches, a labelled dataset is needed for training and this should be taken into consideration for the data collection. Furthermore, we will also "translate" the mathematical models into code, so that they are ready for technical implementation. Lastly, we will test, calibrate and enhance the mathematical models during the simulation and on-road experiments to assure a sufficient and efficient data collection as well as timely initiation of the interventions."*

This all sounds very technical, so I don't think I will go into this in more detail. Thank you both very much for talking with me and for explaining to me what work you have done in deliverable 3.2.

Edith Donders

i-DREAMS DisCom manager

**Deliverable 3.2 is part of WP3:**
***Operational design of i-DREAMS***
Download the report here

# Researcher in the spotlight

**EVA MICHELARAKI**

Graduated as *civil engineer* in *2019*

Employed at *National Technical University of Athens* since *2019*

Passionate about *tennis and piano*

Tasks in i-DREAMS:
*Participation on the analysis of risk factors and the evaluation of safety interventions*

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