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Pilot Execution Plan

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Authors

Luisa Andreone, Nereo Pallaro, Pandeli Borodani, FCA-CRF
Francesco Bellotti, Università degli Studi di Genova
Mehrdad Dianati, Uni. Warwick
Hristiyan Stoyanov, EICT
Elias Demirtzis, APTIV
Julian Schatz, AUDI AG
Viktoria Mayr, BMW
Frederic Christen, FORD
Robert Kastner, Honda
Adrian Zlocki, IKA
Natalia Neila, Jaguar Land Rover
Jean Luis Sauvaget, PSA
Yves Page, Renault
Nicolas Vignard, Toyota Europe
Mats Petersson, Volvo Cars
Aria Etemad, Silviu Homocenanu, VW

Coordinator

Aria Etemad
Volkswagen Group Research
Hermann-Münch-Str. 1
38440 Wolfsburg
Germany

Phone: +49-5361-9-13654
Email: aria.etemad@volkswagen.de

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www.L3Pilot.eu

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Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Background to the L3Pilot Project

Over the years, numerous projects have paved the way for automated driving (AD). Significant progress has been made, but AD is not yet ready for market introduction. Nonetheless, the technology is rapidly advancing and is currently at a stage that justifies the pilot testing of automated driving.

Automation is not achieved simply by integrating more and better technology. The implementation of automation and deployment of automated vehicles on our roads needs a focus on understanding driver behaviour, willingness to use, and acceptance of automated driving systems, both from the perspective of the driver and the wider society. User acceptance is one key aspect of the successful deployment of ADFs, in addition to other factors such as understanding the legal challenges and restrictions, which need to be discussed and solved in this context. It is also crucial to investigate the technical feasibility of novel automated driving systems.

L3Pilot is taking important steps towards the introduction of automated cars in everyday traffic. The project will undertake large-scale testing and piloting of AD with developed SAE Level 3 (L3) functions (Figure 1.1) exposed to different users, including conventional vehicle drivers and Vulnerable Road Users (VRUs), in mixed traffic environments along different road networks (SAE, 2018). Level 4 (L4) functions and connected automation will also be assessed in some cases. It should be noted that an important distinction between Level 2 and Level 3 systems is the shift in supervising responsibility from the human to the AD system (SAE, 2018). With a Level 2 function, the task is on the human in the driver's seat to constantly supervise the driver support features, and the human is driving even when the feet are off the pedals and he/she is not steering. With a Level 3 function, the human is not driving when the AD features are engaged but he/she must drive when the feature requests. This difference means that there is a considerable change in the technical capabilities of a Level 3 automated driving function (ADF) compared to Level 2.

Extensive on-road testing is vital to ensure sufficient AD function operating performance and to allow an assessment of ongoing user interaction with and acceptance of the system. A large and varied sample of test user needs to be involved in this work, to ensure effective piloting, testing, and evaluation of ADFs.

L3Pilot will investigate four ADFs performing automated driving tasks in three driving environments: motorway, urban, and parking. In the motorway environment, there will be functions capable of either performing high-speed driving or operating in traffic jams, or both. In this project, L3 systems of this type will be termed "chauffeurs", for example a *Motorway Chauffeur*. L4 systems will be termed "pilots", for example a *Motorway Pilot.* However, this distinction does not necessarily reflect the publicly marketed names of the AD functions.

Figure 1.1: SAE Levels of Driving Automation J3016, June 2018 (Copyright 2018 SAE International).

The data collected in these pilots will support the main aims of the project, which are to:

- Lay the foundation for the design of future, user-accepted, L3 (and L4) systems, to ensure their commercial success. This will be achieved by assessing user reactions, experiences, and preferences relating to the AD systems' functionalities.
- Enable non-automotive stakeholders, such as authorities and certification bodies, to prepare measures that will support the uptake of AD, including updated regulations for the certification of vehicle functions with a higher degree of automation, as well as incentives for the user.
- Create unified de-facto standardized methods to ensure further development and testing of AD applications (Code of Practice).
- Perform detailed data analysis to show the performance and effects of ADFs in all relevant conditions, in terms of weather, visibility, and traffic volumes within the current Operational Design Domain (ODD).

The consortium addresses the four major technical and scientific objectives listed below:

1. Create a standardized Europe-wide piloting environment for automated driving.

2. Coordinate activities across the piloting community to acquire the required data.

3. Pilot, test, and evaluate automated driving functions and connected automation.

4. Innovate and promote AD for wider awareness and market introduction.

The L3Pilot consortium brings together stakeholders from the entire value chain, including original equipment manufacturers (OEMs), suppliers, academic and research institutes, infrastructure operators, governmental agencies, the insurance sector, and user groups. More than 1000 users will test L3Pilot vehicles across Europe.

The work in L3Pilot is structured into different subprojects that deal with different aspects. An overview is given in Figure 1.2.

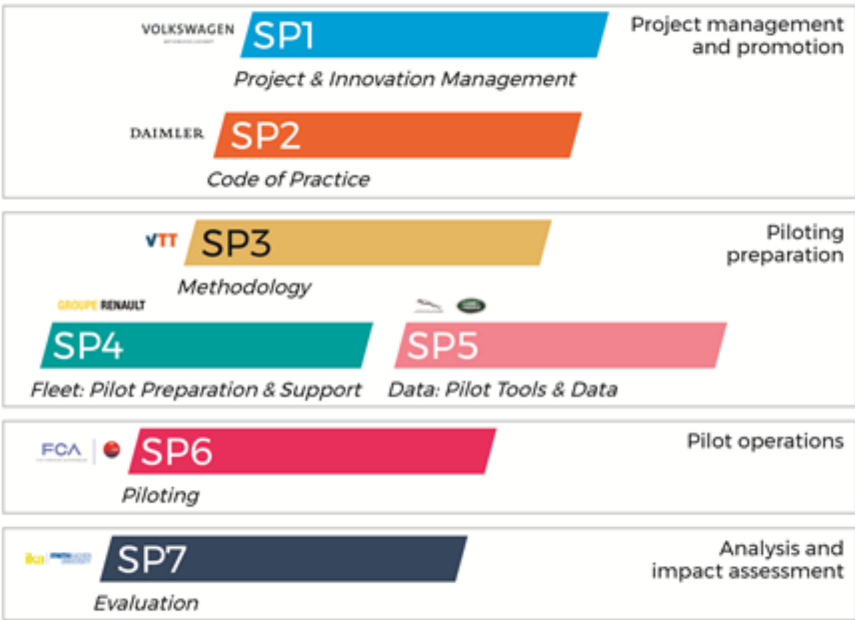

Figure 1.2: Project structure of L3Pilot.

This report focuses on the work of the L3Pilot SP6 Piloting subproject, which is closely linked to the work that will be done later in the evaluation subproject.

The key in Piloting is to ensure that the performance is consistent, reliable, and predictable and that the functionality of the systems used is exposed to variable conditions. This will enhance a successful experience for the users. A good experience of using AD will accelerate acceptance and adoption of the technology and improve the business case to deploy AD. Figure 1.3 shows the L3Pilot timeline at a glance.

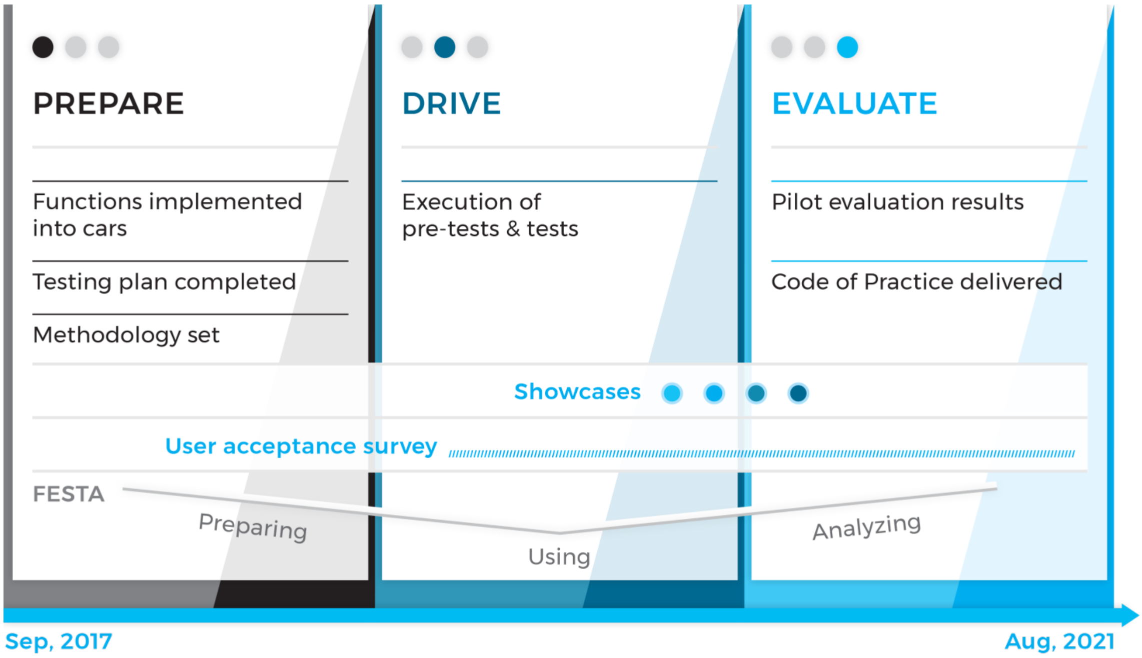

Figure 1.3: L3Pilot timeline.

Vehicles will be tested across Europe with bases in several European countries, including:

Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Sweden, and the United Kingdom. Since the development of ADF, especially at SAE L3, is fairly well advanced, the aim is not only to test and demonstrate the functions, but also to study user preferences, reactions, and willingness to use vehicles equipped with AD applications in the pilots. The L3Pilot concept can be split into the following two large parallel, but interconnected, activities:

(i) Development of test and evaluation methodologies, and actual testing and evaluation of L3 (and L4) ADFs, to answer the need to evolve SAE L3 towards deployment and to reply to the call text open questions. In this scientific part, a variety of controlled experiments will be carried out at each pilot site.

(ii) Promotion of the project work to maximize the impact. This includes dissemination of the project results and communication to the public, through showcases, to accelerate the deployment of AD. The L3Pilot showcases are:

- Showcase 1: Dynamic pit stop – Software Defined Vehicles, already held at the EUCAR Reception & Conference 2018 in Brussels
- Showcase 2: L4V2X – Connected automated vehicles (2019)
- Showcase 3: Urban driving + Automated parking (2020)
- Showcase 4: Cross-border driving – Motorway automation (2021).

1.2 Methodology and Evaluation

The project follows the FESTA V process methodology of setting up and implementing tests, and adapting the methodology to suit L3Pilot needs, with the four main pillars as follows: (i) Prepare, (ii) Drive, (iii) Evaluate, and (iv) Address legal and cyber-security aspects. FESTA was originally created as an ADAS testing methodology to be used in Field Operational Tests (FOTs). L3Pilot adapted it to piloting ADFs.

Once functions and use cases were determined, Research Questions (RQs) and Hypotheses (HYPs) were formulated. The piloting is mainly focused on RQs and HYPs in the selected impact areas (Figure 1.4): driver behaviour, user experience, mobility, safety, efficiency, environment, and socio-economics. Legal aspects and cyber security are important aspects of the project and are being handled within the SP4 Pilot preparation subproject.

In the evaluation stage, a holistic approach will be applied when analysing different aspects of AD based on real world driving data. As such, the approach will follow the FESTA evaluation domains: technical, user acceptance, driving and travel behaviour, impact on traffic, and societal impacts.

However, in addition to different evaluation aspects, another dimension is needed: for instance, the analysis of driving situations is locally limited to the surrounding traffic, road environment, and other environmental conditions, such as weather. Hence, this is an analysis on single vehicle and fleet levels, whereas a European level is required, using aggregated data and statistics. The holistic evaluation approach of L3Pilot considers aspects in all dimensions: single vehicle, fleet, and European. Investigating fleets in different pilots will allow L3Pilot to analyse certain intercultural differences in the interaction with and user acceptance of AD applications. The evaluation will also take into account the fact that the test vehicles are not market-ready products.

Specifically, the analysis of the technical performances focuses on the situations in which AD functions operate within and outside their specifications, taking into account potential misuse and the operational limits due to environmental conditions.

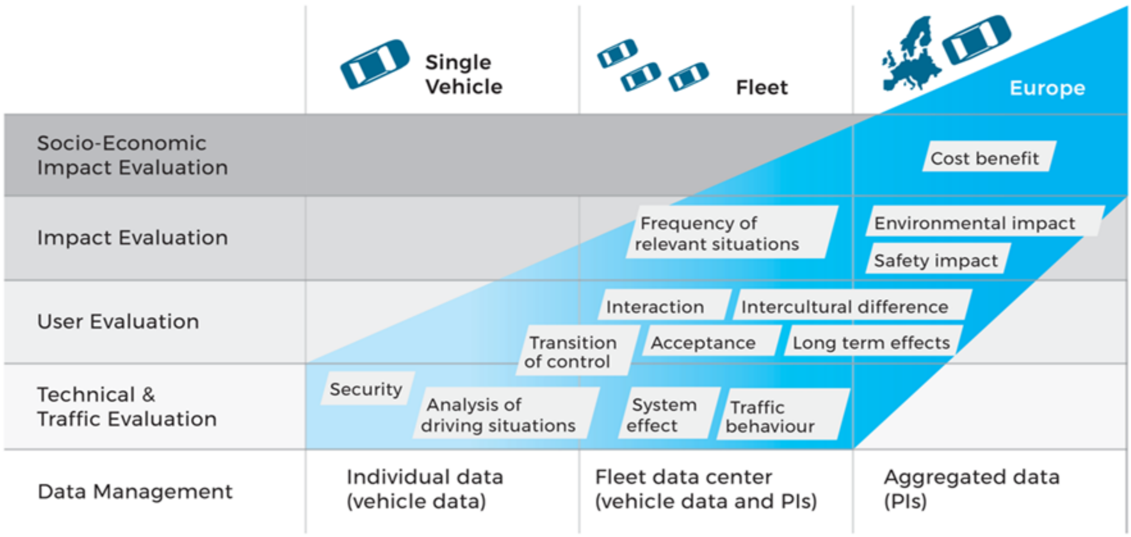

Figure 1.4: Process for evaluation in L3Pilot.

2 Introduction to Piloting Plan

2.1 Background

Road tests are an indispensable part of the vehicle development chain. For AD functions, intensive road testing is essential to bring vehicles towards deployment maturity and to assess driver behaviour and user perspectives in real context. It is common practice that testing of new systems is typically broken up into four stages: System and off-road safety testing, Pilot Testing, Field Operational Testing (FOT) and Naturalistic Driving studies (NDS). Pilot projects, FOTs, and NDS all involve vehicles being driven on public roads, in real and varying traffic conditions.

Pilot projects are pre-deployment projects and are therefore expected to demonstrate how services can be deployed beyond the scope and duration of the testing phase towards a general use in ordinary traffic. They involve moderate to extensive road trials, under different conditions, often with professional drivers (i.e. drivers with the qualification to drive testing vehicles). An FOT, on the other hand, is a study employing series production vehicles undertaken to evaluate a function, or a group of functions, under normal operating conditions in environments typically encountered by the vehicle(s) using quasi-experimental methods (Barnard et al., 2017). NDSs investigate real traffic situations and provide useful information for critical events, (near-) crashes, as well as normal driving in mixed traffic situations, and allow evaluation of the impacts of technologies in everyday driving and mobility behaviour.

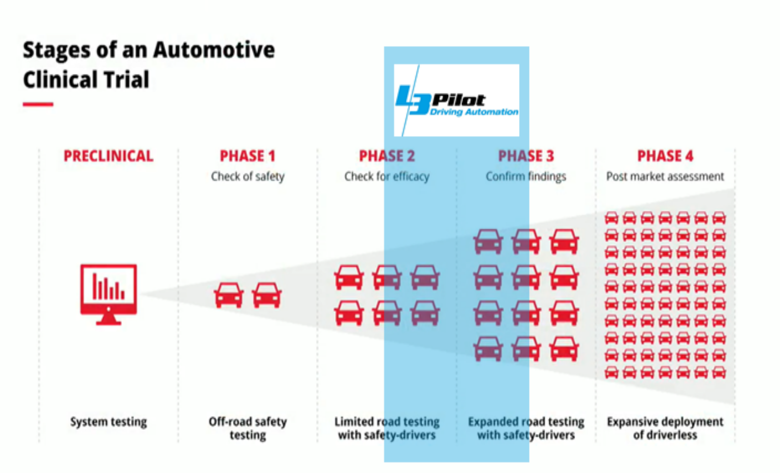

Figure 2.1: Stages of an automotive clinical trial (Reimer, 2018).

L3Pilot covers Phases 2 and 3 (Figure 2.1) of the stages of an automotive clinical trial. It aims to check efficacy of the new AD functions and to confirm the findings with moderate to extensive road testing, normally with trained (safety) drivers (i.e. professional drivers that act as safety drivers, e.g. with double pedals and steering wheels). As per its name, the project focuses on pilot testing, applied in different locations and circumstances and thus not necessarily producing test results that are fully comparable across different test sites. The main methodological approaches have been agreed in SP3 and reported so far in D3.1 and D3.2.

In order to deal with the challenge and complexity of the pilot execution, the L3Pilot project includes a subproject – SP6 Piloting – that is specifically dedicated to managing piloting activities across the European test sites. It also ensures that the developed methodology and defined time-plan are adhered to, while guaranteeing consistency of data to be transferred to SP7, the Evaluation subproject of L3Pilot. SP6 is closely linked with SP3, which specified the research questions (RQs) and provided the methodological guidelines for the pilots. SP6's main task is to follow up and support pilots when applying the commonly agreed principles, as defined in SP3, in practice.

This includes to:

- Plan and manage pre-tests all the way up to the test site ramp-up, providing feedback to improve/tune piloting procedures if needed, and provide the data samples for the analysis.
- Ensure that the procedures and tools are properly set up at each test site.
- Ensure that data collection is performed at each test site according to the agreed procedures.
- Monitor that data delivery is properly handled by data owners and by the project, with regards to agreed data verification rules.
- Coordinate the test preparation activities in terms of subject and data management.

From a methodological point of view, the L3Pilot project follows the aforementioned FESTA methodology (Figure 2.2) for setting up, implementing, and conducting road tests within the four main pillars: (i) Prepare, (ii) Drive, (iii) Evaluate and (iv) Address legal and cyber security aspects.

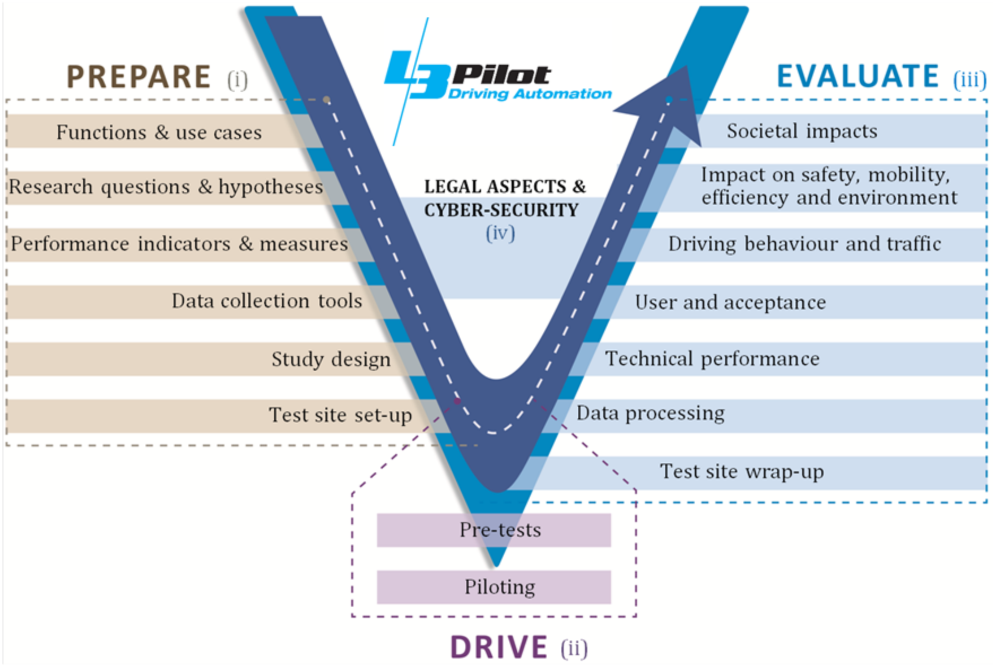

Figure 2.2: FESTA implementation plan adapted to L3Pilot.

This document focuses on pillar (ii) *Drive*, as it concerns the execution of the pilots. For this purpose, two phases are considered:

- A *Pre-tests* phase, with the main goal being to validate the system under evaluation, as well as the complete toolchain, before the full-scale experiment. Pre-tests simulate the subsequent pilot and include a verification of the complete process from road data collection to final data preparation and storage.
- A *Pilot execution* phase, with the focus on collecting a large set of consistent and high-quality data for the analysis and assessment activities to be carried out in the subsequent evaluation phase.

In order to achieve effective pilot tests, it is of utmost importance to apply the common testing methodologies defined in step (i) *Prepare*. This deliverable thus describes the procedures and guidelines defined in L3Pilot to execute the *Pre-tests* and the *Pilots.* These procedures and guidelines have been shaped on the basis of the L3Pilot methodology and experimental design that is detailed in the L3Pilot deliverables D3.1 and D3.2 respectively.

The L3Pilot operations are organized in each different pilot site and are grouped into three specific geographic areas: Northern Pilot (led by Volvo Cars and Safer), Central Pilot (led by Toyota Europe and EICT), and South-West Pilot (lead by CRF and the University of Genoa), as shown in Figure 2.3. Along with their strong similarities, the three geographical areas also propose interesting different features and expected user behaviours. The Northern Pilot offers the possibility of checking the AD vehicles in harsh weather conditions. The Central Pilot execution is strongly characterized by urban/extra-urban conditions with complex traffic scenarios and automated parking, up to SAE automation Level 4. The South-West Pilot is characterized by inter-urban tests on motorways. In addition, automated and home-zone parking will be investigated in several different pilot sites.

At the same time, it should be clarified that L3Pilot piloting procedures, tools, and methods are the same for all pilots: the subdivision into Pilot Geographical Areas is established purely to facilitate local support, whenever needed.

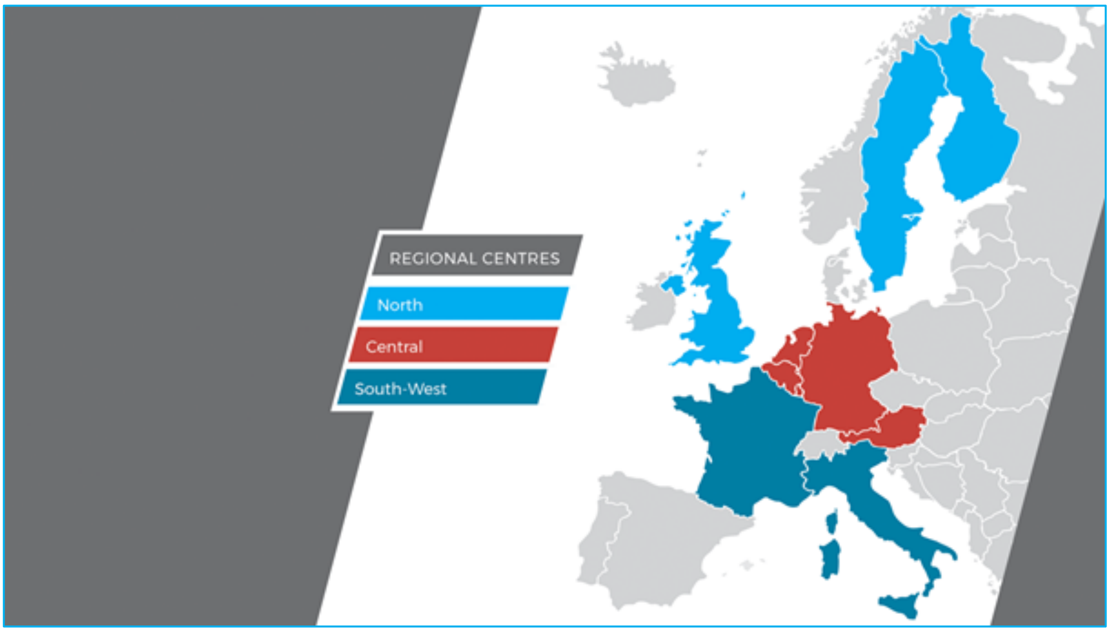

Figure 2.3: L3Pilot Regional Centres.

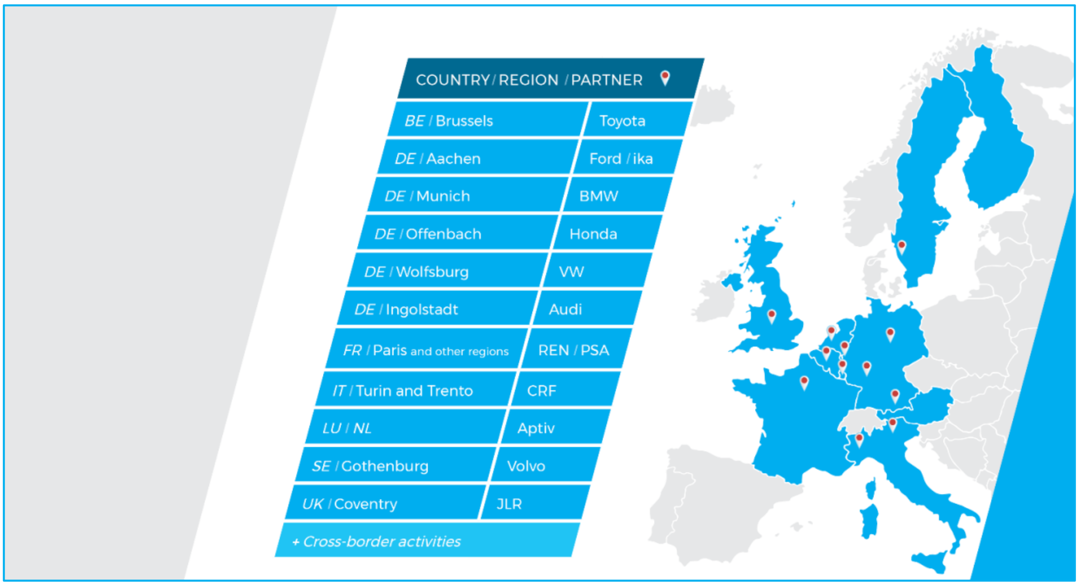

Figure 2.4: L3Pilot pilot sites.

2.2 Focus of the Project Pilots

The L3Pilot project focuses on large-scale piloting of ADFs, primarily SAE automation Level 3 functions, with additional assessment of some L4 functions.

To pave the way towards higher levels of automated driving, the L3Pilot consortium has identified the Automated Driving Functions in different contexts for passenger cars, namely *traffic jam*, *motorway*, *parking*, and *urban*.

- *Traffic Jam Chauffeur* functions operate at up to 60 km/h on motorways and similar roads. When the detection of slow vehicles in front of the ego vehicle indicates a traffic jam, the function can be activated and the car takes over the driving task. In some instances, the car can change lanes to react to a slower vehicle ahead or to deal with infrastructural factors such as exit lanes. All *Traffic Jam Chauffeur* functions to be tested in L3Pilot are of SAE Level 3.
- With the *Motorway Chauffeur* function, the car adapts to various traffic conditions. It follows the lane and adjusts its speed considering various factors and rules, such as keeping a safe distance from the vehicle in front or following the speed limit. If a slow vehicle is detected, the car can also overtake automatically as soon as it is safely possible to do so. *Motorway Chauffeur* functions to be tested in L3Pilot are primarily Level 3.
- *Parking Chauffeur* functions allow the users to request their vehicle to complete manoeuvring into and out of garages and driveways. The car learns a trajectory from the street to the home garage and vice-versa. This automated driving feature relieves the driver from repeating parking manoeuvres in selected areas. *Parking Chauffeur* functions to be tested in L3Pilot are primarily Level 4, however Level 3 assessment is planned as well.
- With the *Urban Chauffeur* functions, the vehicle automatically follows the lane, starts and stops, and handles overtaking on urban roads. When coming to an intersection, the car handles right and left turns, recognizes on-coming traffic and vulnerable road users such as pedestrians, and selects the correct path, even if no lane marking is present on the road. This category of functions involves particular challenges due to the complex and highly dynamic traffic environment. All *Urban Chauffeur* functions to be tested in L3Pilot are Level 3.

A detailed description of the functions to be tested, together with Operational Design Domains (ODD), which include infrastructure requirements, road and traffic environment, weather, etc. is available in the D4.2 deliverable “Description and Taxonomy of Automated Driving Functions”. An anonymized schema of the ADFs that are to be tested in the project is shown in Figure 2.5. Since L3Pilot is a pre-competitive collaboration project, anonymization is essential, in order to protect the individual business interests of the vehicle owners. At the same time, in light of the global race for the first marketable AD applications, the whole consortium strongly benefits from pre-competitive collaboration in the field of AD. ADF comparison and possible benchmarking during the pilot tests will be avoided, which is an important prerequisite for a successful future deployment. Data from the different pilot sites will be merged and reported as average results for the different L3Pilot ADFs.

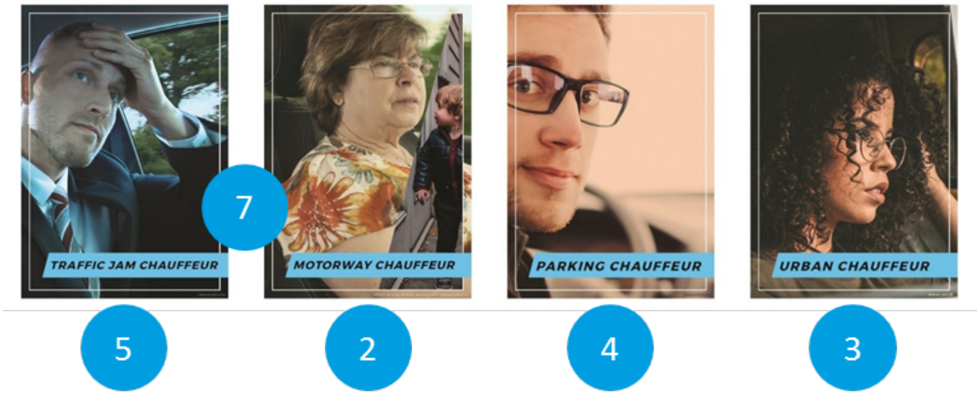

Figure 2.5: Grouping of L3Pilot Automated Driving Functions.

L3Pilot is the first project that will demonstrate and test such a comprehensive variety of ADFs. It is unique in that 13 vehicle owners (original equipment manufacturers), suppliers, and research institutes will provide a large set of test vehicles and check the performance of ADFs in a variety of roads and conditions across Europe.

Pilot test subjects will be selected on the basis of the specifications provided by the SP3 subproject, which has established a comprehensive piloting methodology based on all the research questions to be answered during the study. The specific instructions for participant type, etc. are available in L3Pilot project deliverable D3.2, which also includes further details of the methodological aspects of the L3Pilot piloting phase.

Requirements for recruiting test subjects mainly concern two aspects: user selection criteria and sample size. At the same time the recruitment of testing subjects has to cope with the fact that in several cases vehicles are subject to vehicle owners' rules, which may limit human drivers to company employees or even professional drivers.

Due to safety regulations, vehicle owners in L3Pilot have specific requirements about who is allowed to drive the prototype vehicles used in the test piloting. Two aspects should be taken into account when working with the company drivers. First, they have a different relationship towards the product due to their employment. This has an influence on the attitude and perception of the systems, and can bias the subjective evaluation of features depending on the level of identification with the brand. Second, the developer point of view can influence the behaviour of the drivers, due to their expectations and knowledge about the system. For this reason, when company employees and professional drivers are the only ones allowed to drive the piloting vehicles, the selection should exclude, if possible, those who have been involved in the design and development of the vehicle AD systems.

During the road tests, a professional driver can also act in the same way as a driving instructor, with double vehicle controls available on the passenger's side to actively intervene in the driving task. This driver is usually called a "safety driver" and serves as a supervisor and backup in the event of an emergency. Such a setup may be mandatory in the case of testing prototype systems in normal traffic environments.

3 Pilot Management

Phases of Pilot Management

The pilot activities are organized in three phases: preparation, ramp-up, and execution, which are described in the following sub-sections.

3.1 Pilot Preparation

The pilot preparation phase consists of two main major tasks running in parallel:

- *Vehicle preparation:* ADF implementation and verification of technical readiness.
- *Approval for testing on public roads*: Compliance with laws and regulations (including data privacy and insurance) and cyber protection are considered. Each vehicle owner prepares the documentation to obtain permission to execute the pilot in the different member states. Preparation of L3–L4 automated vehicles is a challenging and resource-consuming process. The L3Pilot vehicles were originally series production vehicles that were modified into test piloting vehicles through the installation of comprehensive sensor suites (HW and SW) and technical equipment, including data loggers. Data loggers are selected by vehicle owners from among the best performing data loggers that are already in use and have proven to be resilient, reliable, and robust to any data loss and to the length of each pilot. The ADF implementation requires the involvement of specialized workshops as well as extensive testing and validation. The process includes sensor installation, computing equipment installation, adaptations of vehicle controls (steering, braking, and double vehicle primary controls if required for a safety-driver), specific data storage clusters, navigation systems, and additional Human-Machine Interfaces (HMI). As vehicles are driven in the pilots not only by professional test drivers but also in supervised mode (i.e. with a professional driver in the passenger seat with double steering and pedals), it is necessary to implement additional measures, such as, for instance, an automatic minimum-risk manoeuvre to safely stop the car when needed. Correspondingly, a robust system calibration and validation is needed for the entire hardware and software chain. A final key point is the risk and functional safety analysis, to be performed in detail at each system level by vehicle owners.

Each of these steps is the responsibility of the vehicle owner who will perform the pilot.

Concerning the approval for testing on public roads, in most of the EU member states, legislation or regulations require a specific authorization for experimenting with automated vehicles on open roads. The consortium partners in the subproject SP4 “Pilot Preparation” have compiled a comprehensive review of these requirements for each country where experiments are planned. The project deliverable D4.2 describes the procedures to be followed by the vehicle owners, along with suitable guidelines and a detailed analysis on cyber security. This facilitates access to the national procedures and thus accelerates the process of obtaining the necessary permits.

To ensure a timely, efficient preparation and execution of the pilot at each test site, a time-plan has been prepared, as shown in Figure 3.1. Also, the progress is monitored on a regular basis, using on-line tools, in order to guarantee the proper achievement of the project's objectives.

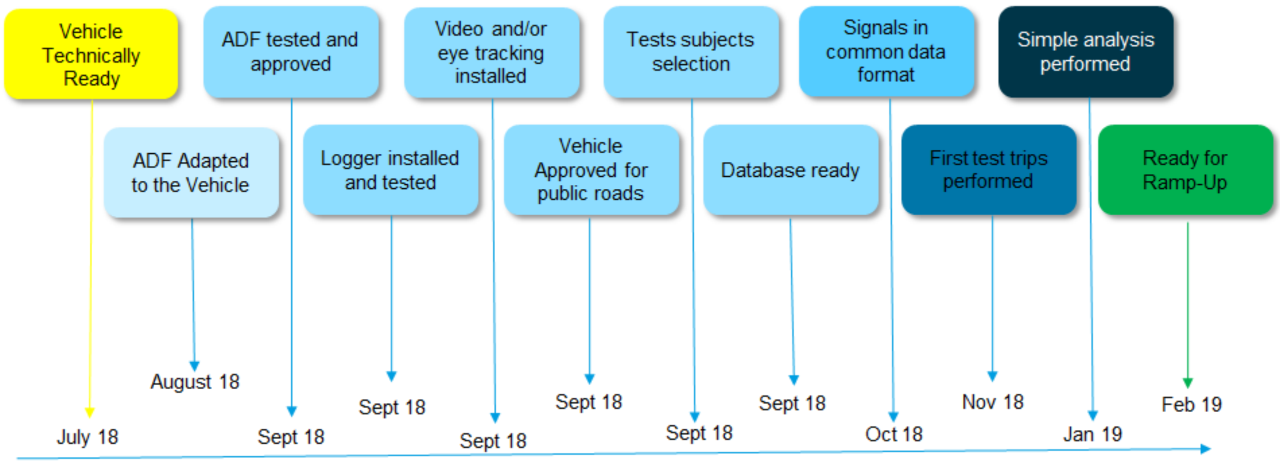

Figure 3.1: Pilot preparation time-plan.

3.2 Pre-pilot Tests and Preliminary Analysis of Data

The overall target of the pre-pilot tests is to ensure that all the systems, test procedures, and methods to be used during the final pilot activities are as designed. It is of utmost importance that the pre-pilot tests apply the actual L3Pilot methodology as accurately as possible. This includes testing the complete pilot chain from data collection to the provision of consistent input to the subsequent evaluation, as well as testing the algorithms with the pre-pilot data by the evaluation partners. In particular, the pre-pilot tests will involve, for each vehicle owner, a specific preliminarily-defined evaluation partner (i.e. the partner responsible for analysing the data). In order to monitor the progress and ensure an efficient flow of information, a progress table (Table 3.1: L3Pre-pilot tests progress table for data flow) has been set up in the L3Pilot internal collaboration tool. The vehicle owners and the respective evaluation partners are requested to update it on a regular basis, thus allowing an efficient monitoring of the progress and prompt interventions to provide needed support on a case-by-case basis.

Results of the pre-tests as well as the first outcomes from the pilot will be presented in the project deliverable D6.3 “Pre-tests results”.

Table 3.1: L3Pre-pilot tests progress table for data flow

	DATA			ANALYSIS TOOLS		VIDEO		SP7 DATA FLOW			
VEHICLE OWNER & EVALUATION PARTNER	DATA SAMPLE RECEIVED	ENTIRE TRIP RECEIVED	DATA MANAGEMENT IN PLACE	DATA ANALYSIS TOOLS READY	L3Pilot SP5 DATA SCRIPTS TESTED	VIDEO SAMPLE RECEIVED	VIDEO ANNOTATION TOOL IN PLACE	AGGREGATED DATA FOR IMPACT ASSESSMENT EXTRACTED	EVALUATION PARTNER ↔ CONSOLIDATED DATABASE DATA FLOW OF AGGREGATED DATA TESTED	COMMENTS	HELP REQUIRED
PARTNER NAMES	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Free text	Free text

3.3 Pilot Ramp-Up

After the successful completion of the pre-tests, and before launching the full-scale piloting, the project decided to implement a ramp-up phase. Based on lessons learned from previous projects (in particular euroFOT) a ramp-up phase with a sample of vehicles on the road is very useful for obtaining feedback from field tests, regarding e.g. data acquisition, driver behaviour, annotation of unexpected events, intervention, etc. The L3Pilot consortium adheres to such recommendations, and therefore decided to start the pilot with a sample of vehicles, to be gradually increased up to full scale during the pilot execution timeline.

While preparing the fleet, it is important to strictly adhere to the vehicle preparation procedures established during the *pilot preparation* phase. From the vehicle preparation point of view, the test vehicles that are set up (i.e. on which additional sensors and actuators are installed) must be fully comparable with the final test vehicles, to ensure the consistency of the data delivered.

3.4 Pilot Execution

3.4.1 General principles for quality assurance

The full-scale pilot is the core activity in the project, with the main objective of providing a full set of consistent and high-quality data: well documented, complete, and time referenced. Therefore, quality assurance is a particularly crucial point for this phase. In this respect, both operational quality and data quality are key aspects to be addressed. As a consequence, the consortium has put in place a procedure to appoint one operational quality assurance supervisor (OQS) and one data quality assurance supervisor (DQS) per vehicle owner. These persons are to be identified before the pilot begins (see Table 3.2).

The OQS will be in charge of regularly reporting the pilot status, thus giving an overview of the pilot execution. He/she will also be in close contact with the L3Pilot methodology experts (subproject SP3), in order to regularly check (typically, every month) that the pilot is being properly executed from the methodological point of view.

In parallel, the DQS will take care of data flow and data quality. This means that he/she will be in close contact with L3Pilot data management experts (subproject SP5) and with L3Pilot evaluation experts (subproject SP7) during the execution of the pilot. Moreover, he/she will be responsible for applying corrective actions when needed. Given this specific role, the DQS will be appointed by the vehicle owner’s evaluation partner.

The vehicle owners that are going to perform L3Pilot piloting are: APTIV, AUDI AG, BMW, CRF, FORD, HONDA, Jaguar Land Rover, PSA, RENAULT, Toyota Motor Europe, Volvo Cars, VW, and IKA.

The evaluation partners that are working in tandem with the vehicle owners are: ICCS, IKA, SAFER, TNO, Uni. Leeds, VTT, and WIVW.

Table 3.2: Quality supervisor for vehicle owner

VEHICLE OWNER	EVALUATION PARTNER	OPERATIONAL QUALITY SUPERVISOR	DATA QUALITY SUPERVISOR
PARTNER NAME	PARTNER NAME	NAME and CONTACT DETAILS OF THE PERSON IN CHARGE	NAME and CONTACT DETAILS OF THE PERSON IN CHARGE

3.4.2 Pilot progress traceability and reporting

A structured time-plan for pilot execution was established at the beginning of the project. The vehicle owners are committed to following and using it as a basis for the creation of their own, detailed time-plans. To facilitate the process of creating and following a detailed day-by-day plan, one page for each vehicle owner has been created in the L3Pilot collaboration tool. This tool is suitable for supporting the effective management and coordination of progress against the pilot timeline.

Safety is obviously a key factor for the tests. This involves the users, supervisors, equipment, etc. In general, pilot execution may involve various kinds of risks that are managed under the responsibility of the vehicle owners. In particular, they will use suitable procedures to foresee and prevent any potential problems, while also implementing suitable countermeasures when necessary.

Another important aspect to be considered during the pilot tests is traceability, considering the variety of situations for the pilots in terms of countries, road types, number of test participants and vehicles, etc. To this end, the L3Pilot consortium has defined a set of data to be regularly provided by each pilot in tabular format, as shown in Table 3.3: L3Pilot piloting progress traceability table. The table should be filled in promptly for every pilot session (one for each row). A pilot session is defined as one testing session targeting the same function (or more than one function tested at the same time) with the same route, start, and stop date. The pilot methodological procedure includes recording annotations that will be either derived offline from the test videos and/or recorded online on board the vehicle; this is needed in particular to analyse unexpected events.

A thorough cooperation among the pilot sites and the L3Pilot experts – on methodology, vehicle automated functions, and L3Pilot evaluation – will support activity synchronization, exchange of experiences, and problem solving, and will ensure that L3Pilot follows a common approach.

The table is organized in four parts:

- “Pilot” describes the test and its conditions;
- “Users” concerns test users and administered questionnaires;
- “Data collection” concerns the amount of objective data collected in the test;
- “Data flow” tracks the status of the data flow from the vehicle until data delivery to the evaluation partner responsible for performing the data analysis.

During the operation of the pilot, the status will be checked on a weekly basis. This activity is crucial to guaranteeing a precise check of the evolution of the pilot execution and to identifying potential bottlenecks and, if necessary, suggesting the need for implementing contingency plans.

Table 3.3: L3Pilot piloting progress traceability table

PILOT										USERS			DATA COLLECTION		DATA FLOW
# Pilot	**Pilot Start & End Date**	**# Vehicles in use in the Pilot**	**AD Functions in the Pilot**	**Pilot geographical location**	**Pilot road type**	**Weather conditions**	**Light conditions**	**Traffic density**	**Km driven**	**# drivers & type of driver**	**# of pre-test questionnaires administered**	**# of post-test questionnaires administered**	**Baseline data collected – AD function off – (Gbytes)**	**Treatment data collected – AD function on – (Gbytes)**	**Status of data flow**
Insert a sequential number for each Pilot Session, 1, 2, ..., n	Insert dates e.g. Mar. 19 - Oct. 19	Insert number of vehicles involved in the Pilot	Insert list of AD functions	Insert Pilot geo-references, indicate if cross-border	Insert urban / motorway / close distance, indicate if hilly, curvy	Insert clear / cloudy / rainy / foggy / windy / snowy / icy	Insert daylight or night (with or without road illumination) or twilight	Insert quiet / normal / rush hour	Insert km driven (if relevant to the specific pilot session)	Insert professional / company / ordinary drivers			Insert the amount of data collected (not considering video)	Insert the amount of data collected (not considering video)	(*)

(*) STATUS OF DATA FLOW – for each pilot session, the following steps are to be checked and the completion date is to be included:

- Raw data transferred from vehicle data logger to each vehicle owner database
- Data available to evaluation partner
- Data conversion to CDF (Common Data Format)
- Data delivery to SP7 for evaluation

4 Data Management

4.1 Data Processing Flow

This section describes the L3Pilot data management tools developed in subproject SP5 and presents the procedures for a proper application during the piloting phase.

The data processing flow involves different levels, starting from raw data acquisition from the pilot vehicles and ending with the analysis and display of the results. Figure 4.1: L3Pilot overall data management architecture (source: L3Pilot SP5) shows an outlook of this process. A summary of the overall data flow is presented in the following section of this document, as it is very relevant for planning the pilots. In particular, the Consolidated Database is the L3Pilot database defined to be structured and used by L3Pilot experts of the evaluation subproject SP7: with this target in mind the detailed structure of the Consolidated Database has been agreed among the experts of the L3Pilot Data Tools (in subproject SP5 and SP6) and the experts on L3Pilot Evaluation (SP7).

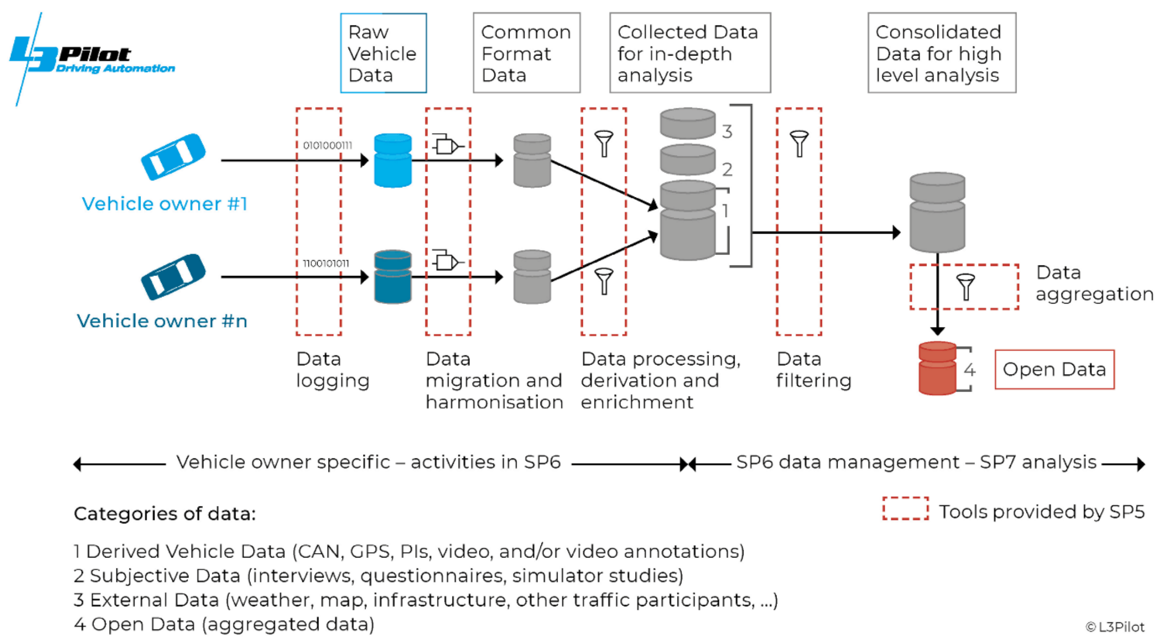

Figure 4.1: L3Pilot overall data management architecture (source: L3Pilot SP5).

4.2 Logging and Storing Data in HDF5 Files

The first step consists in logging data, in a proprietary format, from the vehicular communication buses. The logged data are then converted into the L3Pilot Common Data Format (CDF), which has been designed ad hoc to allow a common processing of heterogeneous source data. Filtering of confidential and sensitive data is possible at this level too. Conversion is made through Matlab or Python scripts that produce HDF5 files (HDF Group, 2018). One HDF5 file is produced for every pilot vehicle trip. This binary file format has been adopted for its capability to include and compress structured data. In L3Pilot, an HDF5 file is organized in a series of datasets, as reported in the following list. For each session, data are reported row by row in a timeline with a 10ms frequency sampling.

- **Ego vehicle.** This dataset contains the main signals of the vehicle. Examples: speed, acceleration, braking, etc.
- **Positioning.** This dataset contains information about the position and heading of the vehicle.
- **Objects.** This dataset contains information about the other road users that surround the vehicle (e.g. cars, bicycles, pedestrians). Information includes parameters such as, for example: typology/classification, longitudinal and lateral positions, relative speed, angular rates, etc.
- **Lane lines.** This dataset contains information about the road lane markings. Information includes parameters such as, for example: vehicle lateral position with respect to road markings, road curvature, etc.
- **Video.** This dataset contains the 10 fps video signals from the cameras monitoring the human driver's hands, etc.
- **External.** This dataset contains information about the external environment. Information includes parameters such as, for example: number of lanes, road type, speed limit, etc.
- **Meta data.** This dataset contains descriptive information about the trip. It includes information about the driver, vehicle, timing, type of experiment, experimental conditions, etc.

Detailed information about all the data is available to L3Pilot pilot sites on the L3Pilot project collaboration tool.

Data quality check

Data converted into the common data format are then checked for correctness and consistency. This step is performed through a data quality check tool that parses the HDF5 files to guarantee that all the defined data structures are present and correct, so that they are compatible with the post-processing tools. The code for the tool is available on the L3Pilot GitLab SP5 repository, together with some examples.

GitLab Community Edition (CE) is an open source end-to-end software development platform with built-in version control, issue tracking, code review, etc.

4.3 De-identification

De-identification (or pseudonymization) is performed by vehicle owners and concerns the trip ID and the user ID. The ID is an 8-character string, obtained through a simple procedure, based on a SHA-256 hashing. Source information (e.g. driver name, date of birth, trip place, vehicle owner, etc.), integrated with a secret word for "salting", is processed through a hash function (e.g. SHA-256, available online for instance here: https://passwordsgenerator.net/sha256-hash-generator/) to generate a 64-character identifier. For our purposes, it is sufficient to extract the left-most 8 characters to have the driver/trip ID. Using this ID, vehicle owners can then track their participants and trips through the HDF5 files, subjective questionnaires, and consolidated database.

4.4 Data Post-processing and Enrichment

The second major step is represented by data enrichment. This involves the processing of the data in an HDF5 file in order to obtain additional information. Typical examples of additional information include:

- Derived Measures (DMs). These are quantities computed as functions of the above-mentioned raw signals. Examples of derived measures include: time headway, time to collision, take-over time, etc. The calculated derived measures are then stored in the HDF5 derived measures structure.
- Performance Indicators (PIs). PIs aggregate information from a timeline in an HDF5 file. In general, performance indicators are single values and no longer time-series data. Examples include: distribution of difference between speed and speed limit, time spent in automated mode, etc. The calculated performance indicators are then stored in the HDF5 performance indicators structure.
- Events and scenarios. These are stereotypical situations that may happen during a drive. These situations are recognized by analysing the raw signal timelines and then saved in the scenarios' timeline data structure. Examples of calculated events and scenarios include: uninfluenced driving, lane change, merge, cut-in, etc. The different events and scenarios are defined on the L3Pilot project collaboration tool.

This additional information, which is essentially related to the research questions defined by the L3Pilot methodology experts, is added directly in the HDF5 file, so that the new version is enriched with this computed data, in addition to the original signal values.

This step is achieved through Matlab or Python scripts that are available for developers on GitLab, and are responsible for the enriching process. More detail on the process is provided by the relevant Wiki.

Another important post-processing step is provided by the video annotation. To this end, a specific Matlab viewer tool has been developed. Through this software interface a user can display one or more video signals stored in an HDF5 file, watching the current signal evolution and inserting annotations about events. Examples of events include the activities being performed by the driver, e.g. eating/drinking, reading/writing, smoking, mobile phone, etc.

4.5 Subjective Data Tool

Until now, this section has dealt with data about the pilot vehicles and the environment. Another important aspect is provided by the collection of subjective data, which will be obtained by an online survey tool administered to pilot vehicle users in order to reflect and report about their test experience. LimeSurvey is the tool chosen by L3Pilot to support the execution of subjective data collection. Based on the content provided by subproject SP3, a reference version has been implemented for each of the three contextualized questionnaires, namely Urban, Traffic Jam/Motorway and Parking functions. Each pilot site manager will have to import these surveys in their LimeSurvey Pro service account (or perform a free local installation) to manage the local subjective data.

The imported surveys can then be customized and translated into local languages (the reference version is in English). Results can be exported in an Excel file or in a PDF format that can be used to provide information to the evaluation partner. LimeSurvey serves as an efficient facility for administering the survey to the test participants.

In some cases, partners are constrained to use a specific tool different from LimeSurvey for internal or practical reasons. It has been decided that they are allowed to do so, provided that they adhere to the rules for the dataflow established with the evaluation partners and allow correct data transfer to the consolidated database.

4.6 Consolidated Database

The final step of the data processing involves the preparation of data for the consolidated and open database. The goal of this database is to collect aggregated and de-identified information from all the HDF5 files (i.e. pilot trips) and make it available, with different information access rights in order to respect confidentiality.

From an architectural point of view, subproject SP6 is preparing a software platform to support project-level data aggregation and presentation. The platform relies on a MongoDB non-relational database, which is accessed through a Node.js layer. The platform exposes a set of REST-ful APIs for inserting and retrieving data. A Graphical User Interface (GUI) is being implemented in order to allow user-friendly access to data. Different user roles have been defined for administrators, site managers, vehicle owners, the consortium, and public users. Such roles implement different data read/write rights, in order to meet the project information confidentiality requirements. This differentiation in user roles implements the difference between the consolidated and open databases. The platform will be described in detail in the L3Pilot deliverable D6.2.

Matlab scripts are also being implemented, to enable vehicle owners and site managers to post relevant data from their HDF5 files to the database.

5 Conclusions

Since March 2019, major European automotive manufacturers have begun testing automated in-vehicle functions on public roads across ten countries in Europe. Altogether, there will be about 1,000 drivers testing the automated driving technologies over a period of 18 months.

The pilot begins with a six-month ramp-up phase to field-test the pilot procedures, gather first user feedback, and allow interventions to optimize the pilot execution. To ensure successful evaluation at the end of the project, all pilot sites and the partners specialized in methodology and evaluation have jointly defined the experimental procedures.

Prior to the start of the pilot, automotive manufacturers implemented the automated driving functions. All L3Pilot cars are series production vehicles modified into test prototype vehicles through the installation of sensor suites and technical equipment including data loggers. The approval of the testing on public roads considers compliance with individual national laws and regulations including data privacy and insurance as well as cyber protection.

This document describes the overall structure of the pilot management in the L3Pilot project, together with operational procedures and rules regarding the data flow. A common methodological framework is applied in all pilot sites, covering different geographical areas in Europe.

A number of guidelines for conducting the pilots are given in this report, summarized as follows:

- **Pilot management** is deployed in three phases, namely Pre-test, Pilot Ramp-up and Pilot Execution. According to the experience of past projects, significant (and sometimes underestimated) effort is required also in the first two phases, in order to prepare the vehicles and equipment, obtain the necessary authorizations, and especially gain experience from a set of preliminary trials during ramp-up. These trials should cover all the operational steps in a comprehensive manner, thus providing important feedback for tuning the whole process. Pilot management includes a number of well-specified procedures to coordinate the work and keep track of the progress at each Pilot Centre.

- **Data management** has the key objective of guaranteeing the completeness and high quality of the data. The project takes into account objective data from the vehicle and from the external environment, as well as subjective data such as user judgements and statements. A series of software tools has been developed to facilitate all the steps from data logging to quality check, data transfer, enrichment, and storage. Anonymization and other suitable techniques are put in place to guarantee that confidentiality and privacy are respected, in particular following the GDPR European regulation. The evaluation performed on the L3Pilot Consolidated Database is a key output from the pilot phase, to be used in the project for the assessment of automated driving functions, as well as stored for possible future studies.

A point requiring further attention is the timing needed in some countries to obtain permission to test SAE L3 vehicles on real roads: at the time of delivery of this document, this process had not yet been completed in all of the countries.

Nevertheless, there are several key indicators that enhance the confidence of the project consortium in being able to start the pilot sessions with a common and systematic approach. As outlined in this report, these indicators are: the consistency of the methodologies, the availability of tools, the precise rules for data handling, and the matrix of collaboration within the project team, including established liaisons between the vehicle owners and the respective evaluation partners.

In conclusion, this document represents the link among key aspects of the L3Pilot project: the methodologies and tools developed in subprojects SP3 and SP5, the vehicle preparation accomplished in subproject SP4, the execution of the pilots by each vehicle owner, and the future evaluation sessions that will be performed in subproject SP7.

6 References

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L3Pilot Public Deliverable D3.2: Experimental Procedure.

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L3Pilot Public Deliverable D4.2: Legal Requirements for AD Piloting and Cyber Security Analysis.

7 List of Abbreviations and Acronyms

Abbreviation	Meaning
AD	Automated Driving
ADAS	Advanced Driver Assistance Systems
ADF	Automated Driving Function
CDF	Common Data Format
DM	Derived Measures
DQS	Data Quality Assurance Supervisor
FESTA	Field opErational teSt supporT Action
FOT	Field Operational Tests
GDPR	General Data Protection Regulation
GUI	Graphical User Interface
HDF5	Hierarchical Data Format “5”
HMI	Human-Machine Interaction
L3 / L4	Level 3 / 4 automation
NDS	Naturalistic Driving Studies
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
OQS	Operational Quality Assurance Supervisor
SAE	Society of Automotive Engineers
SHA	Secure Hash Algorithm
V2X	Vehicle to X communication. X can be vehicle, infrastructure, etc.
VRU	Vulnerable Road Users