1 Publishable summary

1.1 Project context and objectives

The objective of AdaptIVe is to develop and demonstrate new functionalities provided by partially-automated and highly-automated vehicles. These applications cover different speed regimes and driving scenarios and aim at improving safety, energy efficiency, dependability and user-acceptance of automated driving. In order to meet this general objective, AdaptIVe considered seven major tasks:

1. Extend the range of possible situations for the application of automated driving
    - Focus on supervised automated driving n highway scenarios, urban-traffic and close-range manoeuvres.

2. Enhance the perception and communication capabilities
    - Implement features regarding the sensor platform, communication to other vehicles or to the infrastructure.
    - Improve safety in potentially dangerous situations by cooperative manoeuvres.

3. Develop solutions for cooperative control addressing driver needs
    - Ensure continuous interaction between human and automation.
    - Obtain and evaluate guidelines for implementation.

4. Design and demonstrate resilient behaviour for the applications
    - Develop fail-safe architecture and an automated function to bring the vehicle on a halt.
    - Implement support functions according to the infrastructure and driver capabilities.

5. Improve the safety and adaptability of automated driving
    - Integrate solutions for driver status monitoring.

6. Develop and apply specific evaluation methods
    - Develop new methods for the technical and the user-related assessments.
    - Evolve new methods for the analysis of safety and environmental impacts at European level.

7. Provide guidelines on legal aspects
    - Analyse the legal framework for an introduction of partially and highly automated system into the market.
    - Establish requirements for the safety validation and specifying qualifications for system availability.

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1.2 Work performed

Overall, the project work was in-line with the plan outlined in the DOW. A summary of the activities for each subproject is given hereafter:

SP2 Response4

The focus of SP2 was on safety validation and legal topics in order to identify legal barriers which could hinder or substantially delay the introduction of automated vehicles.

The analysis of safety validation aspects progressed towards the definition of methods to assess the safe and reliable operation of a system at the end of the development phase. The investigation of approaches in other industries was concluded and further work was done on the impact of sensor limits.

Regarding legal issues, the work addressed the identification of legal challenges, from civil liability, to data privacy and security law. Due to the need of a highly specialised knowledge, a law firm supported the work as subcontractor.

The study on privacy issues concentrated on investigating what obligations must be fulfilled by automated private vehicles equipped with data recorders, in order to comply with the legal requirements on personal data protection. At first, general principles and requirements were analysed, as set by the European Regulations. Then, the study focused the specific questions raised by data recorders on automated private cars, such as the nature of the data stored as well as the modalities and purposes of the storage.

After a very detailed examination and approval by legal experts, the work done in SP2 was documented in two deliverables D2.2 and D2.3.

In addition, two internal reports were released to the Commission and Reviewers providing supplementary insight into the work done: I-5 (Proposal for methodology on safety validation) and I-9 (Preliminary definition of legal aspects on automated driving).

SP3 Human-Vehicle Integration

This subproject concluded the series of experiments on several modes of cooperation between drivers and automated applications in different driving scenarios (WP35). In total 18 experiments were finalised including 12 simulator studies, 3 test track studies, international surveys, and a study on benchmarking vehicle automation systems on the market. The main topics under investigation were: driver in/out of the loop, driver state, distraction and secondary tasks, transitions, shared control, HMI. Overall, these

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studies covered the four categories defined in AdaptIVe: Agent State, Awareness, Arbitration, and Action. The corresponding deliverable D3.2 was submitted.

The work on Human Factors recommendations (WP34) was focused - in collaboration with the vertical subprojects - on a study of the HMI solutions in the demonstrators, and how they substantiate the research findings within SP3. The term "requirements" was changed to "recommendations", in order to better describe the idea of providing a set of guidelines. The Human-Factor recommendations were refined and structured in a new improved framework. The catalogue of recommendations (Deliverable D3.3) was submitted.

SP4 Automation in close-distance scenarios

SP4 equipped two demonstrator vehicles and one test car supporting the design and development of the functions for close distance scenarios and parking. A major part of the work regarded sensor fusion and perception (WP45) with a focus on digital maps created from blueprints (OSM format), on object contour classification and on the creation of accurate ground-truth data, using a lidar and SLAM techniques. At the same time various advanced areas have been studied like radar-based height measurement, estimation of the alignment of the parking slots, and methods for describing the layout of the parking area.

The application development (WP46) concentrated on the installation of HW, especially the sensor platform. This work included accurate calibrations of the sensors and testing of localisation procedures with high precision. A key activity was the enhancement of trajectory control and stability. Other important work regarded to the valet parking system and the minimum risk manoeuvres.

Vehicle owners with the support of research institutions conducted several tests in parking areas on both the Daimler car in Ulm and the Ford car in Aachen. The IKA test vehicle, conceived as a support to the evaluation, was fully developed and tested. For all the vehicles, key parking situations were demonstrated at the Final Event of AdaptIVe.

SP5 Automation in urban scenarios

Three passenger cars have been developed by SP5 for automated driving in an urban environment. One of them is shared with SP6. The activities of interest were concentrated on work packages WP55 and WP56, regarding the equipment of the cars with all the components (sensors, cables, bus distribution, processors, HMI, etc.). The major part of the work was devoted to the development of sensor data fusion (WP55). In this area, all partners (BMW, CRF, VCC) dedicated significant effort

(jointly with suppliers and research partners) to enhancing the environmental models and the sensor platforms.

The application development (WP56) proceeded in parallel, leading to the final implementation of the three demonstrators. The more relevant activities were: the integration and testing of SW modules in the vehicles, the improvement of the vehicle control modes, the development of the co-driver concept ,and the integration of different functions, especially for the BMW demonstrator used in both urban and motorway scenarios.

Activities of the testing phase allowed to obtain an overall validation of the systems. Several representative manoeuvres were tested on both private tracks and different public roads. The autonomous driving functionalities were successfully demonstrated during the Final Event in Aachen.

SP6 Automation in highway scenarios

SP6 has equipped four vehicles (one in common with SP5) demonstrating automated driving at high speeds in highway scenarios. The work on architecture and specifications (WP64) was completed with studies on the functional safety measures (especially finalised to lane-change manoeuvres) and on advanced concepts for the sensor architecture. The development of sensor fusion and perception (WP65) addressed various use cases of interest, as well as solutions based on redundancy for the minimum risk manoeuvre. The implementation work (WP66) continued with a focus on system integration, up to the obtainment of demonstrator vehicles ready for the evaluation. . Here, a special focus was given to cooperative manoeuvres, like merging on highways using V2V communication. Joint work with the other vertical subprojects was put in place for these topics.

The final testing (WP67) was concentrated on the overall vehicle control (BMW), Lane-Change applications (CONTI) and cooperative manoeuvres (VW and VTEC).

Final demonstrations on public roads were performed during the Final Event in Aachen.

SP7 Evaluation

After finalising the evaluation framework, this subproject addressed several specific issues affecting the assessment phase (WP74). Thus, in collaboration with vehicle owners, methodologies and schedules were adapted and finalised, while considering the demonstrator requirements as well as the different approaches needed for event based versus continuously operating functions.

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The subsequent evaluation work (WP75) involved several aspects: (i) Verification of the evaluation tools, like signal acquisition techniques, observation protocols and questionnaires, automated data processing; (ii) Selection of the most suitable demonstrators for each assessment category: technical, user-related, in-traffic; (iii) Definition of detailed test schedules via extensive discussions with the partners; (iv) Execution of the tests in the different environments; (v) Evaluation of results leading to conclusions on the current performance of the automated functions. The planned experiments were executed in cooperation with the vertical subprojects. The tests involved all the demonstrators with a subdivision of tasks and functionalities under examination per vehicle.

Concerning the impact analysis (WP76), a simulation based approach was implemented and two domains were analysed: traffic scenarios at the macro level for safety and environment; specific driving situations for safety. This work was prepared by collecting a number of data as input for the investigation (e.g.: traffic in European countries, driving populations, accidents). Possible limitations of the method were pointed out. The models were refined and applied to the automated functions of the project, using the results of the previous assessments as a basis. The work provided a safety impact assessment, focusing the traffic safety aspects of the automated driving functions, and an environmental assessment, focusing the energy demand and travel times respectively. The outcome of SP7, as a key result summing-up the whole work of the project, was documented in two deliverables D7.2 and D7.3.

SP1 – IP management

Activities in SP1 addressed all the management processes to ensure a good collaboration in the project and achievement of the expected results. The cooperation among partners was good, with frequent interactions. SP1 also dedicated special effort to the preparation of the Final Event.

The main activities of IP management in the period were:

IP coordination: The second Project Review was organised in Aachen on April 7th-8th, 2016. The General Assembly, together with several SP meetings, was held in Athens (April 20-21, 2016). The Assembly was followed by a Technical Workshop (April 21-22, 2016) open to external speakers and attendees representing different stakeholders. SPL face-to-face meetings and phone conferences were regularly arranged in the period to assure a proper coordination of project work and to discuss the management, technical and dissemination issues, especially organisation of the Final Event.

Operational management and finance: The second and the third contract amendments were finalized and approved by the EC. The consortium was supported in all reporting tasks. The Periodic Report PR2 was prepared and submitted to the EC in conjunction with the corresponding cost claim session. After approval of the cost claim session, funding to be transferred to the partners was calculated and checked. Financial and administrative topics were prepared and presented during the 2nd Technical Review and Final Review. All internal communication tools: mailing lists, document repositories in Redmine and NEF were continuously maintained.

Technical management support: The Technical Expert Group supported the interaction of subproject activities with a focus on V2X communication, perception and the definition of manoeuvres to a safe condition. The members were active in the peer review of deliverables and in providing guidance for IP level reports. The Group was especially involved in the preparation of the Technical Workshop, including the choice of speakers, quality review of the presentations, management of the meeting and preparation of the assessment report after the event. The group supported the definition of follow-up actions after the 2nd Project Review and contributed to the preparation of the Final Event, within the dedicated SP1 team.

Dissemination and exploitation: The partners continued their presence during industry events and organised a Special Interest Session PR08 "European efforts on automated driving: findings from ongoing research" for the 11th ITS European Congress on June 6th-9th, 2016 in Glasgow, as well as a Special Interest Session "SIS 47 Automated Transport Systems: How far are we?" for the 23rd ITS World Congress on October 10th-14th, 2016 in Melbourne. A number of changes were made in existing printed dissemination material, which was subsequently reprinted and re-distributed among partners. The work on the preparation of the AdaptIVe video, involving all demonstrators built-up in the project, with shootings in different countries around Europe, was concluded: the video was released on September 1th, 2016 and distributed through project website, AdaptIVe Youtube and Vimeo channels. The AdaptIVe Final Event // Driving Automation was organised and successfully held in Aachen, on June 28th-29th, 2017 with more than 250 experts from 20 countries all over the world. The event offered automated driving demonstrations in and around Aachen, a dedicated conference and an exhibition showing 54 project posters and 13 videos.

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1.3 Final results

The following main results were achieved in the period:

- The second and the final Project Reviews had a positive outcome, with an assessment of "Excellent Progress".

- The whole Consortium could interact and receive information at the 2nd General Assembly.

- All due project deliverables, two internal reports I-5 and I-9, and an account of the Legal Aspects Workshop were submitted. The planned Milestones were reached.

- A round of experiments on Human Factors for Automated Driving was conducted, and their results analysed. Guidelines on Human Factors were defined, according to a comprehensive framework.

- Overview provided of techniques for validating the safety of automated driving.

- Evaluation of key findings from the experiments on Human Vehicle Integration done.

- Recommendations made regarding Human Factors issues for automated driving, together with an analysis of the corresponding applications in the project.

- Automated driving functions implemented into eight demonstrators vehicles with novel concepts regarding sensor fusion, functional integration, and driving strategies for different road environments.

- Acquisition of a good fraction of data for the comprehensive technical and user-related evaluation in the three scenarios: parking areas, cities and highways.

- An extensive definition of the evaluation plan, including the finalisation of methodologies for the technical assessment, user-related assessment and impact analysis. Corresponding test and evaluation tools were identified and verified. Simulations for the impact analysis available and checked in the three scenarios.

- Wide dissemination of project concepts and achievements in several events at international level. AdaptIVe Final Event // Driving Automation successfully held.

1.4 Project public website

https://www.adaptive-ip.eu/

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