

# Enhanced ADAS II

Public report



Project within  
Author  
Date

Trafiksäker Automatisering  
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2025-10-31



Fordonsstrategisk  
Forskning och  
Innovation

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#### FFI in short

FFI, Strategic Vehicle Research and Innovation, is a joint program between the state and the automotive industry running since 2009. FFI promotes and finances research and innovation to sustainable road transport.

For more information: [www.ffisweden.se](http://www.ffisweden.se)

## 1 Summary

This report summarizes the Enhanced ADAS II project, a three-year initiative (2022-2025) funded by FFI and undertaken by a consortium including RISE, Aptiv, and Smart Eye. The project aimed to increase the safety, acceptance, and trust in Advanced Driver Assistance Systems (ADAS) by integrating driver and cabin monitoring systems (DMS/CMS) with external sensors to create more context-aware, adaptive, and explainable systems. The core hypothesis was that by making ADAS more intelligent and their actions more transparent, user frustration from false or unnecessary warnings could be reduced, leading to higher usage rates and consequently, greater safety benefits.

The project followed an iterative, user-centered methodology, progressing through three major test cycles of increasing complexity. This approach began with foundational on-road testing with expert drivers (Test 1), moved to more technical validation evaluations on a proving ground (Test 2), and culminated in a controlled simulator study investigating driver-ADAS interaction (Test 3). This methodology allowed for the organic development of concepts, where findings from each stage informed the design and focus of the next.

Key results from the three test iterations demonstrated that: (1) an adaptive Lane Keeping Aid (LKA) that adjusts its intervention strategy based on driver attention significantly improves user satisfaction and usefulness compared to a standard LKA; (2) providing explanations for system actions through ambient light displays or on-screen visualizations significantly enhances user comprehension and acceptance; and (3) an attention-aware pre-collision warning system (Pre-FCW) has the potential to reduce the need for FCW.

The project delivered on its objectives, producing proof-of-concept prototypes, a deeper understanding of drivers acceptance of ADAS, and a set of validated methodologies for evaluating enhanced ADAS. The findings have and will continue to be disseminated through multiple academic publications, conference presentations, and student theses, contributing valuable knowledge to the fields of human factors and automotive HMI.

## 2 Sammanfattning på svenska

Denna rapport sammanfattar projektet Enhanced ADAS II, ett treårigt initiativ (2022–2025) som finansieras av FFI och genomförs av ett konsortium bestående av RISE, Aptiv och Smart Eye. Projektet syftade till att öka säkerheten, acceptansen och förtroendet för avancerade förarassistanssystem (ADAS) genom att integrera förar- och kupéövervakningssystem (DMS/CMS) med externa sensorer och kartdata för att skapa mer kontextmedvetna, anpassningsbara och förklarbara system. Den centrala hypotesen var att genom att göra ADAS mer intelligenta och deras åtgärder mer transparenta skulle användarnas frustration över falska eller onödiga varningar kunna minskas, vilket skulle leda till högre användningsgrader och därmed större säkerhetsfördelar.

Projektet följde en iterativ, användarcentrerad metodik och genomgick tre stora testcykler med ökande komplexitet. Detta tillvägagångssätt inleddes med grundläggande tester på väg med expertförare (test 1), övergick till mer tekniska valideringsutvärderingar på en testbana (test 2) och kulminerade i en kontrollerad simulatorstudie som undersökte interaktionen mellan förare och ADAS (test 3). Denna metodik möjliggjorde en organisk utveckling av koncept, där resultaten från varje steg låg till grund för utformningen och inriktningen av nästa steg.

De viktigaste resultaten från de tre testomgångarna visade att: (1) ett adaptivt filhållningssystem (LKA) som anpassar sin interventionsstrategi utifrån förarens uppmärksamhet avsevärt förbättrar användarnas tillfredsställelse och användbarheten jämfört med ett standard-LKA; (2) att förklara systemets åtgärder genom omgivande ljusdisplayer eller visualiseringar på skärmen avsevärt förbättrar användarnas förståelse och acceptans; och (3) ett uppmärksamhetsmedvetet pre-kollisionsvarningssystem (Pre-FCW) har potential att minska behovet av FCW.

Projektet uppnådde sina mål och resulterade i prototyper som bevisade konceptets genomförbarhet, en djupare förståelse för förarnas acceptans av ADAS och en uppsättning validerade metoder för utvärdering av förbättrad ADAS. Resultaten har spridits och kommer att fortsätta spridas genom flera akademiska publikationer, konferenspresentationer och studentuppsatser, vilket bidrar med värdefull kunskap inom områdena mänskliga faktorer och HMI för fordon.

### **3 Background**

Advanced Driver Assistance Systems (ADAS) are developed to increase safety, efficiency and comfort in road transport. However, studies show that users sometimes deactivate ADAS functions due to false warnings, unclear feedback, or mismatches between user expectations and system behavior. Research shows that users prioritize improvements to existing ADAS over development of fully autonomous vehicles. One promising approach to improving existing ADAS is by enriching the ADAS with improved contextual awareness by integration of Driver Monitoring Systems (DMS), Cabin Monitoring Systems (CMS) other relevant sensors, which can translate to improved support decisions e.g. alerts, warnings, interventions when the driver really needs it.

Driver inattention is a major factor in traffic accidents and research demonstrates that integrating Driver Monitoring Systems (DMS) with lane keeping aids can reduce false positive warnings by adapting intervention thresholds to driver attention levels. Drivers engaged in non-driving-related tasks (NDRTs) exhibit increased lane deviations but often remain within lane boundaries; adaptive systems that account for driver state can provide targeted support when needed and avoid unnecessary interventions when drivers are attentive. Similar approaches can be taken towards other ADAS such providing earlier and softer collision alerts about objects that the driver has not observed.

All in all, ADAS have become integral components of modern vehicles, offering features designed to enhance safety and comfort. However, their increasing complexity has led to challenges in user understanding and trust. Many drivers find ADAS features confusing or intrusive, leading to their disuse and a consequent loss of potential safety benefits. A significant factor is a lack of comprehension regarding how ADAS functions operate and their limitations.

This project was built on the hypothesis that by making ADAS more intelligent and their actions more transparent, it is possible to create a more cooperative and less frustrating interaction between the driver and the vehicle. The project aimed to increase the safety, acceptance, and trust of ADAS by developing and evaluating systems that are more aware of the driver and the driving context.

### **4 Purpose, research questions and method**

The purpose of this project has been to advance the development and evaluation of Advanced Driver Assistance Systems (ADAS) through improved sensor integration, dynamic human-machine interaction, and explainable interface design. The technical ADAS development and implementations in this project has aimed to reduce false positives while increasing true positive detections in systems such as LKA and FCW by

achieving a more comprehensive understanding of both the internal and external driving environment. This improved perceptual accuracy supports more contextually appropriate system responses and interventions.

Furthermore, the project addresses the growing need for dynamic and adaptive human–machine interfaces (HMIs) that can communicate complex system states, alerts, and warnings with suitable timing, modality, and salience. As ADAS functionalities become more complex by incorporating more sensors, their interaction strategies must evolve to ensure that users maintain appropriate levels of awareness and trust.

Finally, the work emphasizes the importance of explainability in HMI design, acknowledging that the introduced variability and adaptivity of these ADAS can otherwise be perceived as inconsistency by drivers. By embedding explainability mechanisms both in the interface design as well as onboarding and introduction to the ADAS, the project seeks to foster user comprehension of ADAS, promote correct mental models of system behavior, and thereby support sustained and safe use of the ADAS.

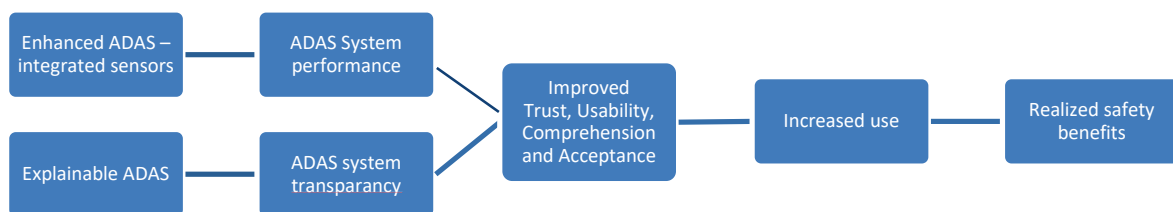


*Figure 1: Describing the parallel ADAS and HMI work leading to realized traffic safety benefits. In order to reach realized traffic safety benefits there needs to be increased ADAS use, which in turn depends on users attitude toward ADAS.*

## 4.1 Research Questions

The overarching research question was: How can ADAS be improved through integration of perception data (external and internal), and adaptive HMI, in terms of system performance and driver behavior?

Specific research questions include: (1) What types of user needs exist for increasing safety, acceptance and trust in ADAS? (2) What novel enhanced ADAS features emerge from integrating internal-, external perception, and HMI, that match user needs? (3) How do expanded data sources (DMS, CMS) affect ADAS performance (e.g., false/true positives) and driving assistance (e.g., less need for LDW, FCW, AEB)?

## 4.2 Project Execution

The project was executed over a three-year period, from October 2022 to October 2025, and was structured into five main Work Packages (WPs). The project followed its planned iterative methodology, with development and testing activities progressing in a sequence.

- WP1: Project Management: Handled coordination, meetings, and reporting. (Led by RISE)
- WP2: Use Cases and Test Planning: Defined the research questions, use cases, and detailed experimental designs for the three test iterations. (Led by Smart Eye)
- WP3: Technical Development and Integration: Focused on the development of the prototype systems, including sensor integration, algorithm development (DMS/CMS), and HMI prototyping. (Led by Aptiv)
- WP4: User Studies and Data Collection: Carried out the three main user studies, including participant recruitment, data collection, and initial data processing. (Led by RISE)
- WP5: Analysis, Results, and Dissemination: Involved in-depth data analysis, interpretation of results, and dissemination through publications and presentations. (Led by RISE)

### 4.3 Milestones

| Date    | Milestone           | Description                                                                                   |
|---------|---------------------|-----------------------------------------------------------------------------------------------|
| Q4 2022 | Project Kick-off    | Official start of the project, initial workshops, and finalization of project plan.           |
| Q1 2023 | Use Case Definition | Workshops to define partner focus areas and brainstorm initial use cases for all three tests. |
| Q2 2023 | SOA Evaluation      | Hands-on evaluation of production LKA/LC systems (Volvo/Kia) to inform prototype design.      |
| Q4 2023 | Test 1 Execution    | On-road study with 8 expert drivers evaluating the adaptive LKA and ambient light HMI.        |
| Q1 2024 | Test 1 Analysis     | Analysis of data from Test 1, leading to the first conference publication (DDI 2024).         |
| Q3 2024 | Test 2 Execution    | Proving ground study at AstaZero focusing on technical validation.                            |
| Q4 2024 | Test 2 Analysis     | Analysis of data from Test 2.                                                                 |
| Q3 2025 | Test 3 Execution    | Simulator study with 38 participants investigating explanation quality and Pre-FCW.           |
| Q3 2025 | Test 3 Analysis     | Analysis of simulator data.                                                                   |
| Q4 2025 | Final Dissemination | Final project presentations at SAFER and FFI.                                                 |
| Q4 2025 | Final Reporting     | Completion of the final project report for FFI.                                               |

## 4.4 Partner Contributions

| Party     | Contribution                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RISE      | Overall project management and coordination (WP1). Led the definition of use cases, experimental design, and test planning (WP2). Led all user studies, data collection, and analysis (WP4, WP5). Led dissemination activities and final reporting.                                                                                                                                                              |
| Aptiv     | Led the technical development and integration of the in-vehicle hardware and software platform (WP3). Provided the test vehicle (Lincoln MKZ) and the engineering expertise to implement the custom LKA, FCW, AEB, and external sensor functionalities. Contributed strongly to use case definition, data analysis and result interpretation.                                                                    |
| Smart Eye | Provided the Driver Monitoring System (DMS) and Cabin Monitoring System (CMS) hardware and software (WP3). Developed and refined the algorithms for estimating driver attention, gaze, and distraction levels. Contributed expertise in driver monitoring to the design of the adaptive functionalities. Smart Eye also developed the simulator environment (physical and digital) for the last study iteration. |

## 4.5 Methods

The project employed a user-centered and iterative design methodology, structured around three main test cycles. This approach allowed for a progressive and organic development process where insights from each phase informed the next. The methodology began with foundational work in real-world conditions, moved to controlled scenario testing on a proving ground, and concluded with a focused psychological investigation in a medium-fidelity simulator. This structure enabled the consortium to tackle the complex challenge of integrating multiple advanced systems by starting with basic integration and progressively adding more sophisticated functionalities and scenarios.

The three main studies done in this project were conducted with varying levels of ecological validity, ranging from public road field tests with expert users to controlled technical validation on a test track, and finally to simulator-based user studies with general participants.

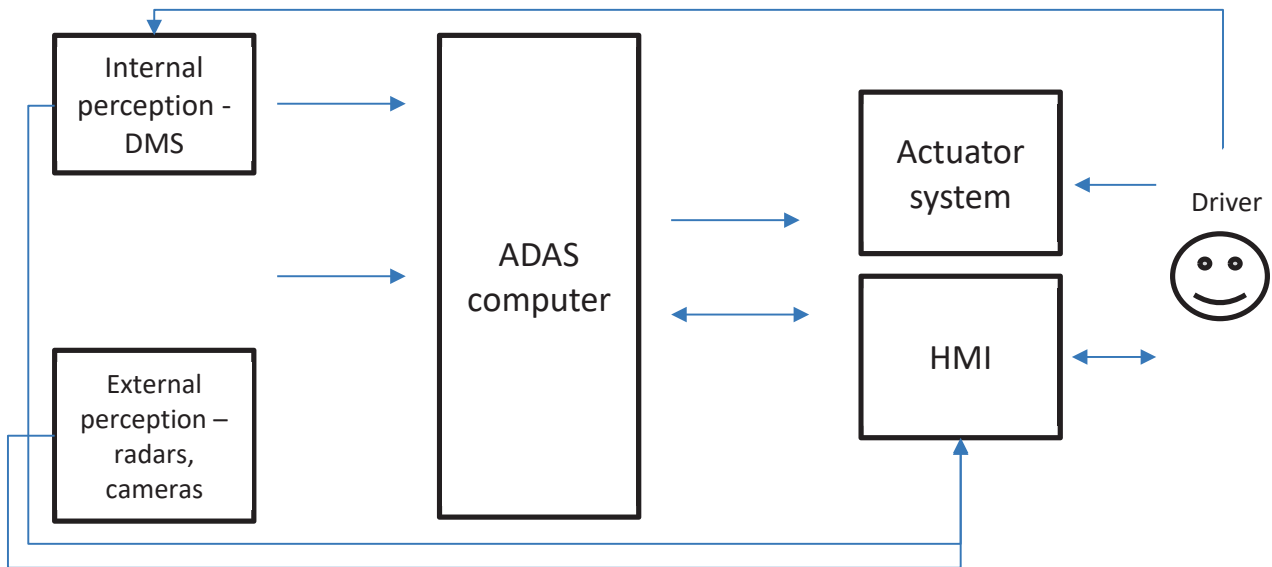


Figure 2: The integrated system architecture illustrates how data from multiple sources were fused to enable the adaptive ADAS functionalities.

## 5 Objective

The project's general objective was to develop proof-of-concept prototypes and evaluate driver support functions resulting from integration of the data sources presented in the application (DMS, CMS, external perception, map data, and dynamic HMI). Specific objectives included: (1) Understanding how traffic safety can be increased by expanding the technical system's situational picture (adding new data sources, integrating them, and employing dynamic HMI with directional audio-visual cues). (2) Defining requirements for enhanced ADAS based on new knowledge from each iteration. (3) Reporting improvements in safety, comprehension, acceptance and trust compared to prototypes tested in the predecessor project and compared to each previous iteration.

Minor changes were made in the objective set in the application of this project to the actual execution. Firstly, map data was not integrated into the investigated ADAS features. The exclusion of map data came naturally with the decision to focus on safety-critical systems rather than what is usually referred to as comfort-systems. Our decision to focus on safety critical systems were informed by participating in discussions on ADAS in international working groups.

Secondly, the scope of what is called *dynamic HMI* in the application was extended to include *explainable HMI*. This extension in scope was informed by the projects PhD students work, which indicated that adding more complexity into ADAS-activations would require more transparency and explainability towards the driver, who otherwise might experience inconsistent ADAS-activations.

## 6 Results and deliverables

### 6.1 Test-iterations:

#### 6.1.1 Test 1: Driver Monitoring System for Adaptive Lane Keeping

##### Goal

Investigate whether adapting lane-keeping aid (LKA) warnings based on driver attentiveness (using a Driver Monitoring System) combined with ambient light displays can reduce false warnings and improve driver acceptance compared to standard LKA systems.

##### Method

Eight test drivers completed four 26-km drives on public roads (mix of rural roads and highway) in a Lincoln MKZ test vehicle. Four conditions were tested: standard LKA with dashboard icon warnings, standard LKA with ambient light on A-pillars, Adaptive LKA (A-LKA) that monitored driver attentiveness and adjusted warning triggers, and A-LKA with ambient light. On highways, drivers performed controlled distraction tasks; on rural roads, they drove naturally. Acceptance, effectiveness, situation awareness, preference, trust, ease of use, and workload were measured through questionnaires (Van der Laan scale, NASA-RTLX) and semi-structured interviews.



Figure 3: Illustration of the location and shape of ambient light that showed the approach or breach of the lane line or lane edge.

##### Key Findings

Drivers strongly preferred the combination of adaptive warnings and ambient light (A-LKA + ambient), reporting it as more useful, satisfactory, and effective than standard LKA. The ambient light made warnings clearer and more comprehensible than dashboard icons. However, the improved clarity also made drivers more aware of false warnings when they occurred. The adaptive system successfully reduced false positives by considering driver attention state.

## Lessons Learned

Technically integrating driver monitoring data to suppress warnings when drivers are attentive and alert is feasible and well-received. Ambient light displays on A-pillars effectively communicate lane departure warnings peripherally. While these enhancements significantly improved subjective ratings and acceptance, the DMS must account for situations where drivers look but don't see (e.g., mind wandering) to avoid false negatives. The combination of adaptation and improved warning presentation shows promise for increasing LKA acceptance in production vehicles.

### 6.1.2 Test 2: Driver Awareness for Adaptive Emergency Braking

#### Goal

Investigate whether monitoring driver awareness (via DMS) can enable earlier collision warnings from Automatic Emergency Braking (AEB) systems in low-overlap scenarios where it's uncertain whether the driver intends to maneuver around an obstacle or is unaware of the hazard.

#### Method

Tests were conducted on a test track using a robot-controlled vehicle for centimeter-precision repeatability. Four Euro NCAP scenarios with low overlap (15-25%) were selected: CBLA, CPLA, CCRm, and CCRs. These scenarios are particularly challenging because they rely heavily on predicting driver behavior. For each scenario, the driver was instructed to either look toward the target (aware) or down into their lap (distracted). All scenarios were true positives that would result in collision without system intervention. Warning timing differences between aware and distracted states were measured.

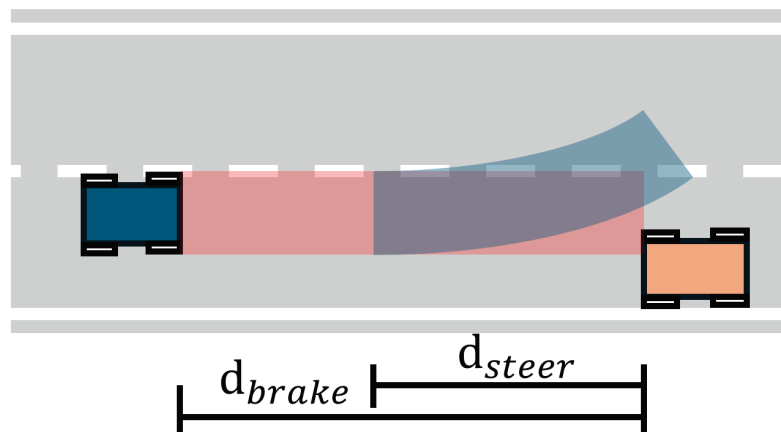


Figure 4: Illustration of how in many common speeds collision can be avoided by steering much later than braking.

## Key Findings

The system provided warnings significantly earlier when drivers were distracted compared to when they were aware (average 0.66 seconds earlier, median 0.80 seconds). This demonstrates that driver awareness can be used to adjust warning timing, giving distracted drivers extra time to assess and react while reducing unnecessary early warnings for aware drivers.

### **Lessons Learned**

Driver awareness monitoring can improve AEB feature availability and potentially reduce false positives by tailoring warnings to driver needs. The approach has limitations: it relies on "eyes on road" definitions (front windscreen and mirrors), which may not detect hazards from crossing vehicles or other road users entering from outside the monitored zones. The system could be designed for explicit use within specific operational domains where these limitations are manageable. Proper timing of warnings based on awareness shows potential for balancing safety and user acceptance.

## **6.1.3 Test 3: Attention Zone Awareness with Early Informative Warnings**

### **Goal**

Investigate whether attention zone awareness can enable graduated warnings (early informative "Pre-FCW" when driver isn't looking at hazard zone, escalating to urgent "FCW" if needed) and whether better explanations of this feature improve understanding, acceptance, and emotional response.

### **Methods**

Thirty-eight licensed drivers experienced three urban cyclist scenarios (Intersection, Parking Lot, Left Turn) in a driving simulator, each scenario run twice: once with attention awareness enabled (Pre-FCW possible) and once with only standard urgent warnings (FCW only). Scenarios were based on Euro NCAP cyclist crossing situations requiring attention outside the front windscreen. Participants were randomly assigned to receive either high-quality (comprehensive, structured) or low-quality (short, basic) explanations via chatbot before driving. Mental models, acceptance (Van der Laan), performance (warning escalation rates), and emotional response (SAM scales) were measured.

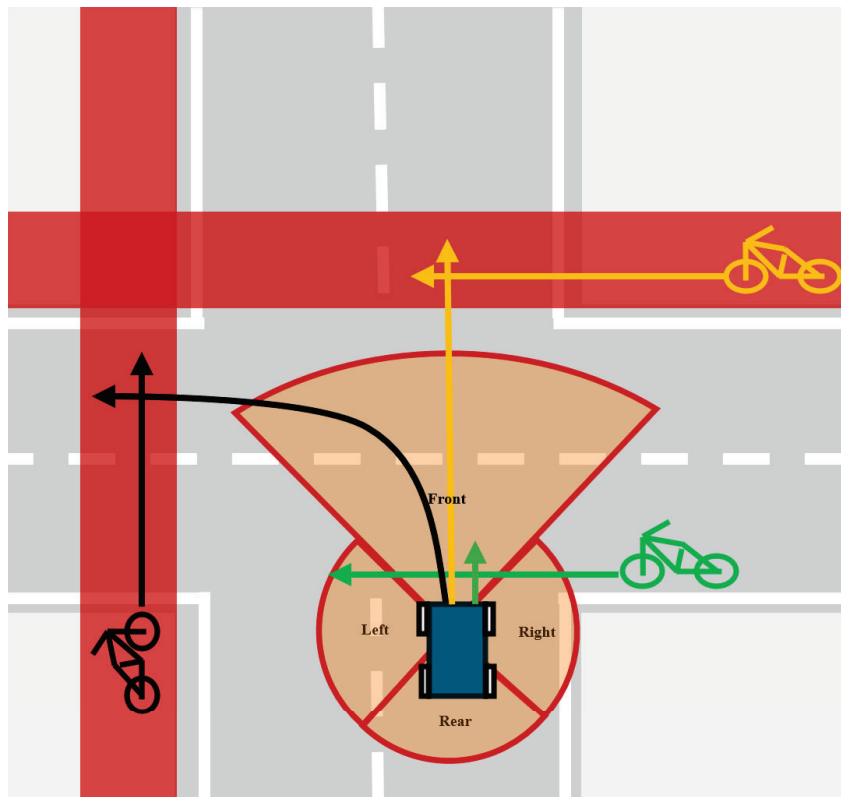


Figure 5: Illustration shows an aggregation of the three scenarios and relation to awareness zones.

### Key Findings

Better explanations improved initial understanding and acceptance, though the gap narrowed after driving experience. Early warnings successfully prevented escalation to urgent warnings in 54% of cases (ranging from 50-59% across scenarios), demonstrating practical benefit without causing different emotional responses compared to urgent-only warnings. Interestingly, better understanding after driving led to more critical evaluations of the feature.

### Lessons Learned

The "look but did not see" problem seem to affect zone awareness approaches, drivers assessed as aware may not have actually perceived the hazard, explaining high escalation rates. System performance was also affected by simulator limitations: objects occluded by environment structures or A/B-pillars remained visible to the function but not to drivers, potentially causing inappropriate warnings. Sector size granularity is challenging, too wide and the system may incorrectly assume perception; too narrow and it requires very high accuracy. The approach would benefit from line-of-sight modelling and may be best suited for specific operational design domains where false warnings are less problematic. False warnings are likely to occur in a real world application due to the combination of sensor noise and the necessary long range predictions, putting high

requirements on which data is used and how. Although similar to test 2 there may be specific operational design domains where false warnings are less probable and/or the benefits of a false warning is less problematic.

#### **6.1.4 Conclusion for all test-iterations**

Adapting driver assistance interventions based on real-time driver awareness and context offers clear value: it improves vehicle-to-driver interaction, reduces unnecessary and distracting warnings, and is preferred by users.

Non-intrusive, attention-aware feedback works best when it intuitively matches the driver's needs in the moment based on the driving environment and the driver's state. However, reliably measuring true driver awareness remains a core challenge. In order to avoid the look-but-did-not-see phenomenon, it is suggested that assessing drivers attention to threats should be done on a more granular level than what was implemented in the present studies.

Finally, explainable ADAS improve both acceptance, but the technology must deliver on its promises to maintain that acceptance. In study one, it was apparent that if less ambiguous HMI is used, its benefits will be appreciated when accompanied by a reduction in false positives, however, if it is accompanied by false positives it will be even less tolerated than standard HMI. A similar take-away was noted from test 3, where participants who received more in-depth explanations had a drastic decrease in acceptance when the system encountered failure modes.

## **6.2 Academic Work**

### **6.2.1 Bachelor and Master Thesis Work**

**Behavior Based Secondary Task Action Detection In Driver Monitoring Systems** investigated improved approaches for detecting phone-related distractions within in-vehicle monitoring systems. By collecting simulator data from a variety of secondary tasks and analyzing temporal features in driver behavior, the thesis demonstrates that explicit behavioral definitions and chronological modeling enhance system accuracy, particularly for complex and extended phone interactions. Nevertheless, detection challenges persist in cases involving occlusion or atypical object handling, and extending these results to more diverse, real-world driver behaviors is highlighted as an ongoing need.

**Upplevelse av visuell plottrighet i Augmented Reality Heads-Up Displays** explored the limits of visual clutter from AR HUD icons in vehicles, examining how the quantity and presentation of visual elements affect subjective driver experience. Through survey responses from over one hundred participants, the thesis finds that perceived clutter rises

sharply after four icons, especially in urban settings, and that thoughtful colour coding and interface design can moderate visual overload. The study recommends keeping concurrent HUD icons below this threshold and tailoring display strategies to traffic context for optimal safety and usability.

**Multimodal Interfaces for Advanced Driver Assistance Systems: Addressing the User Experience and Needs through Norm-Critical Perspectives** investigated how norm-critical and gender-inclusive approaches can improve the design and acceptance of ADAS interfaces. Using pilot studies, interviews, and practical workshops, the thesis shows that inclusive, user-centered design not only fosters positive attitudes and trust toward driver assistance functions, but also uncovers specific usability challenges and diverse user needs. It concludes that an intentional focus on diversity and social sustainability is essential for developing equitable and widely accepted driver support technologies.

### **6.2.2 Doctoral Studies up to Half-Time Seminar**

**Acceptance of Automated Driving Systems: The Role of Explainability** presents an investigation into how user comprehension and explainability influence the acceptance of automated driving systems (ADS). Combining theoretical modeling with empirical studies, the thesis presents a conceptual framework integrating explainability, comprehension, and acceptance (E-C-A), grounded in extensions of traditional technology acceptance models such as TAM and UTAUT but tailored to the automotive domain. The work emphasizes that while perceived safety, trust, and usability remain core predictors of acceptance, comprehension—achieved through clear, context-sensitive explanations plays a foundational role. Through a series of experiments involving both external human-machine interfaces (eHMIs) on heavy trucks and advanced driver assistance system (ADAS) features in simulators and real road contexts, the thesis demonstrates that enhanced explainability improves user comprehension, which in turn improves user acceptance.

However, the findings also reveal a nuanced relationship: although better explanations increase comprehension, the link to acceptance is mediated by additional factors, including system performance and user experience. Users exposed to high-quality explanations initially showed superior understanding but sometimes became more critical when system behavior did not meet expectations, highlighting the need for alignment between explanation quality and system reliability. The thesis also finds that explainability cannot be a one-size-fits-all approach; instead, explanation needs differ significantly across road user types and contexts. The proposed E-C-A model offers a structured way to map these needs along cognitive depth and explanation triggers, guiding the design of more effective, user-tailored communication strategies for ADS. Future research directions include validating these conceptual relationships in naturalistic settings and refining explanation design to support long-term acceptance and safe adoption of automated driving technologies.

## 7 Dissemination and publications

The project's results have been disseminated to a wide range of audiences through various channels. The primary target audiences are academia and the Swedish automotive industry, with secondary audiences including standardization and validation bodies and lastly, the general public. Key dissemination partners include SAFER Vehicle and Traffic Safety Centre at Chalmers, FFI, and EuroNCAP. The project has been especially successful in ensuring that the results will be of value for the automotive domain by anchoring ADAS features and test scenarios to on-going work in EuroNCAP.

### 7.1 Dissemination

#### 7.1.1 Impact:

For RISE: The project facilitated competence-building within the topic of next-generation ADAS and user needs for these systems. Moreover, methodology for evaluating these systems were developed and iterated in this project which will be built upon for future projects on the topic.

For Aptiv: The project provided insights into the system architecture for next-generation ADAS. The concepts for adaptive and explainable systems, and the methodologies for testing them, will be integrated into Aptiv's product development roadmap for automated driving solutions. The findings will help them create systems that are more likely to be accepted and used correctly by consumers.

For Smart Eye: The project served as a key testbed for advanced applications of their DMS and CMS technology. It allowed them to explore and validate new algorithms for detecting nuanced driver states (e.g., different types of inattention) and to demonstrate the value of this data for creating more intelligent vehicle systems. The results strengthen their position as a leading provider of driver understanding technology and will be used to inform the development of their future product offerings. Specifically, the insights from this project will be used in products from 2027.

For standardization and validation bodies: The project provides knowledge and methods for evaluating next-generation ADAS (with driver awareness integration) to EuroNCAP. Currently there are discussions for assessing systems that include drivers awareness towards specific potential dangers on the road in EuroNCAP for the year 2029.

For Society: The primary societal impact is the contribution to increased traffic safety. By developing ADAS that are more accepted and trusted, the project helps to ensure that these life-saving technologies are used more consistently.

| How are the project results planned to be used and disseminated?      | Mark with X | Comment                                                                                                                                     |
|-----------------------------------------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Increase knowledge in the field                                       | x           | Concepts and experience goes into other internal and joint research projects (VERDAS, ConAI, SCREENS II), as well as academic publications. |
| Be passed on to other advanced technological development projects     | x           | Concepts and experience goes into other internal and joint research projects (VERDAS, ConAI, SCREENS II)                                    |
| Be passed on to product development projects                          | x           | Concepts and experience to go into product development projects for both Aptiv and Smart Eye.                                               |
| Introduced on the market                                              |             |                                                                                                                                             |
| Used in investigations / regulatory / licensing / political decisions | x           | Experience from project have and will continue go into standardization and validation working group discussions.                            |

### 7.1.2 Publications

- Rizgary, D., Strand, N., Brandt, V., Larsson, E., Davidsson, E., & Burman, F. (2024). Driver Monitoring Based Lane Keeping Aid for Improved User Acceptance. 9th International Conference on Driver Distraction and Inattention (DDI2024).
- Rizgary, D., Strand, N., & Andersson, J. (2023). Proving ground evaluation of enhanced ADAS: context understanding ADAS. International Conference on Applied Human Factors and Ergonomics (AHFE).
- Bergström, M. (2024). Behavior Based Secondary Task Action Detection In Driver Monitoring Systems. <http://hdl.handle.net/20.500.12380/308730>
- Karlsson, L., & Sjöström, A. (2024). Upplevelse av visuell plottrighet i Augmented Reality Heads-Up Displays.
- Tanha, M. (to be published). Multimodal Interfaces for Advanced Driver Assistance Systems: Addressing the User Experience and Needs through Norm-Critical Perspectives
- Rizgary, D. (journal paper to be published 2026). Situating Comprehension into ADS Acceptance: A Conceptual Model.
- Rizgary, D. (journal paper to be published 2026). Explainability and Acceptance of an Attention-Aware Forward Collision Warning System
- Rizgary, D. (journal paper to be published 2026). Exploring Explainability of External Interfaces to Support On-Ramp Encounters Between Motorists and Heavy Automated Trucks
- Rizgary, D. (journal paper to be published 2026). Exploring Abstract Light-Based Interfaces to Enhance Explainability of Heavy Automated Trucks

- Rizgary, D. (journal paper to be published 2026). Do You Get It? Relationship Between Explainability and Acceptance of Novel ADAS Features

### 7.1.3 Presentations

- SAFER Lunch Seminar (Oct 2023)
- FFI conference (May 2023)
- Applied Human Factors and Ergonomics Conference (May 2023)
- Driver Drowsiness and Inattention Conference (Feb 2024)
- SAFER Research Day (May 2025)
- FFI Programrådet (Nov 2025)

## 8 Conclusions and future research

The Enhanced ADAS II project has successfully met its objectives, delivering insights into the design and evaluation of context-aware driver assistance systems. By integrating data from driver monitoring and the external environment, the project has demonstrated that it is possible to develop ADAS that are more effective, less intrusive, and better accepted by users.

The main conclusions are:

- 1 Adaptive systems are preferred: Drivers consistently prefer systems that adapt to their state of attention. Reducing false and unnecessary warnings is a key factor in improving user acceptance and preventing users from deactivating safety systems.
- 2 Integration is feasible but complex: The project successfully integrated multiple data sources to create context-aware functionalities. However, this integration requires significant resources and careful consideration of potential new failure modes, such as the “Looked but did not See” problem or sensor occlusion.
- 3 Explainability increases user acceptance: Increasing transparency of ADAS perception, functionality, decision making, and failure modes to drivers leads to increased willingness to use the system, but at the same time driver’s become more sensitive to unexpected system behavior when they have a better understanding of the ADAS.

Based on the findings and lessons learned, future research should focus on:

- Long-term studies: Evaluating the long-term effects of these adaptive systems on driver behavior, trust calibration, and safety over weeks or months of use.
- Finer granularity in driver awareness: Improving the granularity of the driver awareness sectoring to better distinguish awareness to specific threats in the environment rather than large sectors in the environment and to address challenges like the “Looked but did not See” phenomenon.
- Personalization: Exploring how these systems can be personalized to individual driver preferences, abilities, and mental models.

- Standardization and Regulation: Continuing to engage with bodies like EuroNCAP and ISO to contribute to the development of standards and testing protocols for these enhanced ADAS features.

## 9 Participating parties and contact persons

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