D8.1 Toolkit for vehicle operator safety

Interview with André Lourenço

The main purpose of deliverable D8.1 is to carry out the synthesis of the research results and the consolidation of the proposed tools, to provide a toolkit for the identification and continuous monitoring of the Safety Tolerance Zone (STZ). Furthermore, this report includes a description of the methodology for the detection of drivers' (car, bus, truck, train) available coping capacity and the task complexity imposed on them in any given situation, a set of tools that provide assistance while driving, as well as post-trip personalized feedback (including a gamified learning and training environment) and exploitation plans for the proposed tools and policy recommendations for the related authorities.

Good day André, we meet for the last time within the context of these interviews and this time we will tackle D8.1 for which you are the main author. When reading this document, it really felt like everything came together. I recognized a lot from the other deliverables. Is that correct?

ANDRÉ: *"Definitely! But it was a team effort. We tried to provide a synthesis of the research results and consolidated the proposed tools. We also described the theoretical and conceptual backbone of the i-DREAMS platform, along with the full set of tools that were implemented. Furthermore, you will find information on the methodologies to assess and measure the relationship between risk, task complexity and coping capacity. There is a chapter where we also address the mode transferability, discussing how our technology can be applied on different modes, like rail, aviation and maritime transport and finally we summarize the proposed exploitation plans and present an overview of the main policy recommendations. So basically, this report comes full circle."*

Let us start with the i-DREAMS tools. What, in your opinion, is so specific about these tools?

ANDRÉ: *"We developed our i-DREAMS framework in such a way that it enables the flexible integration of different technologies (sensors, questionnaires, APIs) for data collection and processing. All of this to realize the fundamental goal of the i-DREAMS platform which is to keep the driver in the normal driving phase (= phase 1 of the STZ) for as long as possible, to prevent the transition from the danger (= phase 2) to the avoidable accident phase (= phase 3) and, where this is not possible, to alert the driver to take immediate corrective action to avoid the crash. To this end, the platform*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.

combines both real-time and post-trip interventions which, respectively, aim to nudge and coach the driver."

Figure 1: The three phases of the STZ

Can you go over the tools you used one more time?

ANDRÉ: *"As you wish! I will start with the tools that we used in the vehicles (see Figure 2). To compute the STZ we use tools that provide data on driver state, driving task complexity and driving performance. To monitor driver state, we use two types of sensors: CardioWheel (in trucks and buses) acquires the electrocardiogram (ECG) from the driver's hands to continuously detect drowsiness and hands-on-wheel detection, cardiac health problems, and biometric identity recognition. As alternative for the cars and rail modes, we used a Wearable, a wristband that measures the photoplethysmogram (PPG) to continuously measure the heart rhythm and heart rate variability (HRV). To monitor driving task complexity, we use on the one hand Mobileye, an ADAS collision avoidance system based on headway monitoring, including detection of vulnerable road users and traffic sign recognition. On the other had we use a dashcam which is a camera targeting the road environment in front of the vehicle. Recordings are triggered when certain safety-critical events occur while driving. Faces and license plates are obfuscated for privacy protection. To monitor driving performance, several functionalities from the OSeven Driver App (such as handheld mobile phone use while driving) are implemented in the i-DREAMS app which is installed on the driver's phone, this app provides an indicator of driver distraction, as well as harsh acceleration and breaking events. The app is also used for post-trip feedback and to nudge the drivers towards safer driving, through the i-DREAMS gamification platform. The gateway, an edge-computing device, is also an important tool for monitoring driving performance. It records data from all input sensors, determines the STZ phase in real-time, provides interventions to the driver, and uploads trip data for analysis. It also has an embedded satellite positioning receiver (GNSS), a Fleet Management System (FMS) reader, and an inertial motion unit to detect harsh driving events (acceleration, breaking, and cornering). It is a very powerful modular system.*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.

Figure 2: In-vehicle monitor components

The <u>intervention device</u> is the display that is installed in the vehicle. It is used for driver identification purposes (when automatic identification via FMS is not an option, e.g. in cars), and it used to visualize the real-time interventions."

Figure 3: Front and back view of the intervention device

And what about the tools outside of the vehicle?

ANDRÉ: *"Then you are referring to the tools that provide personalized feedback to the drivers, leveraged by post-trip data analysis and scoring, and taking advantage of a gamified approach to nudge and coach the drivers to adopt safer driving habits and behaviours. The first step to accomplish this is by uploading trip data from the gateway to a cloud environment, where data processing and aggregation takes place. The gateway has the capability to store all the data allowing synchronization of situations where there is no 3G or 4G signal. Afterwards, for each trip and driver, safety scores are computed, which are then used to provide feedback to the drivers, via both <u>the i-DREAMS Driver App</u> and a <u>web dashboard</u>. We described the technologies that were used to develop the app and we also described the different functionalities that are offered by the app. For the web dashboard we actually did the same. We first provide a description of the used technologies followed by an overview of the different functionalities. Readers really have to check out the deliverable if they are interested in all of those details."*

Chapter 3 of D8.1 is called 'Methodologies'. Can you explain what this refers to?

ANDRÉ: *"This chapter describes the methodologies adopted for the actual computation of the Safety Tolerance Zone phases, in addition to describing how the field-trials were carried out and the methods employed for the analysis of all collected data."*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.

Ok, then let us start with the STZ phases, how are they computed?

ANDRÉ: *"We determined thresholds to define the STZ phases per performance objective. Performance objectives describe an impaired state or driver behaviour, as these are the aspects that the drivers have some control over and therefore can be influenced by the i-DREAMS interventions. Performance objectives are directly related to the construct of* *coping capacity (e.g. is the driver tired or distracted by the phone?)**. However, the algorithms used to trigger interventions also consider other elements, such as age and gender, or aspects associated with* *task complexity**, such as weather (rain measured by windscreen wipers activated) and trip duration. These modifying factors mean that the timing of real-time interventions can be influenced by measures of both coping capacity and task complexity. In practical terms, four real-time in-vehicle interventions were designed to address the i-DREAMS performance objectives, namely headway, illegal overtaking, speeding, and driver fatigue. These warning strategies define specific thresholds representing each of the three STZ phases. Note that these thresholds are dynamically adapted by the specific driving situation, being affected by factors such as age, gender, driving experience, weather (rain), and the state of the other warnings."*

Ok, then the real-world field trials. You mentioned that you described how they were organized?

ANDRÉ: *"Yes, but I don't think I can tell you anything that you don't already know. The field trials are organised in 5 (BE, DE, UK, PT, GR) countries. The purpose of those field trials was to collect the necessary data, to identify the STZ and the correlated conditions and to predict and explain the prevailing level of road safety and driving behaviour. As already mentioned in a couple of other deliverables. Each field trial was organised in 4 phases (see Figure 4). The results are analysed in work packages WP6 and WP7, specifically in the deliverables 6.1, 6.2, 6.3, and 7.2."*

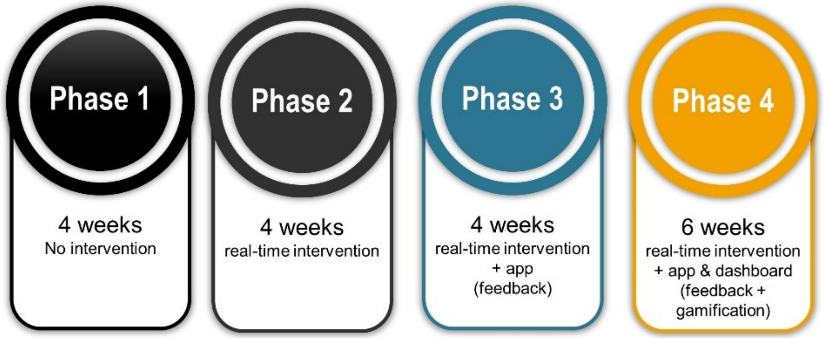

Figure 4: Four phases of the field trials

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.

Would it be possible to briefly say something about those results?

ANDRÉ: *"Of course, I can summarize for you the most significant results regarding the risk factors. They are described in detail in the WP6 deliverables:*

- *Demographic characteristics, such as gender and age, turned out to have a negative correlation, indicating that male drivers and especially elderly people had a lower level of coping capacity.*
- *Increased vehicle age, along with fuel type and trip difficulty, were associated with higher task complexity levels.*
- *Task complexity and coping capacity seem to be inter-related with a positive correlation. This indicates that higher task complexity is associated with higher coping capacity, implying that drivers' coping capacity increases as the complexity of the driving task increases.*
- *Task complexity increase is associated with lower risk, which is not intuitive. Although the initial assumption was that task complexity would increase risk, once its effect is moderated by that of coping capacity, the opposite is the case. It is noted, however, that the task complexity latent variable is measured by environmental indicators (i.e., rainy weather, night-time), which are known to induce compensatory behaviours by drivers.*
- *Male drivers, as well as drivers with sportive driving style, driving faster than the speed limit over the last year, and higher perceived competence compared to the average driver are more likely to exhibit higher levels of the STZ. All these variables reflect the confidence and more aggressive behaviours that are known to be associated with violations.*
- *Drivers who think driving is very dangerous and those who are familiar with the benefits of safe driving have lower propensity of exceeding the normal STZ of speeding.*
- *Night-time driving and driving on rural roads also lead to higher propensity of speeding, possibly due to lower traffic during these hours.*
- *The structural relationship between task complexity and coping capacity remains positive across all trial phases, although it reduces in magnitude in Phase 4. Similarly, the relationship between task complexity and risk remains the same, although the magnitude increases in the negative direction. Moreover, the relationship between coping capacity and risk is also consistent across phases.*
- *The effect of trip duration was negative during Phase 1 of the experiment, but it changed to positive in the following phases of the experiment. It is possible that with the presence of interventions, the coping capacity of the drivers increases, and they can maintain normal driving for longer trips."*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.

And what about the effect of the intervention. Can you say something about that as well?

ANDRÉ: *"To evaluate the effectiveness of the i-DREAMS interventions, we carried out outcome and process evaluation. Outcome evaluation, also known as effect evaluation, measures the effectiveness of the intervention, i.e., it assesses whether the targeted factors of the on-road trials changed because of the intervention or not. Process evaluation, on the other hand, assesses which parts of the intervention were effective and which parts were ineffective. These analyses were performed for both in-vehicle real-time warnings and post-trip feedback. To get insight in these results, I would like to refer to the interview you had with Laurie Brown on D7.2. I think she really explained it well in that conversation."*

That brings me to the exploitation plans. You devoted an entire chapter to them in your report. Can you explain why they are so important.

ANDRÉ: *"I think that a crucial part of the project is the definition and preparation of plans to exploit and foster the adoption of the tools and methodologies developed and validated throughout the project. This includes the commercial exploration of project results, conceiving a set of products and services that address the needs of specific markets."*

Is i-DREAMS easy to exploit in your opinion?

ANDRÉ: *"I do think it has a lot of exploitation potential! The modularity of the i-DREAMS technology allows the creation of multiple versions of the system, with the potential to best adapt the available product features to the target market segments. I think that is an important asset of i-DREAMS which can boost its exploitation. Furthermore, additional third-party monitoring technologies were added to the set of equipment supported by the i-DREAMS system, as an alternative to the gateway and other research equipment that was used during the field trials. And the rest of the system was able to operate, and this characteristic is amazing, since hardware is evolving and the built infrastructure is able to accompany this evolution."*

What do you mean when you talk about 'multiple versions of the system'?

ANDRÉ: *"Well, we identified a couple of market segments we want to pursue (see Figure 5) and for each of those market segments, a set of product features is described (see Figure 6). This approach allows to maximize, on one side, the number of i-DREAMS features that are appropriate for a given segment, while minimizing, on the other side, the cost of deploying the i-DREAMS system."*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.

Figure 5: Potential markets for the valorisation of the i-DREAMS technology

	Gateway	Dashcam	Intervention display	ADAS	Cardio Wheel	iDREAMS dashboard	iDREAMS app	Standard O7SDK	iDREAMS O7SDK	O7API
						x	x	x		x
	x	x	x	x	x	x	x		x	x
	x	x				x	x	x		x
	x	x	x	x	x	x	x			x

Figure 6: Product-Market fit of the i-DREAMS configuration

And what about the additional third-party technologies you were talking about? Why did you need those?

ANDRÉ: *"Adding that third-party hardware has several benefits: (1) It helps to address scalability concerns related to custom hardware, resulting from the global chip shortage. (2) Quality assurance and conformance with market specific directives for fleet monitoring hardware is guaranteed by the third-party supplier. (3) There is an opportunity to reduce the cost-per-installation by using third-party equipment, already being produced in large volumes. (4) Easier adaptation for external installers already familiar with third-party equipment, or vehicles already equipped with third-party equipment."*

And which third-party technologies did you end up using?

ANDRÉ: *"After comparing the solutions offered by different suppliers of GPS-trackers and fleet monitoring hardware, equipment from Teltonika[1] was selected for integration into the i-DREAMS platform. The main reasons being the availability of hardware, the well-documented device features, and the options of device configuration. Furthermore, with the selected Teltonika devices, which includes GPS-trackers, dashcams, and a smart camera similar to Mobileye, it is possible to capture a large part of the driving parameters that are a key part of the i-DREAMS technology. Still, some compromises had to be made. Like most third-party hardware, Teltonika GPS-trackers do not allow for edge computing based on custom i-DREAMS software. Also, the processing power is significantly lower compared to the gateway we used in the field trials. This means that a large part of the trip processing that was*

[1] https://teltonika-gps.com/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.

originally performed on-vehicle now needs to be done elsewhere. To address this, an architecture allowing external trip processing, based on datapoints acquired from GPS-trackers, was created.”

Can the i-DREAMS platform be useful for the maritime and aviation sector as well?

ANDRÉ: *“Although similar risk factors exist in all modes, monitoring operators and applying interventions is more widespread in the road sector. In the rail sector, operator monitoring is implicitly accounted for by the strict timetables and regulations. In addition, the difficulty of installing in-cabin technologies has largely prevented the use of these technologies so far. In the maritime sector, as the relatively low speed and density of maritime traffic leaves quite large reaction time margins for the navigating officers, the emphasis is put on alerting the operator for risks in the environment rather than their own steering behaviour. In the aviation sector, operator monitoring is mostly carried out within standard training, re-training, and fitness screening processes by means of medical evaluations, neuropsychological tools, simulator sessions, etc. Meanwhile, automation and other advanced operator technologies are more common in the aviation sector than in other sectors. Overall, there is no systematic knowledge sharing about operator monitoring and intervention strategies that can provide insight for reducing risk factors that are common among all transport modes, especially human factors. In i-DREAMS we actually investigated that transferability by means of literature review and expert reviews.”*

And what were the findings?

ANDRÉ: *“The literature review and the expert interviews in the rail, aviation, and maritime sectors showed that while there are commonalities between these transport modes, there are fundamental differences which may prevent full transferability of i-DREAMS methodology and technologies to other modes. However, certain aspects of the project are of high interest and may be used for other modes, conditional on further research. These aspects are real-time monitoring of fatigue and sleepiness, and post-trip feedback and gamification. Meanwhile, it is very important to note that such aspects need to be integrated well enough with the general safety culture in each transport industry.”*

The last chapter of D8.1 was about policy recommendations. What can you recommend to the policy level, based on this research?

ANDRÉ: *“I am not going to say too much about that yet, since that is the scope of D8.3 and I don’t think you interviewed to author of D8.3 yet (laughing). But what I can say is that how legal, ethical, and societal aspects are to be handled, is of great importance for the valorisation and exploitation of the i-DREAMS project. In this regard, a set of policy recommendations has been compiled in deliverable D8.3, targeting transport safety stakeholders across Europe. This advice is tailored to individual stakeholder’s requirements, spheres of activity, and areas of influence. It covers all relevant areas, from EU level to national and local authorities, and targets also industrial*

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 814761.

stakeholders. Specifically, the recommendations highlight the added value of wide adoption of the i-DREAMS platform (and similar systems), as well as insights gained from running such a large naturalistic driving experiment. So, your last interview, will definitely not be the least."

No, it definitely won't be! Thanks André, once again, for sitting down with me to have this chat. I wish you all the best!

Edith Donders

DisCom Manager

Deliverable 8.1 is part of WP8:
Roadmap to market and society

i-DREAMER in the spotlight

ANDRÉ LOURENÇO

Graduated as *Electrotechnics and Computers engineering in 2001, master in 2005, and PhD in 2014, all in the same field.*

Employed at and co-founder of *CardioID Technologies since 2014, and professor at Instituto Superior de Engenharia*

Passionate about *hiking, music, humans, and nature*

Tasks in i-DREAMS: *Mainly WP4 – the development of the i-DREAMS full-stack*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814761.