

ICTR 2023



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HELLENIC INSTITUTE OF
TRANSPORTATION ENGINEERS

11th INTERNATIONAL CONGRESS on TRANSPORTATION RESEARCH
Clean and Accessible to All Multimodal Transport
Heraklion, Crete, September 20th - 22nd 2023

Impact Assessment of a novel Human-Machine Interface Prototype: A descriptive analysis from the HADRIAN project

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virtual  vehicle

The HADRIAN project

- **HADRIAN:**
“Holistic Approach for Driver Role Integration and Automation Allocation for European Mobility Needs”
hadrianproject.eu
- **HADRIAN Partners:**
16 partners from 9 EU countries
involving National Technical University of Athens
- **Duration of the project:**
42 months (December 2019 - May 2023)
- **Framework Program:**
Horizon 2020 - The EU Union Framework Programme for Research and Innovation - Mobility for Growth



Introduction

- **Human factor** accounts for up to 94% of all road crashes.
- The introduction of **Autonomous Vehicles (AVs)** is anticipated to improve road safety by reducing human error.
- Up to SAE automation level 4 (high automation), the driving task will still require **human interventions and interactions** with the vehicle.
- **Human-Machine Interfaces (HMIs)** are anticipated to foster cooperation between users and vehicles.
- The **HADRIAN project** aimed at providing seamless and fluid interactions between the driver and the AV.



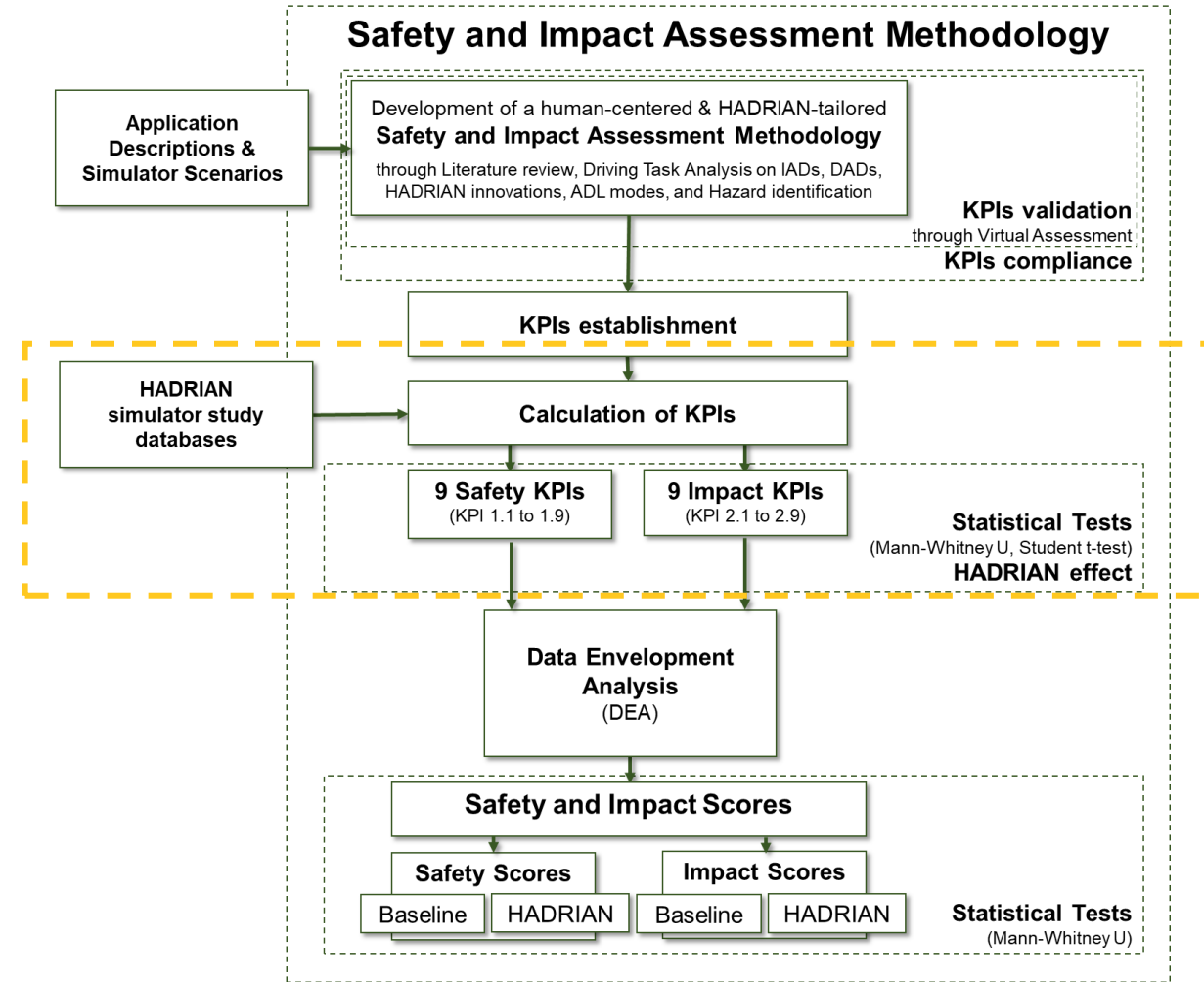
Objectives

- The present study aims at assessing the **impacts of HADRIAN HMI prototypes** on safety, driving performance and drivers' perceptions.
- An "HADRIAN-tailored" safety and impact assessment methodology was developed using special **Key Performance Indicators (KPIs)**.
- The main goal of this study is to investigate **descriptive insights** into KPIs by the developed assessment methodology.
- The driver role for automated vehicles is also investigated and assessed using a **holistic user-centered approach** that evaluates the safety and perceived impact effects.
- Special focus was given to **take-over requests (TORs)** and Automated Driving (AD) level transitions.



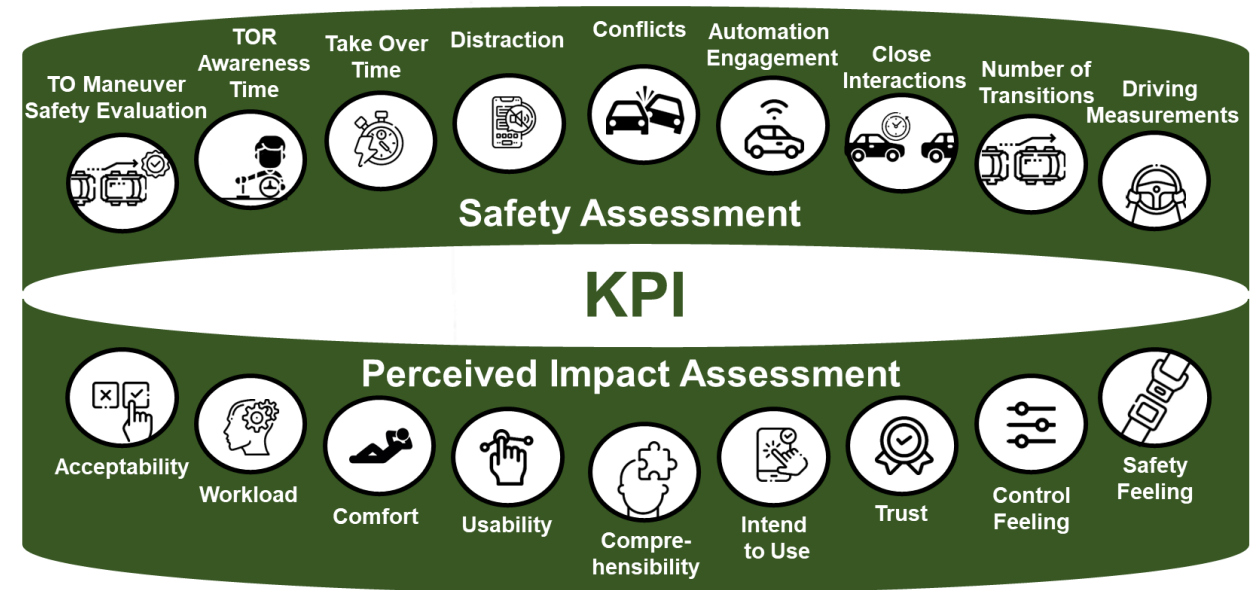
Assessment Development

- The development of **Safety and Impact Assessment Methodology** was based on a literature review, driving task analysis and hazard identification procedure and is described in previous publications and HADRIAN documentation (<https://hadrianproject.eu/results/>).
- This paper focuses on **descriptive insights of KPIs** that were estimated through driving, eye-tracking metrics, and subjective measurements obtained during HADRIAN studies using driving simulators.
- At the final stage, a total score was calculated using **Data Envelopment Analysis (DEA)** to obtain scores for both the "baseline" and HADRIAN innovations for comparison purposes.



KPIs overview

- This **KPI-based assessment** consists of:
 - 9 KPIs related to **safety** and driving performance and
 - 9 KPIs related to the **impact on the drivers' perspectives**.
- **Descriptive statistics** were deployed in order to perform comparisons and prove the safety and impact advancements of the HADRIAN system.
- The detailed **mathematical equations** for calculating the KPIs were fully reported in the HADRIAN documentation (<https://hadrianproject.eu/results/>).

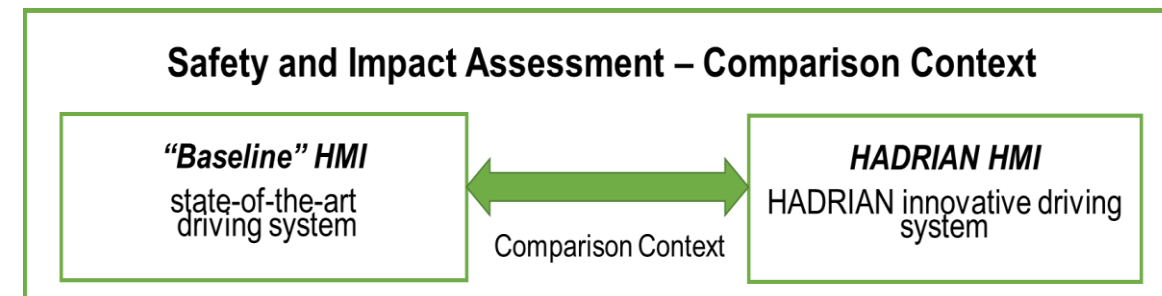
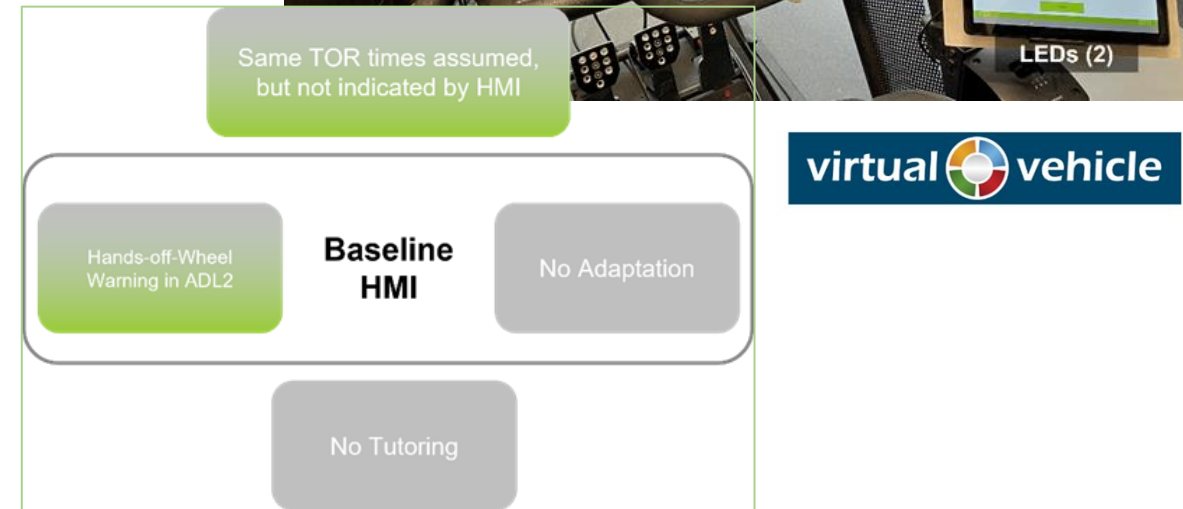


Integrated fluid HMI

- For the **driving simulator experiment**, 20 participants drove with a baseline HMI and 19 with a HADRIAN HMI titled "Integrated fluid HMI".
- The HADRIAN HMIs were compared with state-of-the-art in-vehicle systems, serving as **"baseline" HMIs**.
- The HMI with all the developed HADRIAN innovations aimed to provide better automated driving **predictability, availability, and continuity**.
- The **key feature** was; guaranteed 5 seconds for take over in Automated Driving Level (ADL) 2, and 15 seconds for take over in ADL3, the duration can be predicted through road infrastructure integration.
- **Driver monitoring** ensured that unsafe driver states were detected, while **tutoring** before and during the drive aimed at teaching the driver how to use the automated driving functions and responsibilities.



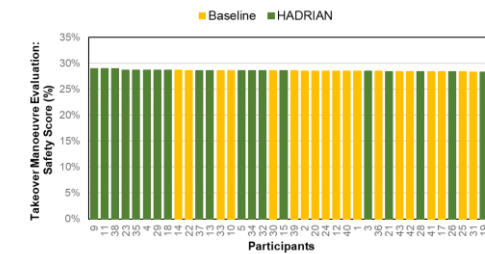
HADRIAN HMI



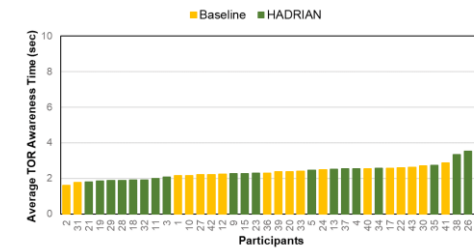
Safety KPIs

- Higher differences with a **positive effect on safety** are depicted in KPIs "Takeover Manoeuvre Safety Score", "Take Over Request Awareness Time", "Take Over Time" and "Distraction Percentage".
- HADRIAN innovations, seem to have a positive impact on **driving performance**, with reduced take-over request awareness time, increased take over time and reduced distraction percentage.
- For KPIs "Speeding Time" and "Average Speed over the Limit", participants presented a higher trend in **HADRIAN conditions**. Similarly, "Harsh Brakings" present a negative trend.

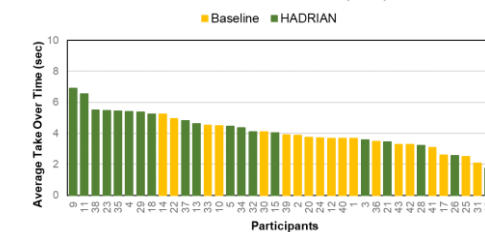
KPI 1.1 - Takeover Manoeuvre Safety Score



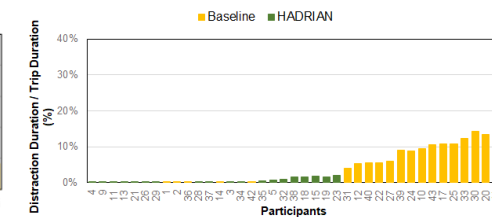
KPI 1.2 - Take Over Request Awareness Time



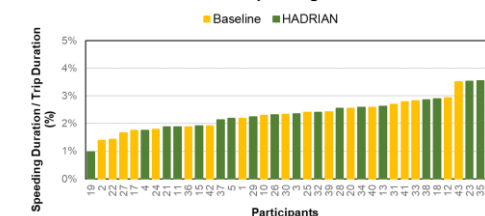
KPI 1.3 - Take Over Time (TOT)



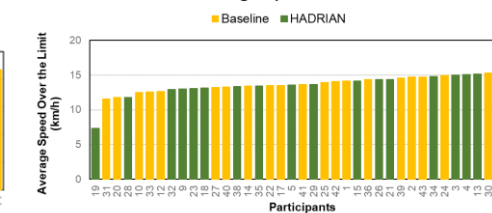
KPI 1.4 - Distraction Percentage



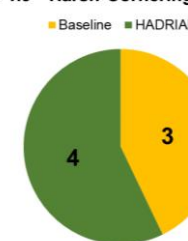
KPI 1.9 - Speeding Time



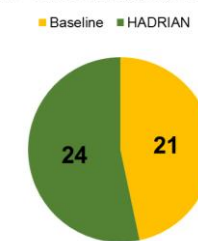
KPI 1.9 - Average Speed Over the Limit



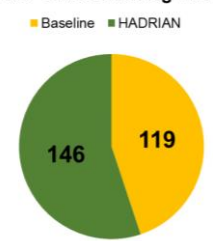
KPI 1.9 - Harsh Cornering Events



KPI 1.9 - Harsh Acceleration Events

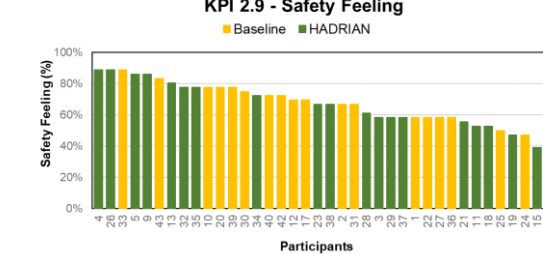
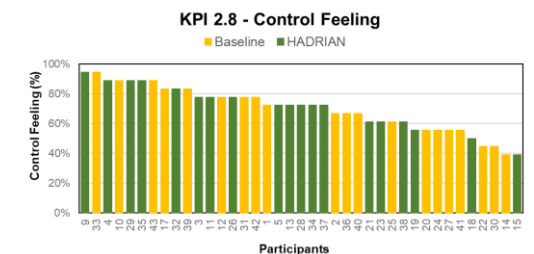
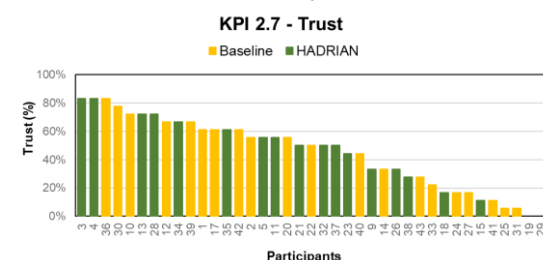
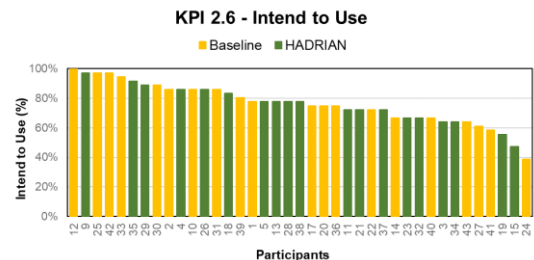
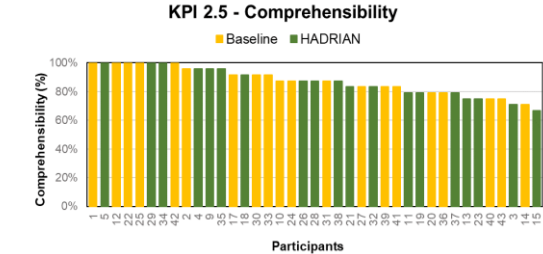
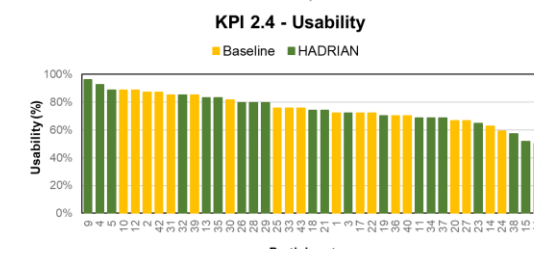
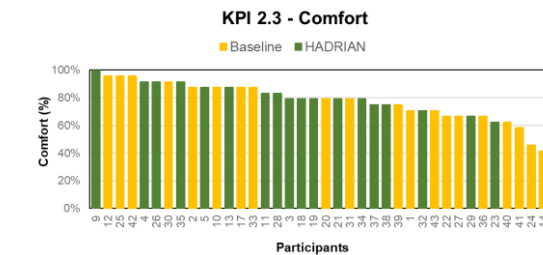
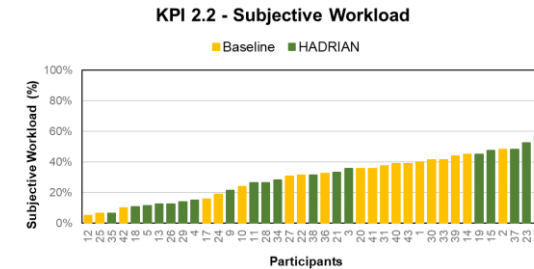
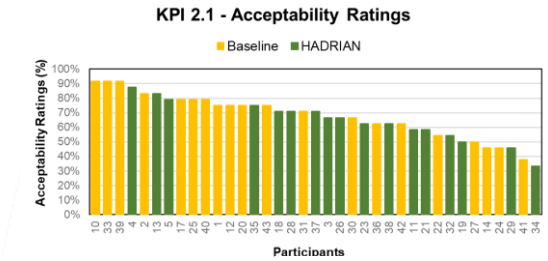


KPI 1.9 - Harsh Braking Events



Perceived impact KPIs

- Higher differences with a **positive effect** on perceived impact are depicted in KPIs "Subjective Workload", "Comfort", "Usability", "Trust" and "Control Feeling".
- **HADRIAN innovations** seem to produce participants with less mental or cognitive effort, higher convenience in use, more usability and more reliability.
- **Lower values** of KPIs "Acceptability Ratings", "Comprehensibility" and "Intend to Use" were observed with HADRIAN HMI demonstrating that the HMI was still unknown and less accepted.



Conclusions

- The results revealed that the investigated HMI prototypes **impact the interaction** between the driver and the AV for the majority of KPIs and specifically improved significantly a distinct group of important indicators.
- The aforementioned outcomes can be exploited by any other **HMI stakeholder**, in order to apply similar human-centered assessment methodologies that evaluates the way human interacts with potential HMI configurations in AVs.
- **Upcoming publications** and HADRIAN documentation reveal the next phases of this assessment with more thorough results.

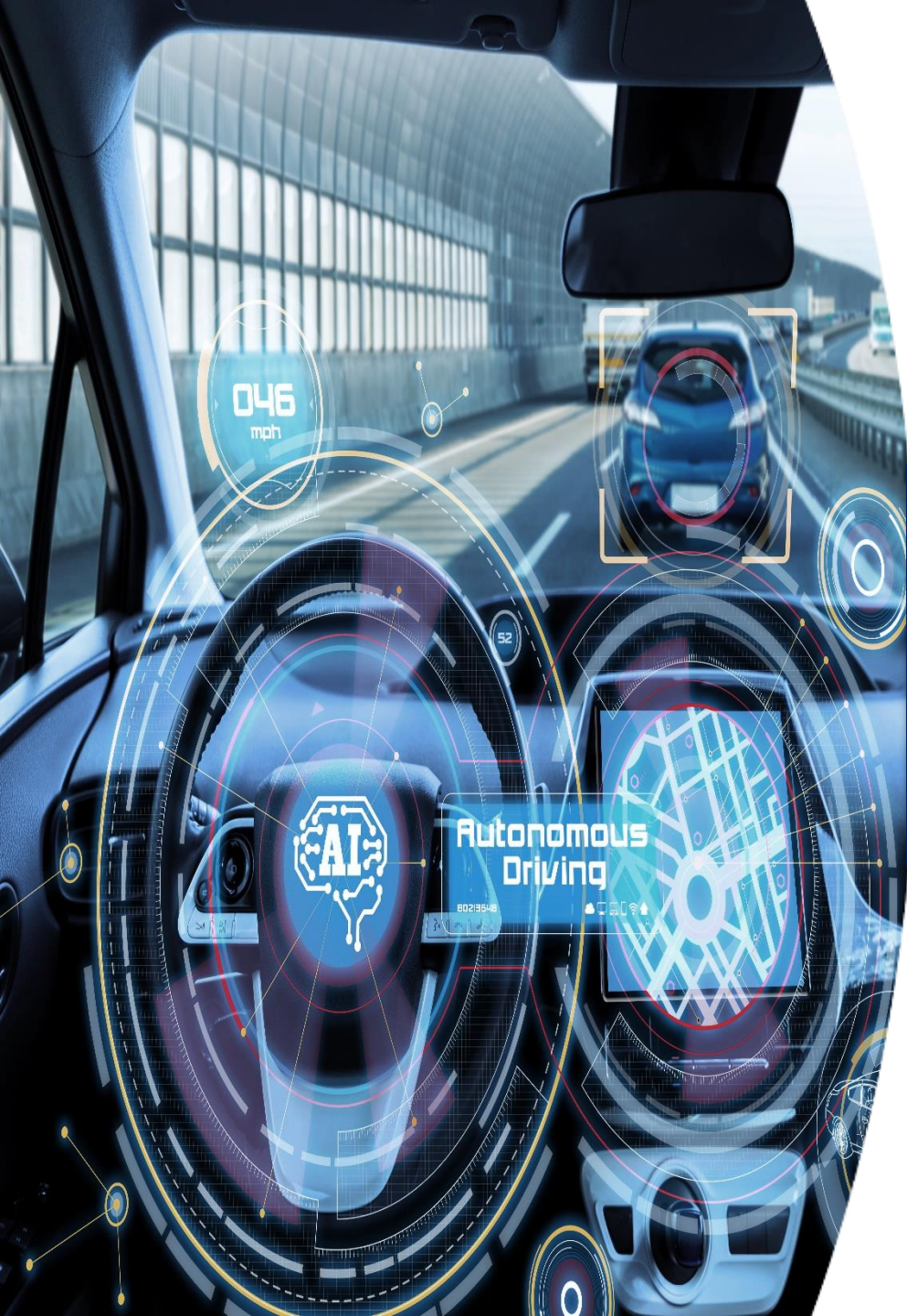
For accessing the full reports and publications of HADRIAN:



HADRIAN

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