D2.2 Technologies for safety interventions and assessment of their effectiveness.

The key output of the i-DREAMS 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. As a first step towards developing the i-DREAMS intervention strategy, **this deliverable aims at reviewing vehicle technologies and applications for safety interventions associated with risk prevention and mitigation.** This is achieved by critically comparing and contrasting existing systems and technologies to inform road users either in real-time or post-trip. This report thus aimed to provide technologies for safety interventions and select the criteria of the most appropriate techniques and challenges. Furthermore, the assessment of their effectiveness, reliability an acceptance is also discussed, taking into account cross-modal considerations and differences between professional and non-professional drivers.

Hello Christos, in the report you reviewed technologies and applications for safety interventions associated with risk prevention and mitigation. Can you explain how we need to understand 'safety interventions' in this context?

CHRISTOS KATRAKAZAS: *"A safety intervention is a set of information, guidance, warnings, feedback or notifications that a driver receives, during or after a trip. The intervention is based on a personal driving performance. Such interventions are developed to prevent drivers from driving in a risky way and to decrease the collision rate or the probability of occurrence of crashes, damages, costs and injuries. Real-time interventions are triggered while driving when specific dangerous conditions arise. They are often provided as visual, auditory or haptic warnings and they are used to maintain and increase the safety and comfort level of a driver. Post-trip interventions provide feedback after a trip. They are based on the principle that a driver self-monitors his/her driving history, identifies behavioral weaknesses and sets goals to gradually build up driving skills. The aim of such retrospective approach is to change driver's behavior, and keep them motivated to drive safer and more eco-efficient over a longer period of time."*

Can you explain what aspects of driving behavior are targeted with real-time interventions and what aspects are targeted with post-trip interventions?

CHRISTOS KATRAKAZAS: *"Real-time interventions are usually targeted at aspects of mental state such as fatigue, drowsiness, attention or distraction, stress, emotions or driver workload in general. In-vehicle feedback uses physiological measures like heart rate, skin conductance, skin temperature and breathing rate as the basis for intervening on these mental state parameters. Lane keeping, location of reckless events and safe distance to the vehicle ahead are also important indicators that require real-time*

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interventions. In i-DREAMS we will monitor all of these factors to provide accurate feedback in real-time to eventually decrease imminent collisions from happening. As I already mentioned, post-trip interventions focus on improving overall driving behavior in a sustainable way. They are usually targeted at the frequency of harsh events (acceleration, braking or cornering), distracted driving or other reckless events."

What is in your opinion the biggest challenge in developing a safety intervention tool?

CHRISTOS KATRAKAZAS: *"Two elements are essential for the success of an intervention tool: its performance (in terms of effectiveness of the interventions) and its acceptance by the user (including usability and satisfaction). The more these criteria are fulfilled, the better the safety effect. This was derived from the fact that if an objectively effective intervention is not easily useable or accepted by the driver, its effect would not be appreciated or demonstrated. So, the biggest challenge for us is to find a balance between maximizing effectiveness, and keeping acceptance, usability and driver satisfaction at high levels during and after the trip."*

> "So, the biggest challenge for us is to find a balance between maximizing effectiveness, and keeping acceptance, usability and driver satisfaction at high levels during and after the trip."

What specific actions are you undertaking in i-DREAMS to maximize user acceptability?

CHRISTOS KATRAKAZAS: *"To maximize future acceptance, we will include the input from drivers as early as possible. Once in-vehicle interventions are implemented and operational in the simulator experiments and the field trials, we will evaluate different facets of user acceptance using both survey and observational techniques. Research has also shown that the evaluation of a new system by users depends on their understanding of the possibilities and limitations. So, it is important that users 'learn' how to use the system. Therefore, we foresee documentation to educate drivers about the benefits and limitations of the system. Lastly, also the post-trip feedback will play a role in user acceptance. Literature revealed that acceptance increases when drivers are given feedback on why alerts were given in the vehicle, even if the alerts were not always considered necessary by the driver at the time they were triggered."*

Do you also have a specific strategy to maximize the performance of safety interventions?

CHRISTOS KATRAKAZAS: *"Certainly. Based on the literature we assessed, it seems that the best warning strategy is to work in stages. Three stages are included in what we call our Safety Tolerance Zone. By specifying multiple stages in the STZ, warnings can be adjusted to each specific stage. Firstly, we will warn drivers early, but in a non-intrusive way by using visual and detailed messages (normal driving phase). When the driver is not adapting to the situation, the driver will move to a second stage (danger phase) where warnings are made more intrusive, for example by adding auditory warnings and/or making visual warnings blink. In a third stage (= avoidable accident phase), immediate action from the driver is required and the intrusiveness of warnings will be*

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maximized without startling the driver. The goal is to immediately capture the drivers' attention or trigger an intuitive reaction. At all times, the warning will be presented in an intuitive way that does not overload the drivers' cognitive abilities."

"The goal is to immediately capture the drivers' attention or trigger an intuitive reaction."

When creating the safety intervention tool, I assume you will use different technological devices to monitor all the elements that require monitoring. How did you determine what technologies would be suitable?

CHRISTOS KATRAKAZAS: *"We took different criteria into account. For the **on-road testing**, feasibility is a critical consideration. The chosen technologies should not only be affordable, but should also be capable of providing custom designed interventions, based on sensor measurements and the Safety Tolerance Zone algorithm. Thus, interfacing with an i-DREAMS processing unit is a requirement. This implies that technologies such as the dashboard or center display cannot be used for on-road experiments. Another crucial aspect is 'ease of installation'. Given the significant number of vehicles that need to be equipped with the i-DREAMS technology, an efficient installation process is essential. So haptic devices such as driver seat vibration, pedal vibration and steering wheel vibration are not ideal because they require custom fabrication or (dis)assembly of large vehicle parts. Based on these constraints, the most convenient solution for on-road experiments would be to use a carefully chosen nomadic device. Taking all pros and cons into account, we decided that devices less portable than for example a smartphone and meant to be permanently installed in the vehicle, seem to be the best solution for a system that aims to improve safety. For the **simulator experiment**, there are fewer constraints. The limited number of simulators eliminates the requirement for installation standardization, custom design and fabrication of parts and interfaces is a possibility."*

You took all the pros and cons of nomadic devices into account you say. The pros seem clear, but what exactly are the cons?

CHRISTOS KATRAKAZAS: *"I will try to make it as concrete as possible. We will be working with Mobileye, a commonly used technology in the automotive industry that provides visual and auditory interventions. A possible con might be the positioning of the device. Ideally, it should be in the drivers' field of view, as close as possible to the viewpoint of the road. But there is the risk of installing it too much in the field of view, becoming obstructive and block the driver's view on the road. Another possible disadvantage can be the lack of communication with other systems. For example, if an auditory warning is given, but the radio is at a high volume, the auditory warning might not be heard by the driver. But also, visual interventions can be problematic due to lack of communication with other vehicle systems. For example, if a vehicle is already equipped with a headway monitoring system, both systems operate completely separate from each other. This might lead to information overload or contradictory information."*

The idea of trying to improve driving skills by intervening during and after trips to increase road safety is becoming more and more clear to me. But what about intervening before trips?

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What about the role of driver education? Is this not considered in i-DREAMS?

CHRISTOS KATRAKAZAS: *"Of course it is. In this report you will find an entire chapter about it. More specifically we focused on employee education and training, thus the role of driver education in a professional context. We looked into the different pedagogical and didactical approaches that can be encountered: theory-based approaches, versus practice-based approaches, traditional methods (such as classroom teaching, safety meetings, in-company coaching) versus innovative methods (such as remote learning, e-learning, web-based instruction, computer-based training, multi-media support, simulator techniques). However, the most important conclusion regarding the effectiveness of professional driver education and training remains a debated and controversial topic. This prevented us to come to firm and evidence-based conclusions as to which pedagogical and didactical approaches can be considered as effective or why."*

The report also discusses the use of gamification within safety interventions. Can you explain this concept?

CHRISTOS KATRAKAZAS: *"Gamification is about the application of game-specific elements, mechanisms and features outside the context of entertainment and play, so a non-gaming context. The main purpose of gamification is to trigger the motivation and to reinforce, change or shape desired behavior, and to sustain this effect over time by developing so-called intrinsic motivation. Intrinsic motivation stands for the idea that humans under the right conditions, perform tasks for the pleasure of the task itself rather than for any kind of reward. It is proven that behavior triggered by intrinsic motivation lasts longer than when externally motivated. To be intrinsically motivated, three basic human needs not to be satisfied: (1) you need to feel competent (able to perform a task or behavior), (2) you need to feel autonomous (decision to engage in a task or behavior is under your personal control) and (3) you need to feel related (engaging in a task or behavior is socially important for you). Gamification is actually about the use of game design elements to satisfy these three basic human needs."*

"The main purpose of gamification is to trigger the motivation and to reinforce, change or shape desired behavior, and to sustain this effect over time by developing so-called intrinsic motivation."

i-DREAMS is not only focusing on cars, but also on trucks, buses and rail modes. Can all your conclusions on what technologies to use and what strategies to follow be easily transferred to all of these different modes?

CHRISTOS KATRAKAZAS: *"A lot is written about all of these intermodal considerations in deliverable 2.2, but also about the differences between professional and non-professional drivers. If you are interested in the details, you can best check out the report. In general, we can summarize the intermodal considerations best as follows. With regards to car-specific interventions, visual and auditory warnings were deemed more appropriate in real-time, while driver telematics with gamification features were found to perform better after a driving session. The results obtained with respect to*

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trucks confirmed that although a combination of monitoring and gamified feedback resulted in the best driving behavior during and after the trip, it was clearly mentioned that such interventions are not provided in isolation. It is important to keep in mind that this kind of feedback is usually imbedded within a broader safety change intervention framework where they are offered in combination with other strategies (i.e. driver coaching and management commitment and support). Therefore, a focus on individual components will probably be insufficient to accomplish sufficient safety culture change. Moreover, little information was found on the acceptance of safety interventions from bus drivers, but advantages for fleet operators were visible in terms of continuous vehicle surveillance and driver compliance to traffic rules. Train interventions operate in a different regime, but evidence from the literature demonstrated that auditory and visual warning could enhance driver alertness in real-time. Transferability of interventions was not found to be troublesome in most of the technologies, apart from the train-specific ones, and thus the i-DREAMS intervention strategy could achieve a cross-modal form."

OK Christos, thank you for this interview. I look forward to seeing how this work will be translated in practice. Good luck with the rest of the project!

Edith Donders

i-DREAMS DisCom manager

Deliverable 2.2 is part of WP2:

State of the art on measuring the driver state and technology-based risk prevention and mitigation

[Download the report here]

Researcher in the spotlight

CHRISTOS KATRAKAZAS

Graduated as *Civil Engineer* in *2013*

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

Passionate about *programming and cinema*

Tasks in i-DREAMS: *Leads work packages on the analysis of risk factors and the evaluation of interventions & Coordinates the mathematical working group and the NTUA team contributions*

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