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Driver Drowsiness Metrics for DDAW and Euro NCAP

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OPTALERT LTD

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CONTENTS

1. EXECUTIVE SUMMARY

This report outlines outcomes conducted by IDIADA as part consultancy services to Optalert. The consultancy concerns the evaluation of metrics for the assessment of drowsiness in drivers, accounting for driver monitoring system requirements and validation procedures pertinent to drowsiness detection functions. This is with the objective of demonstrating applicability and equivalent relative to the content specified in the following:

- Regulation (EU) 2021/1341 of the European Parliament and of the council. This includes requirements for testing outlined as part of the European Commission General Safety Regulation for Driver Drowsiness and Attention Warning (DDAW), and its associated Annex's.
- Euro NCAP 2023 Safe Driving Protocol content defining detection requirements for driver fatigue as part of Driver Status Monitoring

The client can accept or refuse the IDIADA proposals outlined in this document but in any case, IDIADA will not be responsible of the consequences resulting from the clients' decisions. IDIADA cannot guarantee that output from the consultancy will be accepted by homologation authorities as evidence applicable to successful approval according to the DDAW regulation, or by Euro NCAP.

The client may share this report, including IDIADA's written recommendations. This is under the condition that it is shared in its entirety and without modification.

2. INTRODUCTION

The consultancy work examines literature resources provided by Optalert with the objective the applicability of evidence for measures of driver drowsiness. This draws upon IDIADA background knowledge as an official technical service for European vehicle homologation and as an official test laboratory for Euro NCAP.

The reviewed resources pertain to the examination and authentication of the Johns Drowsiness Scale (JDS) as a dependable indicator of drowsiness. As part of this the reported activities establish a means of assessing drowsiness objectively by employing psychomotor vigilance task (PVT) measurements and associated measures of driver performance.

The reported conclusions outline the opinion of IDIADA concerning the applicability of provided evidence with regards to demonstrating applicability to Euro NCAP and GSR DDAW requirements for system performance and validation evidence. Where relevant, the report identifies possible future activities that may be used to further support the applicability of driver drowsiness metrics, with the objective of improving the specificity of evidence.

3. DMS PERFORMANCE AND TESTING REQUIREMENTS

3.1. GSR DDAW

3.1.1. Overview

The General Safety Regulation (GSR) outlines requirements regarding the driver drowsiness and attention warning systems for new vehicles introduced into the market from July 2022, and for all vehicles from July 2023. According to (EU) 2021/1341, Driver Drowsiness and Attention Warning (DDAW) systems are systems that utilize vehicle systems analysis to assess a driver's level of alertness and issue warnings when necessary. DDAW is defined as “a system that assesses the driver’s alertness through vehicle systems analysis and warns the driver if needed. DDAW must detect or recognise the driving and/or steering pattern symptomatic of a driver exhibiting reduced alertness due to fatigue and interact with and alert the driver via the vehicle’s human-machine interface.”

3.1.2. Performance requirements

Performance requirements for DDAW are defined according to the detection of drowsiness relative to driver condition and activation of a corresponding driver warning Driver drowsiness condition uses of the KSS (Karolinska Sleepiness Scale) as a reference measurement to define performance requirements. Critical values defined according to literature supporting evidence of performance drop-off (Huysamen and Pistak 2020). Within the regulation a warning must be activated for a driver who has a drowsiness level higher than KSS 7.

3.1.3. Testing requirements

As part of the approval for DDAW, the vehicle manufacturer must provide a dossier to the technical service, which in part, must provide evidence of the system sensitivity for detection of drowsiness relative to the defined performance requirements. As part of this a validation test must be conducted, meeting requirements outlined in the regulation text. The principal requirements are that a test must be conducted with a sample of real human participants who are drowsy, and their level of drowsiness must be quantified using a reference measurement.

The KSS, in line with its use as the basis for performance requirements, is specified as being the primary means of recording the driver’s sleepiness. This allows for the calculation of system sensitivity according to the defined performance threshold for positive detection. Other measures are accepted, however additional evidence must be provided to demonstrate equivalence to the KSS. Any alternative measure, and evidence presented to support its use in the test, are subject to review and acceptance by the responsible Technical Service.

3.2. Euro NCAP Safe Driving DSM

3.2.1. Summary

Within Euro NCAP, Driver status monitoring forms part of the Safe Driving protocol, for which the latest version applicable for implementation as part of official testing from January 2023. The content for driver monitoring is divided across 3 areas – system sensing, driver state detection, and vehicle response. For driver state detection there are three areas, divided between visual distraction, fatigue, and unresponsiveness. For fatigue, Euro NCAP rewards points for the detection functions pertaining to Sleep, Micro sleep, and Drowsiness.

3.2.2. Performance Requirements

Performance requirements for drowsiness, as with DDAW, are based upon the capability of the system to detect a driver whose drowsiness level is greater than KSS 7. The protocol does specify that an equivalent measurement may be used in place of the KSS.

3.2.3. Testing requirements

As part of the approval process, a dossier must be submitted to Euro NCAP for review by the Secretariat. Within this document, evidence must be presented by the vehicle manufacturer which demonstrated the compliance of the system with requirements specified within the protocol.

In the case of drowsiness detection, test methods used as part of the system validation, including measures used to quantify driver drowsiness (KSS or otherwise) should be presented for review by Euro NCAP. Test outcomes should demonstrate the capability of the system to effectively classify driver drowsiness at the defined critical threshold.

4. ASSESSED RESOURCES

All resources have been provided by Optalert to IDIADA for review under the scope of consultancy. Of the provided resources, IDIADA as considered the following as part of the review outlined in this document.

C. Anderson, A. M. Chang, J. P. Sullivan, J. M. Ronda, and C. A. Czeisler, "Assessment of drowsiness based on ocular parameters detected by infrared reflectance oculography," Journal of Clinical Sleep Medicine, vol. 9, no. 9, pp. 907–920, 2013, doi: 10.5664/JCSM.2992.

Crowley, K., Johns, M., Tucker, A., Chapman, R. & Hocking, C. (2009). Use of infrared reflectance oculography for monitoring the drowsiness of drivers. Proceedings of Jap Soc Sleep Research, Sleep and Biological Rhythms, 7, A23.

Cori, J. M., Wilkinson, V. E., Soleimanloo, S. S., Westlake, J., Stevens, B., Rajaratnam, S. M. W., & Howard, M. E. (2022). A brief assessment of eye blink drowsiness immediately prior to or following driving detects drowsiness related driving impairment. *Journal of Sleep Research*, e13785. https://doi.org/10.1111/jsr.13785

Ftouni, S., Sletten, T., Howard. M., Anderson, C., Lenne, M., Lockley, S., & Rajaratnam, S. (2013). Objective and subjective measures of sleepiness and their associations with on-road driving events in shift workers. Journal of Sleep Research, 22 (1), 58-69.

Optalert Automotive (2023). JDS efficacy with applications in fleet fatigue management

Soleimanloo, S.S., Sletten, T.L., Clark, A., Cori, J.M., Wolkow, A.P., Beatty, C., Shiferaw, B., Barnes, M., Tucker, A.J., Anderson, A., Rajaratnam, S.M. & Howard, M.E. (2021). Backward-rotating shifts are associated with real-time drowsiness during daytime drives in heavy vehicle drivers. Sleep Advances, 2, Abstract Supplement, P133.

Stephan, K., Hosking, S., Regan, M., Verdoom, A., Young, K., & Haworth, N. (2006). The relationship between driving performance and the Johns Drowsiness Scale as measured by the Optalert system. Monash University Accident Research Centre.

5. CONCLUSIONS

5.1. GSR DDAW Applicability

According to the defined requirements for an applicable validation test methodology a reference measurement of driver drowsiness condition must be collected. Testing procedures for DDAW generally incorporate an uninterrupted driving scenario, where the progressive change in a driver's sleepiness level is collected at approximate 5-minute intervals alongside the positive or negative detection output of the driver monitoring system. To meet requirements for calculation of system sensitivity, it is necessary for reference measurements to be collected at intervals of 15 minutes or less.

As previously specified, any reference measurement used as to quantify the driver's drowsiness condition for a test used as evidence in a dossier submitted as part of DDAW type approval, must demonstrate equivalence to the KSS relative to the defined detection threshold at KSS level 8. As part of the regulatory submission, it is necessary that this equivalence is demonstrated with empirical evidence supporting equivalence.

Based upon the reviewed resources with regards to applicability to the requirements of DDAW, IDIADA believes that there is sufficient evidence to support the JDS as a valid and accurate measure of drowsiness, and to support an empirical relationship between the JDS and KSS. This is principally demonstrated by the evaluated resources from Cori et al. (2022), Ftouni et al. (2013), and Anderson et al. (2013) which each present peer reviewed studies where subjective KSS ratings and objective JDS related PVT measurements have been taken from drowsy participants.

Of these Cori et al. (2013) provides the most applicable demonstration of equivalence relative to DDAW, with a methodology including the measurement of driver drowsiness before and after a driving activity on a closed test track. The study did not, however, include any measurements of the driver's drowsiness condition during driving using the KSS.

5.2. Euro NCAP Safe Driving DSM Applicability

As outlined in the protocol description, Euro NCAP requirements for drowsiness detection are based upon the DDAW regulation, with a threshold for detection based upon KSS measurements. The vehicle manufacturer must demonstrate the capability of the system to classify the drowsiness condition of the driver. Evidence of system performance must be provided within a dossier document submitted to Euro NCAP that the system is able to detect drowsiness when the driver reaches a KSS level >7.

Included within the protocol text, is the possibility for an equivalent measure to be used. The applicability for an equivalent measure will be evaluated by the Euro NCAP Secretariat according to provided supporting evidence, which must be included within the submitted dossier.

Based upon the applicability of evidence demonstrating the equivalence of the JDS to KSS, as previously discussed in this document relative to acceptance for DDAW, IDIADA believes that the presented resources supporting a system validated using the JDS as a performance reference may be accepted by Euro NCAP.

Aside from equivalence, for Euro NCAP other evidence may also be acceptable to supporting the applicability of the JDS as a reference measurement for system performance. Of the reviewed resources, this can be supported by the findings of Stephan et al. (2013) relating to the frequency of lane departures during driving relative to their drowsiness condition on the JDS.

5.3. Further Evidence to Demonstrate Applicability

Considering the reviewed evidence IDIADA believes that there is a lack of specificity to common DMS validation procedures for drowsiness detection functions. These concern collection of evidence to demonstrate system performance, involving a continuous measurement of driver drowsiness during a controlled driving scenario. It is therefore not possible to guarantee that reviewed evidence for the relationship between JDS and KSS would be acceptable to all official Technical Services.

In response, IDIADA believes that additional resources would improve the robustness of any use of the JDS as an accepted measure of drowsiness. This would support applicability of JDS to GSR DDAW according to the regulation requirements, and associated acceptance by Technical Services other than IDIADA. Similarly, this would support any data provided to Euro NCAP for review by the Secretariat.

IDIADA believes that the optimal additional evidence would be the outcomes of a test driver using a ‘standard’ DDAW applicable validation test methodology. Such an activity would involve approximate 120-minute driving session within a controlled test track or driving simulator platform. Such a test would involve 15-30 normal drivers recruited as participants, induced with sleepiness through circadian rhythm-based test scheduling and a monotonous test scenario.

Following training on the KSS, subjective rating scores would be collected from participants at 5-minute intervals during driving. In parallel, objective PVT measures applicable to the JDS would be collected. Correlative outcomes between JDS and KSS from this test would be presented to demonstrate the relationship between the measures.

6. REFERENCES

Euro NCAP (2022). Assessment Protocol – Safety Assist - Safe Driving, Version 10.1.1.

European Commission, Regulation (EU) 2019/2144 on the type-approval of motor vehicles with regard to their driver drowsiness and attention warning systems (2021). Official Journal of the European Union L 292. p, 16.

Huysamen K., and Pistak K., (2020). DDR Second Interim Report: Driver Drowsiness and Attention Warning, Advanced Distraction Recognition and Driver Availability Monitoring Systems. TRL: Crowthorne