LIFE Project Number

LIFE18 CCM/FR/001095

Public Report

Covering the project activities from 15/06/2019 to 14/02/2023

Reporting Date

30/06/2023

Emission and Consumption Optimized Transport Missions using Virtual Drives

LIFE ECOTRAVID

Project location:	France, Germany
Project start date:	15/06/2019
Project end date:	14/02/2023
Total budget:	1,908,302 €
EU contribution:	1,044,396 €
(%) of eligible costs:	55%

Data Beneficiary

Name Beneficiary:	CLS Group
Contact person:	Mr Pierre Cuny
Postal address:	11 rue Hermès Parc Technologique du Canal 31520 Ramonville Saint Agne
Telephone:	+33.5.61.39.48.35
E-mail:	p.cuny@clsgroup.com
Project Website:	https://ecotravid.eu/

TABLE OF CONTENTS

List of keywords and abbreviations 3
1. Executive summary 5
2. Introduction 6
3. Technical progress per action 8
4. Deviations to original plan 47
5. Analysis of benefits 47
6. Conclusions 51

List of keywords and abbreviations

CAN	Controller Area Network
CO2	Cardon Dioxide
FMS	Fleet Management System
GHG	GreenHouse Gases
GPS	Global Positioning System
HDV	Heavy Duty Vehicles
ICD	Interface Control Document
ID	Identity
Kg	Kilogram
kph	Kilometer per hour
KPI	Key Performance Indicator
km	Kilometer
L	Liter
NASA	National Aeronautics and Space Administration
NOX	Azote Oxyde
POC	Proof of Concept
SW	Software
TMS	Truck Management System
TTS	Text to Speech
VAT	Value Added Tax
VDS	Virtual Drive Simulation
VMC	Virtual Measurement Campaign

TABLE OF FIGURES

Figure 2. VMC Database 8
Figure 3. Interactions between actions regarding data 11
Figure 4. VMC-Speed Profiles: General workflow, components and embedding in the environment 13
Figure 5. Computation of consumption-oriented route measure 15
Figure 6. Cost function over simulated consumption for high payload routes 16
Figure 7 *SAMAT's vehicles monitored on Trailermatics™ Map Module* 17
Figure 8: *VMC call IHM from Trailermatics™ Planning Module* 19
Figure 9: *Android "Driver connect" application* 19
Figure 10: *Workflow of an itinerary with a VMC Ecotravid call* 19
Figure 11. Map representation of all 1,960 measurements taken on public roads in the southwest of France (and parts of Spain). 37
Figure 12. Example Cluster 175: Shortest route (red, 21.1 km, travel time 49:36, 6.1 kg fuel consumption) vs. fuel-optimal route (blue, 18.2 km, 52:43, 5.7 kg). 38
Figure 13. Representation of the consumption-optimal alternative routes in the original comparison. 38
Figure 14. Ambès - Montayral: Default route by SAMAT (blue, 182.8 km) vs. fuel-optimal alternative (red, 195.1 km). 40

TABLE OF TABLES

Table 1. SAMAT's trucks and trailers (a selection) 10
Table 2. Results coming from driver and traffic parameters 12
Table 3. Final sensor list for Ecotravid project 21
Table 4. Database from 21 trucks 23
Table 5. Recap of the vehicle parameters 25
Table 6. Fuel prices' variation 26
Table 7. Scenarios based on the fuel price 26
Table 8. Clients' savings in a conservative scenario 27
Table 9. Costs and savings in a conservative scenario 27
Table 10. Savings per vehicle and client in a conservative scenario 27
Table 11. Clients' savings in an optimistic scenario 28
Table 12. Costs and savings in an optimistic scenario 28
Table 13. Savings per vehicle and client in an optimistic scenario 28
Table 14. Clients' savings in a pessimistic scenario 29
Table 15. Costs and savings in a pessimistic scenario 29
Table 16. Savings per vehicle and client in a pessimistic scenario 29
Table 17. Original and route comparison 39
Table 18. Routes' description 40
Table 19. Emission standards comparison 43
Table 20. Emissions based on Euro 5 43
Table 21. Calculations based on HBEFA inputs 44
Table 22. Summarize of the fuel indicators 44
Table 23. Expected savings for SAMAT routes per truck and year 45
Table 24. Expected savings for different applications per truck and year 45

1. Executive summary

The LIFE ECOTRAVID project aimed to demonstrate the effectiveness of the Virtual Measurement Campaign (VMC) software[1], a virtual drive simulator, in achieving a 5% to 10% reduction in fuel consumption and related CO2 emissions for trucks and trailers by introducing a consumption-oriented routing approach in mission planning. The VMC software incorporates highly realistic vehicle models that consider driver influence and various system modifications, as well as real-world data that accurately describe the vehicle's environment. By conducting meticulous computations of energy losses, including air resistance, rolling resistance, and slope resistance, the VMC simulations enable a comprehensive analysis of fuel efficiency for specific transport missions.

The project is divided into two phases. Phase I involves data collection, evolutionary processes, and fine-tuning of the VMC software using input data gathered from actual trips and vehicles. Baseline data will also be collected to compare initial conditions with the improvements achieved in Phase II. In Phase II, the integrated VMC software will be utilized by end users to reduce fuel consumption, and the measured data will be assessed and compared to the data from Phase I. It had been expected that fuel consumption will improve by 5% to 10% throughout the project, depending on various factors. However, the final savings turned out to be smaller but still substantial.

The VMC software represents a significant advancement in optimizing heavy-duty vehicle fuel consumption and CO2 emissions. By incorporating realistic vehicle models and real-world data, it provides a more accurate representation of the complex factors influencing fuel efficiency. The software's simulations and computations facilitate the identification of areas for improvement in heavy-duty vehicle performance. This innovative technology has the potential to enhance the sustainability and environmental impact of road transport, addressing the challenges posed by the projected increase in CO2 emissions from the transport sector.

The project started on June 15th 2019 and, although during this period some technical activities suffered a delay, the project has successfully reached its objectives and all the foreseen tasks have been completed by the end of June 2023.

With regards to the COVID-19 pandemic, this did not really affect the progress of the project except in terms of dissemination activities as most of physical conferences / events were cancelled making it difficult to perform these activities.

The LIFE ECOTRAVID has 4 project beneficiaries that signed a Partnership Agreement in line with the LIFE regulation which are the ones that encompass the Consortium: CLS, Fraunhofer ITWM, SAMAT Aquitaine and SAMAT Groupe.

---

[1] Speckert et al.: The Virtual Measurement Campaign (VMC) concept - A methodology for geo-referenced description and evaluation of environmental conditions for vehicle loads and energy efficiency. Proceedings of the 3rd Commercial Vehicle Technology Symposium (CVT 2014), pp. 88-98, (2014).

2. Introduction

Road transport plays a major role in the Global Warming as responsible for more than 25% GHG emissions. In 2050, the transport sector will represent around 40% of the CO2 emissions and the freight transport (heavy duty vehicles - HDV) is expected to become the main source of CO2 emissions from surface transport. Greener transport mode such as blue ways or rail transport cannot replace trucks in most of cases for geographical or infrastructure reasons and battery lifetimes constraints prevent to consider electric/hybrid truck as a viable solution for the coming decades it is thus critical to find alternatives allowing to efficiently optimize and reduce HDV fuel consumptions and related CO2 emissions.

The LIFE ECOTRAVID project aimed to demonstrate the efficiency of a virtual drive simulator, the so-called VMC software, to reduce from 5 to 10% trucks and trailers fuel consumption and related CO2 emissions.
To reach this objective, the proposed innovative VMC software (developed by ITWM) combined two completely innovative aspects:
- Highly realistic vehicle models, driver influence, set of system modifications;
- Real-world data describing the environment of vehicles very accurately, e.g. roads, topography, traffic, climate.

The VMC simulation has led to detailed computations of energy losses for resolute transport missions, including analysis of different losses (air, rolling and slope resistance).
The VMC software has been integrated in an online monitoring and decision-support IT toolkit, added upon CLS's road transport fleet management platform. The integrated system acts as a dynamic planning and decision-support toolkit for road transport fleet management providing the cost optimum route and truck/trailer configuration for a specific transport mission, leading to the expected fuel consumption reduction.

To demonstrate the efficiency of the innovative tool, a two phases pilot has been performed with 20 trucks and 20 trailers provided by the company SAMAT under normal service conditions and for different transport missions.

To ensure the achievements of the projects, a highly experienced team of professionals has been involved in the project:
- CLS, project coordinator, is a company, providing customized business-oriented IT services for road transport fleet management;
- Fraunhofer ITWM, owner and developer of the software virtual measurement campaign (so called VMC);
- SAMAT, a French Transporter Company who will participate as end-user partner, contributing to the identification of user needs, and with at least 20 trucks and 20 trailers for the demo phases.

The demonstration phase consisted of two successive stages:
- Phase I or data collection and model calibration phase;
- Phase II, starting once the new VMC will be integrated to CLS platform as a decision support toolkit.

The Phase I allowed:
- The evolution, adaptation and fine-tuning of VMC, thanks to input data collected from real trips and vehicles
- The collection of baseline data that has allowed the team to compare the initial situation to the improvements obtained once the new tools were used (demo phase II). Within the Phase II, the end-user has used the new decision support tool set for reducing consumption and the fuel reduction has been calculated by comparing the data measured from Phase I and Phase II.

In terms of environmental results, simulations in Phase I have demonstrated savings of around 3.5 % of fuel consumption, while Phase II validations have demonstrated 4.7% of fuel savings on real transport tasks. This is slightly below but close to what was originally expected with savings around 5 to 10%.

As an additional outcome the project achievements has also been an enhanced understanding of the potential fuel savings in the vehicle-based transport sector, which will be highly beneficial for truck manufacturer to optimize their vehicle performances.

3. Technical progress per action

C.1 Realistic model for virtual drives

C1.1 Environment data

The VMC software strongly relies on the quality and completeness of the underlying data it works on. The data needs to be regularly updated for many reasons such as the evolving road network in various regions of the world or enhancing properties, which up to now are only partially available (e.g., roughness or traffic). The database contains information from different sources, which need to be pre-processed before using it in the VMC software. This process is work intensive as well as important for the sensible use of the VMC software. Therefore, ITWM provides for their customers a yearly VMC database update service. The different components of the database are illustrated in the image below.

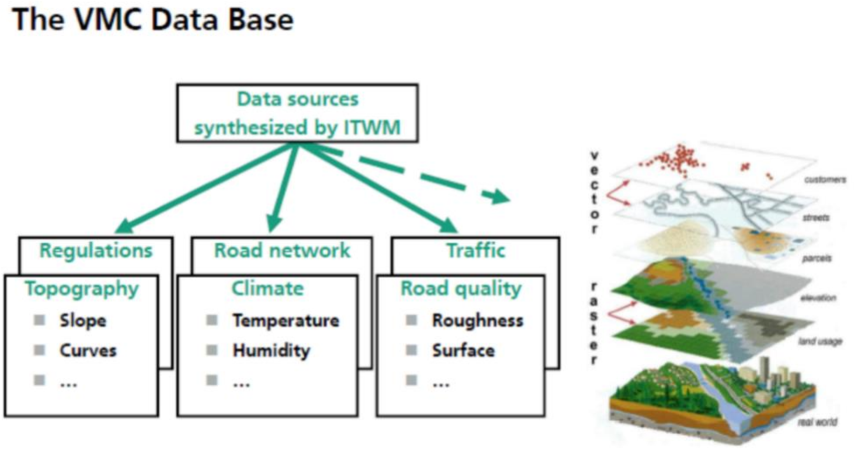


Figure 1. VMC Database

For the above-mentioned influence factors, dedicated data sources are already available within the VMC platform, but it is an ongoing task to find new and even better datasets for an improved model of the environment.

In the context of this project, alternative altitude data sources like the NASA satellite imagery dataset ASTER (Version 3 released August 2019) and the commercial HERE data platform have been evaluated. Another important factor is traffic, which is responsible for a high influence on the speed of a vehicle.

For the verification of the different altitude datasets, we use high-precision measurement data collected in Northern Germany using the ITWM system REDAR (Road & Environmental Data Acquisition Rover; http://www.itwm.fraunhofer.de/en/departments/mdf/usage-variability-and-loading-statistics/redar.html), which is a multi-sensor measurement vehicle equipped with the latest laser measurement technology to capture 3D environmental data as a basis for realistic simulations. The measurement data has a resolution of 10 cm in longitudinal direction. We distinguish data for three different road types: motorways, major country roads and small country roads. Both altitude datasets are then processed in a comparable manner with the help of low-pass filter techniques using different wavelengths to reduce the influence of noise effects. These wavelengths are chosen depending on the type of road: $w \in \{100 \text{ m}, 200 \text{ m}, 500 \text{ m}, 1000 \text{ m}\}$ for small country roads, $w \in \{200 \text{ m}, 500 \text{ m}, 1000 \text{ m}, 1500 \text{ m}\}$ for major country roads and $w \in \{500 \text{ m}, 1000 \text{ m}, 1500 \text{ m}, 2000 \text{ m}\}$ for motorways. For each route type, exemplary altitude and slope profiles over distance had been examined, as well as diagrams of the slope distributions depending on different filtering wavelengths to show their influence on the data processing. Giving a brief simplified summary, one can state that on the investigated routes, the accuracy of the commercial data is exceptionally good, whereas the satellite data shows reduced but still acceptable quality. On the other hand, the satellite dataset includes no license or usage costs and can be used globally for all roads whereas the commercial data is limited to roads with available measurements only.

The field of traffic data is huge and various data sources, suppliers and analyses are available. Unfortunately, most of them concentrate only on one specific aspect of transport or are locally bounded. Certain sources with a focus on France have been checked. Additionally, the HERE data platform is being evaluated on corresponding traffic information. The underlying traffic model is based on historic average speed data. Finally, an evaluation of the influence of traffic data in terms of consumption-optimized routing has been carried out on routes from the project partner SAMAT. For this purpose, four traffic scenarios are defined: no traffic, best traffic, average traffic, and worst traffic. The different traffic scenarios can be analysed in terms of travel time and consumption using data from the HERE data platform. Compared to the simulation without traffic, 'Best Traffic’ has longer travel times by 0.3% on average, 'Average Traffic' by 1.6% and 'Worst Traffic' by 8.1%. Fuel consumption is 0.8% greater on average for ‘Best Traffic,’ 2.2% greater for ‘Average Traffic’ and 1.6% greater for ‘Worst Traffic.’ This means that the various traffic scenarios hardly differ in terms of fuel consumption. Compared to the simulation without traffic, fuel consumption is expected to be about 1% to 2% higher on average.

C1.2 Truck & driver modelling

This sub-action concentrates on adapting the truck and driver models used in the virtual drive engine to the measurement data. The goal is to fit all parameters such that the virtual drives reflect the measurements on the same road very well and are able to provide good estimates on the fuel consumption.

First, a basic setup of the models was created. SAMAT provided a table of different trucks and trailers, which are equipped with the Cello/TTS devices.

Table 1. SAMAT's trucks and trailers (a selection)

truck-trailer	brand truck	height/width truck [m]	engine	brand trailer	height/width trailer [m]	activity	mass [kg]	area [m^2]
DP048ZY-AH449GB	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,55	Carburant	12442	9,18
DP048ZY-FH822FH	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,5	Carburant	12882	9
DQ082ML-DD330PS	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,55	Carburant	12442	9,18
DQ082ML-FF974PC	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,55	Carburant	12442	9,18
DQ082ML-FH822FH	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,5	Carburant	12882	9
EP099NZ-DP271QJ	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,55	Bitume	13302	9,18
EP099NZ-AB024WR	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,55	Bitume	13302	9,18
EP099NZ-DD330PS	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,55	Carburant	12442	9,18
EP099NZ-FH822FH	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,5	Carburant	12882	9
EP099NZ-FQ928MN	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,5	Chimie	13982	9
ER295LC-FK122YQ	Mercedes Actros	3,6/2,5	OM470LA,6,1	Magyar	3,45/2,55	Chimie	12042	9,18
FX294TD-FV157FB	Renault T	3,56/2,52	DTI13 440 EU VI	Magyar	3,45/2,5	Chimie	13403	8,95
FX430TD-FH822FH	Renault T	3,56/2,52	DTI13 440 EU VI	Magyar	3,45/2,5	Carburant	13043	8,95
FX430TD-EL353PK	Renault T	3,56/2,52	DTI13 440 EU VI	Magyar	3,45/2,55	Carburant	12603	9,07
FX430TD-FF974PC	Renault T	3,56/2,52	DTI13 440 EU VI	Magyar	3,45/2,55	Carburant	12603	9,07

In a next step, the data from the measurement campaign is used for further fine-tuning the models according to the first line of the scheme below.

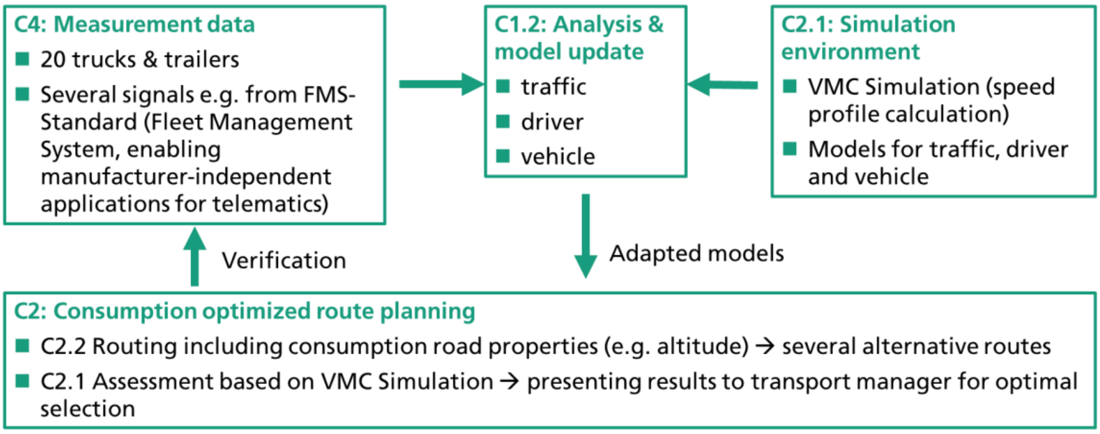


Figure 2. Interactions between actions regarding data

We extract single trips from the measured data (see description of C.4), project them to the digital map and simulate the travel. The results of the simulation are compared to the measurement (especially consumption) and the parameters of the models are adapted.

Since the models contain a large number of parameters whereof several effect the simulation results in the same direction, it is challenging to determine all of them to a satisfactory level. The engine efficiency for instance can be used to shift the results globally, whereas other parameters have influence on single components only. Due to different environmental conditions like weather, traffic, or the behaviour of the driver, we try to reproduce the mean values and leave the variation for the stochastic parameters. Applying several types of analysis in combination with repeated simulations using differing parameter sets, most parameters could have been approximated satisfactorily.

Although the quality of the parameter set was good enough for the most important intended application (finding routes with less fuel consumption using a vehicle-specific routing and simulation approach), we tried to further tune the vehicle parameters. The basic idea was to map the measured speed profiles to the VMC -representation of the routes, apply the VMC consumption model, and compare the results to the measured consumption. This excludes uncertainties due to imperfect driver and traffic modelling and lets us concentrate on the vehicle parameters only.

The Table 2 below show the results (driver and traffic parameters as reported before and the updated vehicle parameters).

Table 2. Results coming from driver and traffic parameters

Driver parameter	unit	description	determination
vLimitRelativeOffsetMap		road type dependent factor on speed limit	Fitted to data: 1.025
slope_adaption_coefficient		coefficient c for slope adaption based on the formula f=1 - c*slope	Fitted to data: 1.4
max_slope_adaption_factor		f=min(maxf,1 - c*slope)	Fitted to data: 1.1
min_slope_adaption_factor		f=max(minf,1 - c*slope)	Fitted to data: 0.9
st_inc	m	update interval for stochastic variation of desired acceleration	Default: 100 m
sigm_a		AR1 coefficient for stochastic variation of desired acceleration	Fitted to data: 0.2
eta_a		AR1 coefficient for stochastic variation of desired acceleration	Fitted to data: 0.1
axmin	m/s^2	mean desired deceleration	Fitted to data: -2
axmax	m/s^2	mean desired acceleration	Fitted to data: 1.5
aymax	m/s^2	maximum lateral acceleration	Default: 3
eta		AR1 coefficient for desired speed update	Fitted to data: 0.1
sigm		AR1 coefficient for desired speed update	Fitted to data: 0.002
low_env_window	m	length of window for calculating the lower envelope of desired speed	Default: 200 m
Fu	(m/kg)^2	Coefficient for considering driving force/torque in optimal control	Fitted to data: 2*10^(-5)
Traffic parameter	unit	description	determination
Average vehicle length	m	average length of vehicles on the road (used within safe distance rue)	Default: 8
StochasticIncrement	m	Update interval for stochastic variation of traffic density	Default: 200
a	s	Linear coefficient of safe distance rule	Default: 1.08
b	s^2/m	Quadratic coefficient of safe distance rule	Default: 0
eta		AR1 coefficient for traffic density update	Fitted to data: 0.5
sigm		AR1 coefficient for traffic density update	Fitted to data: 0.08
Vehicle parameter	unit	description	determination
R_wheel	m	wheel radius	From Samat specification
lambdaMax		Coefficient for drivetrain losses	Default: 1.2
vEndMax	m/s	Coefficient for drivetrain losses	Default: 100/3.6:
Pmax	W	maximum engine power	From Samat specification
Paux	W	average power of auxiliary consumers	Fitted to data: 3000
PmaxBrake	W	maximum brake power	Default (10 times Pmax)
cW for activity carburant		air resistance coefficient	Fitted to data:0.68
cW for activity bitume		air resistance coefficient	Fitted to data:0.55
A	m^2	front area	From Samat specification
m	kg	total mass	From measurement data
fRoll (high mass)		rolling resistance	Fitted to data:0.004
fRoll (low mass)		rolling resistance	Fitted to data:0.007
muk		coefficient of friction	Default: 0.8
driveaxles		number of driven axles	From Samat specification
n_axles		number of axles	From Samat specification
aymax_veh	m/s^2	maximum lateral acceleration	Default: 5 m/s^2
veh_length	m	length of the vehicle	From Samat specification
vehicle_class		type of vehicle (truck, bus, passenger car)	From Samat specification
engine_efficiency DP048ZY		power at engine output shaft over fuel energy	Fitted to data: 0.427
engine_efficiency DQ082ML		power at engine output shaft over fuel energy	Fitted to data: 0.399
engine_efficiency EP099NZ		power at engine output shaft over fuel energy	Fitted to data: 0.434
fuel_energy_density	Ws/kg	Energy contained in 1 kg fuel	Default: 4.3·10^7 Nm/kg

C.2 Virtual Drive Engine

C2.1 Computation and Analysis of Virtual drives

The Fraunhofer ITWM Software VMC contains algorithms for estimating a vehicle's speed profile based on models for the driver, the vehicle, and the route. In ECOTRAVID this context is referred to as virtual drives. The kernel of this approach is the vehicle model for longitudinal dynamics. The basic idea is to combine geo-referenced data characterising the route such as trajectory, topography, speed limits, traffic signs or traffic with driver and vehicle models of different complexity in order to obtain a deeper understanding of the vehicle's performance with respect to durability or drivetrain properties.

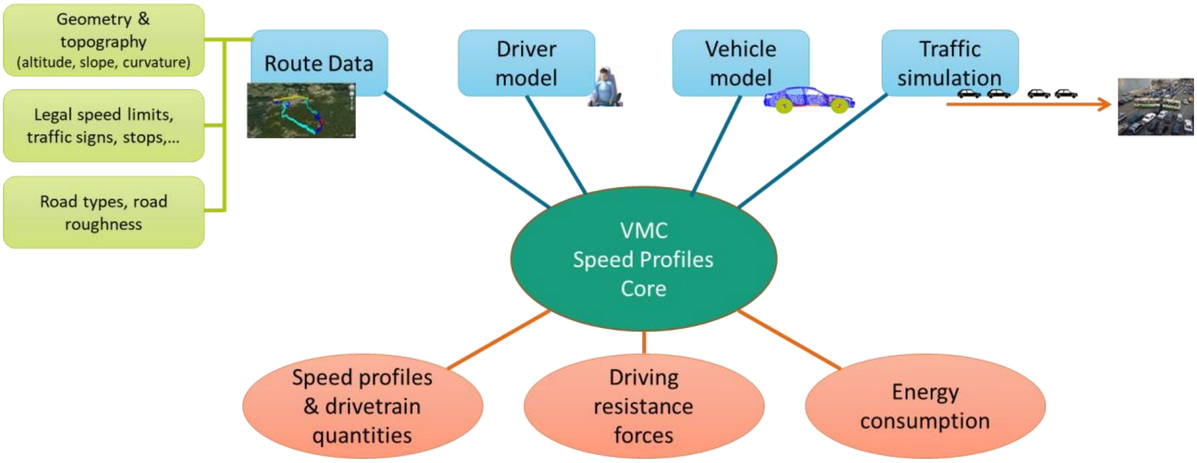


Figure 3. VMC-Speed Profiles: General workflow, components and embedding in the environment

The basic ingredients of the process are:

- the route with its properties (road type, slope, curvature, stop events),
- the driver model (speed tolerances, preferred values for acceleration …),
- the vehicle model, as well as
- the traffic model (probabilities of active stop events, traffic density …).

In this task C2.1 the following adaptations and enhancements for the application within ECOTRAVID have been implemented:

- Algorithms for modelling of traffic effects taking into account traffic patterns (average speeds on road segments with a spatial and temporal resolution)
- Models for fuel consumption and emissions based on the calculation of energy consumption for a simple vehicle model without drivetrain parameters
- Computation of driving resistances and work shares.

This task is part of a two step approach, where firstly the team applies enhanced routing techniques on the road network with simplified consumption measures and truck restrictions to find several route alternatives. In the second step the team is focused on compute speed profiles and energy consumption for selection of an optimal route. The first version of the compute services simply provided too many route alternatives which initially has been set to a maximum value of 10. This setting has been reduced to 3 which proofed to be sufficient from many verification simulations.

The influence of this parameter on the performance is low for the routing step but the more time-consuming second step now requires much less computation time.

These enhancements are used in C1.2 for fitting simulation parameters to measured data.

C2.2 Routing with consideration of energy consumption and truck restrictions

Standard routing algorithms usually suggest the trip with e.g., minimum distance or minimum travelling time. Some alternatives supporting the user’s decision in case of risk of very dense traffic added also. A transport manager at e.g., a logistics company such as SAMAT applies routing algorithms. This task C2.2 aims at introducing simulation concepts for energy consumption into routing based on two steps:

1. Routing on the road network with simplified consumption measures and truck restrictions, delivering several alternative routes
2. Simulating speed profiles and energy consumption for the alternative routes and presenting the results to the user for selection of an optimal route.

Reasons for that two-step procedure are the following:

- A full virtual drive computation within the routing optimization is not feasible due to the computation performance.
- The user (e.g., transport manager) will hardly accept suggesting a single energy optimized route without alternatives.
- Dividing the process into these two sub-steps keeps computation time in a reasonable range while maintaining the accuracy of the C2.1 models.

The first step of the virtual drive concept requires an enhanced routing. It considers truck restrictions in the routing engine to avoid infeasible solutions. The dimensions and the weight of the truck-trailer-combination are respected to bypass impassable bridges and gates. Roads not allowed for driving with hazardous material are excluded if necessary. Moreover, steep turning angles at crossings are prevented if another acceptable route is possible. In addition, the cost function of the routing optimization is enabled to consider not only shortest path or shortest time but also minimum fuel consumption. Doing this based on the advanced virtual drive simulation techniques would be too time consuming. Therefore, we developed a consumption-oriented route measure, which can be used to modify the routing cost function towards small consumption. Moreover, it does not slow down the optimization since it can be pre-calculated.

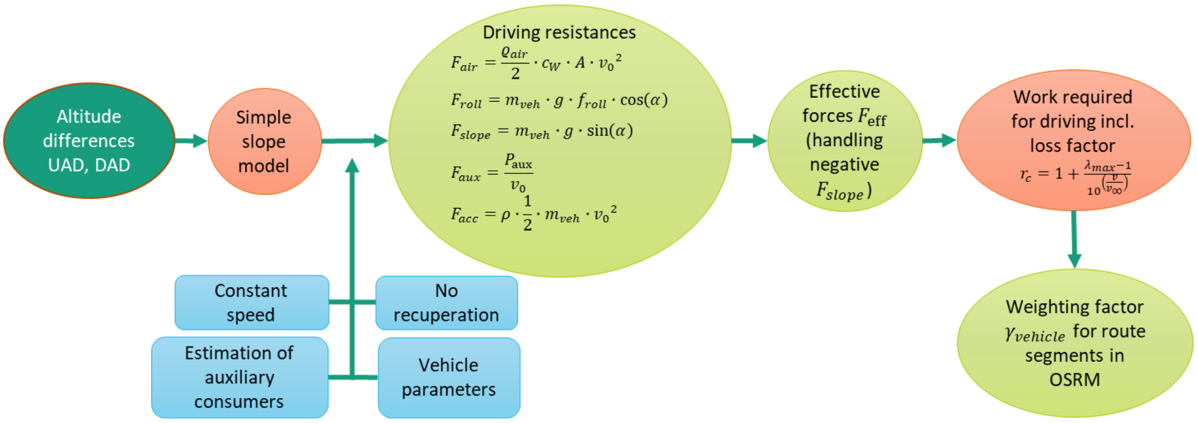


Figure 4. Computation of consumption-oriented route measure

The key approach is that the cost function shall model the energy required for driving a vehicle across the road. The road and vehicle properties used within the approach shall be limited such that the corresponding costs can be assigned to a piece of road in a routing engine prior to solving the routing problem. The idea is to use the average spatial energy density as weight for each segment, such that the final cost function value equals the energy (length times weight). The spatial energy density is just the average longitudinal force needed for driving the vehicle. Thus, we need to estimate the different parts of the longitudinal forces during driving, namely the resistances due to air density, rolling, slope, inertia as well as auxiliary consumers. We assume for all road segments: a simple slope model based on the altitude differences, driving at a constant and road type-dependent speed v_0, and adding a road type-dependent density ρ of stop events. We then can compute the driving resistances and have to consider that some force components may be negative (e.g., slope resistance). These parts do not contribute to consumption but save energy instead. For a proper decomposition of the consumption, these savings need to be distributed to the remaining positive parts which leads to effective forces. Computing the integral of the effective forces over distance yields the required work or energy, where the effective forces serve as weighting factors for the road segments during the routing computation.

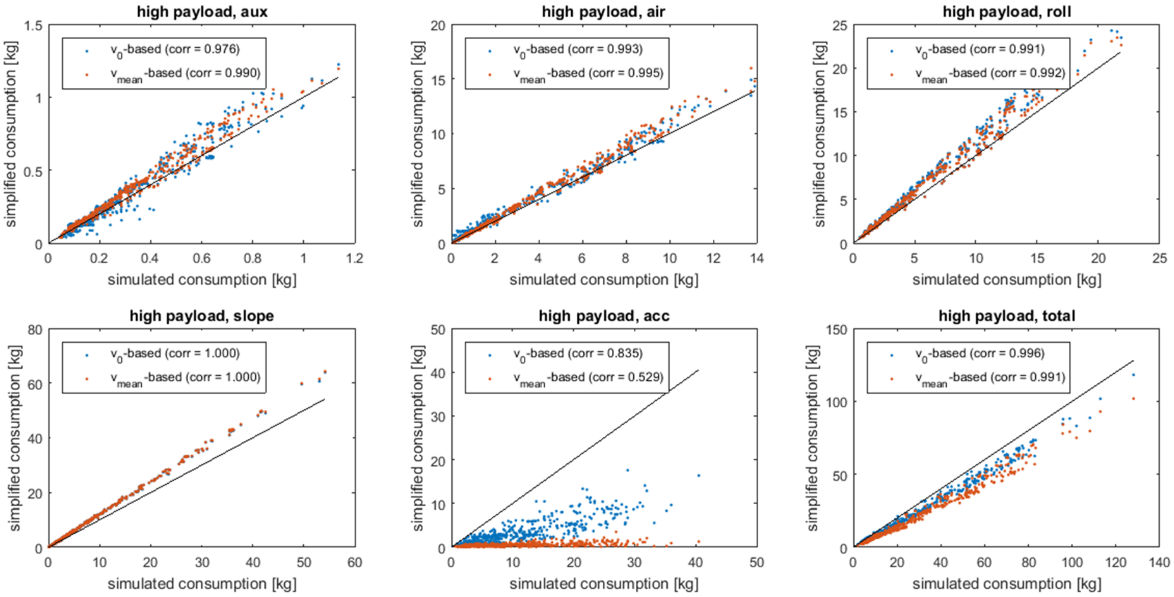


Figure 5. Cost function over simulated consumption for high payload routes

To validate the approach, we used a large number of routes taken from the C4 measurement campaign of SAMAT data. In total, we considered data from 1180 routes with approximately 90,000 km length, divided into more than 30,000 road segments (14,300 full payload, 15,800 low payload). We compare the consumption calculated via the full VMC simulation with the simplified approach as explained above. The figure illustrates the results for the roads with full payload (results for low payload look similar), where the two colours denote two different variants how to handle speeds v_0 and stop event densities ρ. The first five diagrams of the figure show the separated results for the different driving resistances in the order: auxiliary consumers, air density, rolling, slope, and inertia, where the rearmost diagram shows the cumulated consumption, respectively. Within the first four diagrams one can see that the results for the simplified approach of the different driving resistances are in particularly good accordance with the simulated forces, except for a slight overestimation. The inertia forces in the fifth diagram show the largest deviation with a clear underestimation. This component still has the highest potential of improvement but is definitively the most difficult topic due to the underlying traffic influence. The final diagram with the cumulated results shows in total a slight underestimation of the simplified approach against the full simulation.

C.3 Set-up of the Demonstrator and pilot run

C3.1 System Requirements

After workshops and interviews with SAMAT, high-level functional requirements were defined, with different goals:

- understand all details about current operations management, methods, existing IT systems, integration constraints
- collect user requirements related to route planning optimization, fuel consumption estimation and optimization
- define the set of vehicle’s data channels required to feed the VMC, at the right precision, resolution and time resolution.

- define the best user interface of the final routing solution with VMC integrated into CLS’s platform, with a smooth workflow, from Transport manager to the final Driver of the Truck.

Then, several major transport fleet companies (customers of CLS) were contacted and interviewed, to complement SAMAT’s bill of user needs with other transporters’ particularities. This approach helped the commercialization among a wider customer portfolio.

Use cases have been grouped inside “User Stories” which can be gathered in 7 major themes:

- General settings and system requirements
- VMC-based route optimization Module
- Planning Module
- Tracking and Tracing Module
- Dashboard Module (analysis of LIFE ECOTRAVID trips)
- Android application for Drivers
- Driver's behaviour, performance and rating

C3.2 Online Computing Service for Virtual Drive Simulation

First, VMC software of ITWM was designed as a desktop application only. To make it easier to use for Transport companies, it was needed to integrate the VMC software into Trailermatics™.
Trailermatics™ is the user friendly telematic CLS road transport platform daily used by many logistic and transport customers.

Figure 6 *SAMAT’s vehicles monitored on Trailermatics™ Map Module*

Firstly, ITWM setup a simple web services mock-up. An URL was provided to CLS, accepting requests and sending answers with the kind of data that the final tool will provide (at this stage there were no computation, just a mock-up; asynchronous implementation, as it will be in reality). The result format has been provided as API description in YAML. Integration of VMC on CLS platform by Web Services has been done and performed with this mock-up version.

Then, thanks to the development of the Web Service, a first version of the VMC was interfaced with Trailermatics™, allowing application and first test in real condition of the virtual drive engine.
A final version of the VMC with all settings available was integrated at CLS's side since December 2021

C3.3 Development of the Demonstrator

For the demonstrator building, the first step was to equip SAMAT vehicles with CLS telematic hardware solution (more details in C4.1 action), allowing two important steps:

1. Collecting data to feed the virtual drive model to build it and optimize it (Demo phase I - Pilot measurements phase and baseline)
2. Track in real time vehicles, allowing to use Trailermatics platform for the second phase of the pilot (demonstration phase)

As the way of working of these telematic terminals selected for LIFE ECOTRAVID project was specific (a lot of information coming from vehicle and sensors, with a high frequency), CLS needed to engage several developments for those embedded terminals adaption. Most of this work was to adapt the embedded SW to be able to retrieve all necessary data channels from the specific sensors and from the vehicles data buses (FMS, CAN); and to generate this information at the required precision and time resolution.

Thanks to the Web Service developed and activated in sub-task C3.2 the VMC software is integrated into Trailermatics™ platform. After developments around it, the VMC software could be called from the "Planning module" of Trailermatics™.
For every transport order of Trailermatics™ Planning Module, the new VMC toolkit could call the VMC, with the possibility to indicate in the Platform specific characteristics of the trip (dangerous goods transportation, features of the vehicle as size, power engine…). The VMC considered these specific features to calculate and propose different alternative sets of routes, with different goals displayed in the form of a table (estimated fuel consumption, kilometers and time runs for every different alternative). The user (usually the transport manager) could select one or another and set-up his route plan for the trip, which can be sent to the driver's Smartphone (running CLS's Android application) for GPS navigation. Then, the Driver could follow the right route and effectively optimize the trip and fuel consumption.

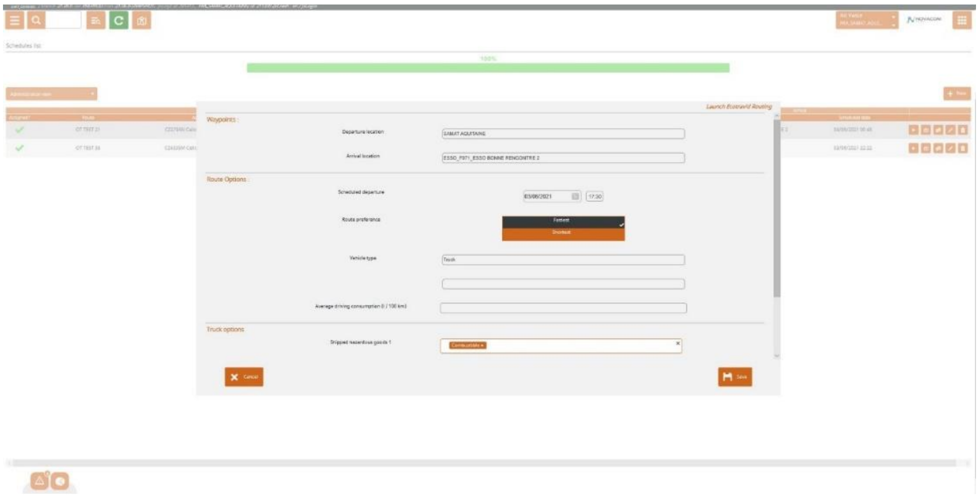

Launch Ecotravid Routing
Waypoints :
Departure location: SAMAT AQUITAINE
Arrival location: ESSO_F971_ESSO BONNE RENCONTRE 2
Route Options :
Scheduled departure: 03/06/2021 17:30
Route preference: Fastest ✓ / Shortest
Vehicle type: Truck
Average driving consumption (l / 100 km)
Truck options
Shipped hazardous goods 1: Combustible

Figure 7: *VMC call IHM from Trailermatics™ Planning Module*

This last step could be done with the first version of Android “Driver connect” application, which was developed by CLS, allowing transmission to the driver of his Ecotravid transport schedule (in a Driver Connect Planning declination).

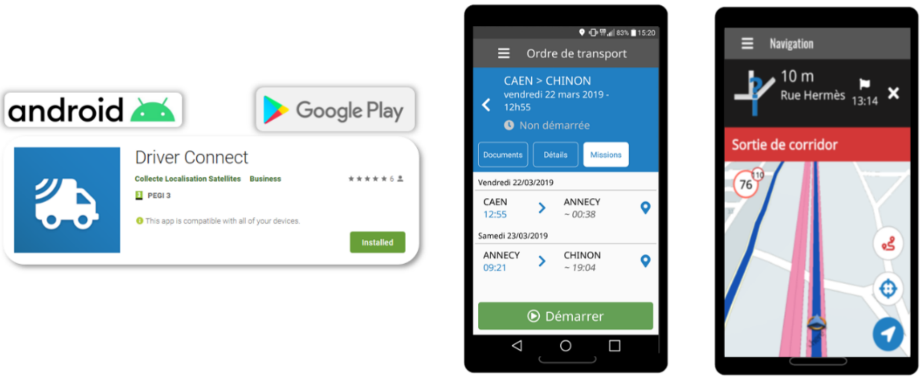


Figure 8: *Android “Driver connect” application*

CLS completed the development related to the integration of SAMAT’s TMS, which allowed to import necessary information to feed at the same time the Trailermatics™ Planning Module and the VMC algorithms (Full chain of planning + goods content)

This decision-making help was completed with a report displaying and analyzing different KPI’s and enabling the user to compare the initial estimations to the actual values achieved.

C3.4 System integration and validation tests

The different components, including VMC, CLS Platform, SAMAT’s TMS, the new embedded terminals, the new VMC toolkit and the driver’s Android application, were progressively integrated, with validation tests running. Integration tests required the collaboration of the three partners SAMAT, CLS and ITWM.

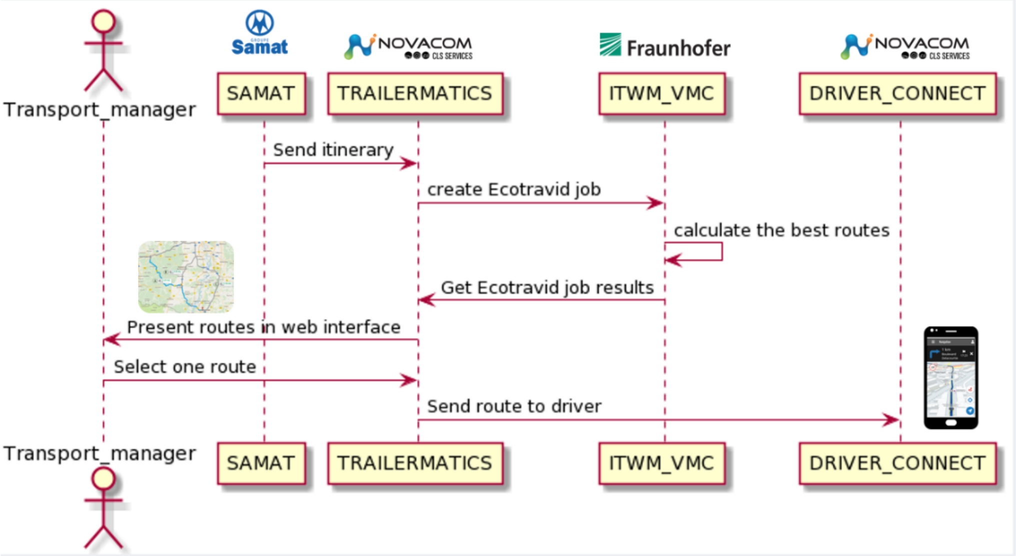


Figure 9: *Workflow of an itinerary with a VMC Ecotravid call*

C3.5 Demonstrator – Pilot run

As much as possible, the fleet operator from SAMAT selected recent vehicles which are frequently moving, with high probability to have the same couples of “Truck Trailer.” Device installations have been done by SAMAT, 20 trucks have been equipped with CelloCANiQ FMS terminal and 20 trailers have been equipped with TTS400 terminal. Pilot measurements phase and baseline (phase I of the Pilot) has started beginning of 2020. It produces real measurements and feed the VMC to verify the new models and fine-tune the algorithms and to be used as baseline for the performance assessment of the new fleet management VMC-based toolkit that has been used in the phase II.

During the second phase of the Pilot (demonstration phase), the final version of new fleet management VMC-based toolkit will go live and SAMAT’s operations manager will use it for the daily route planning. The VMC’s predictions and the effective results have been compared; all KPI’s have been measured and the performance of the new toolkit have been evaluated. Trucks and trailers equipped have been monitored on cluster roads defined by ITWM during phase I (action C4.3), where alternative routes have been found by VMC.

The definition of the Pilot gave clear guidelines to SAMAT for this phase II (“cluster routes” used, staff involved, explanations for Drivers, monitoring of the KPI’s…)

C.4 Measurement on Public Roads

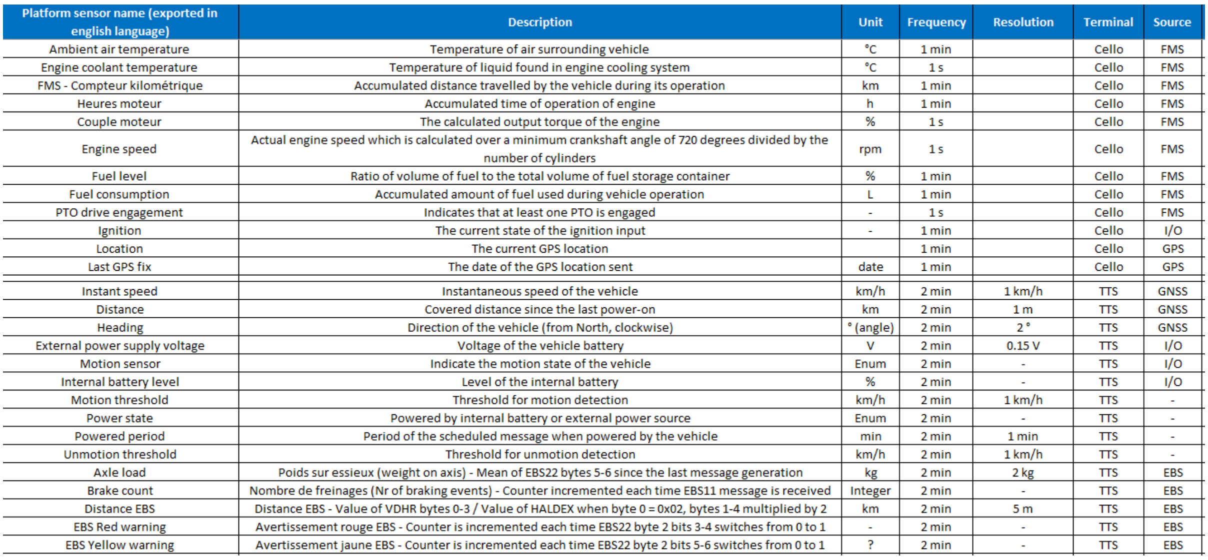
C4.1 Definition and preparation of the measurements

Collecting real data from SAMAT’s vehicles equipped, with enough precision and a right time resolution is one major step of LIFE ECOTRAVID project, as this data is like a “raw material” to build the VMC.
For that reason, two kinds of terminals have been selected, for their ability to collect many data on vehicles. These data are produced with a high frequency (from 1 second up to several minutes), from 2 main channels:

- Information from vehicles data buses (FMS for Trucks, EBS for Trailers), such as speed, acceleration fuel consumption… etc
- Additional sensors installed (TPMS and truck ID sensors) and GPS signals.

The set of data channels needed for the VMC analysis has been defined by ITWM and CLS, with a list of desired sensors including the resolution needed for the intended analysis frequency level and units. Then this “wish list” has been compared with properties of CLS’s terminals, to have a final table.

Table 3. Final sensor list for Ecotravid project



Platform sensor name (exported in english language)	Description	Unit	Frequency	Resolution	Terminal	Source
Ambient air temperature	Temperature of air surrounding vehicle	°C	1 min		Cello	FMS
Engine coolant temperature	Temperature of liquid found in engine cooling system	°C	1 s		Cello	FMS
FMS - Compteur kilométrique	Accumulated distance travelled by the vehicle during its operation	km	1 min		Cello	FMS
Heures moteur	Accumulated time of operation of engine	h	1 min		Cello	FMS
Couple moteur	The calculated output torque of the engine	%	1 s		Cello	FMS
Engine speed	Actual engine speed which is calculated over a minimum crankshaft angle of 720 degrees divided by the number of cylinders	rpm	1 s		Cello	FMS
Fuel level	Ratio of volume of fuel to the total volume of fuel storage container	%	1 min		Cello	FMS
Fuel consumption	Accumulated amount of fuel used during vehicle operation	L	1 min		Cello	FMS
PTO drive engagement	Indicates that at least one PTO is engaged	-	1 s		Cello	FMS
Ignition	The current state of the ignition input	-	1 min		Cello	I/O
Location	The current GPS location		1 min		Cello	GPS
Last GPS fix	The date of the GPS location sent	date	1 min		Cello	GPS
Instant speed	Instantaneous speed of the vehicle	km/h	2 min	1 km/h	TTS	GNSS
Distance	Covered distance since the last power-on	km	2 min	1 m	TTS	GNSS
Heading	Direction of the vehicle (from North, clockwise)	° (angle)	2 min	2 °	TTS	GNSS
External power supply voltage	Voltage of the vehicle battery	V	2 min	0.15 V	TTS	I/O
Motion sensor	Indicate the motion state of the vehicle	Enum	2 min	-	TTS	I/O
Internal battery level	Level of the internal battery	%	2 min	-	TTS	I/O
Motion threshold	Threshold for motion detection	km/h	2 min	1 km/h	TTS	-
Power state	Powered by internal battery or external power source	Enum	2 min	-	TTS	-
Powered period	Period of the scheduled message when powered by the vehicle	min	2 min	1 min	TTS	-
Unmotion threshold	Threshold for unmotion detection	km/h	2 min	1 km/h	TTS	-
Axle load	Poids sur essieux (weight on axis) - Mean of EBS22 bytes 5-6 since the last message generation	kg	2 min	2 kg	TTS	EBS
Brake count	Nombre de freinages (Nr of braking events) - Counter incremented each time EBS11 message is received	Integer	2 min	-	TTS	EBS
Distance EBS	Distance EBS - Value of VDHR bytes 0-3 / Value of HALDEX when byte 0 = 0x02, bytes 1-4 multiplied by 2	km	2 min	5 m	TTS	EBS
EBS Red warning	Avertissement rouge EBS - Counter is incremented each time EBS22 byte 2 bits 3-4 switches from 0 to 1	-	2 min	-	TTS	EBS
EBS Yellow warning	Avertissement jaune EBS - Counter is incremented each time EBS22 byte 2 bits 5-6 switches from 0 to 1	?	2 min	-	TTS	EBS

C4.2 Execution of data measurements

All trips of trucks and trailers equipped are monitored, and these data are collected on the vehicles and sent to the CLS Trailermatics Platform. Then, all input data that are required for VMC development are daily extracted and shared with ITWM for analysis (more details in C4.3 action) Measurement campaign has been launched in January 2020 after the first installation. Daily data exports are available for ITWM for analysis. When new installations have been done, the data from the newly added vehicles were automatically added to the daily data exports. The data has been checked by ITWM, corrected if necessary (shift between GPS signals and remaining signals) and forwarded to a bundle of analysis procedures. The main purpose of the first phase was to calibrate the VMC models, to study potential truck and driver effects, as well as to predict fuel consumption savings based on simulating SAMAT’s missions and alternative routing results.

During the last months of the project, we had (at least) weekly meetings to plan and conduct verification measurements and specific routes to drive in detail. Based on the short-term planning of SAMAT’s operation, which has been sent to ITWM by SAMAT on a daily basis, we checked the trips planned for the coming days for alternative routing with hopefully less consumption and proposed to travel those alternatives in the future. By that procedure, we wanted to obtain a couple of repetitions of truck travels on the originally foreseen route as well as on the proposed alternative route. The corresponding data has been analysed to produce fuel consumptions savings verified by real measurements. More details and the specific figures on the saving potential are described in the corresponding sections below.

C4.3 Analysis of measurement data

The data from the vehicles as described in C4.1 and C4.2 is provided by CLS as csv-files and processed by ITWM as follows:

- Detection of trucks running with Cello device and monitoring distance and consumption
- Detection of truck-trailer pairs running together and being equipped with the Cello resp. TTS devices
- Splitting data into individual trips (transport tasks)
- Filtering out trips with missing important data such as the total weight of the vehicle.
- Analysing the remaining data and preparation for import into VMC and simulation

The simulation of the trips and the adaptions of the models based on the comparison of measured and simulated data is described in C1.2.
In a subsequent step, the trips have been clustered to get an overview of the diversity and frequency of the transport tasks. This is important for the evaluation of the saving potentials as described in D1.

The following exemplary Table 4 contains data between February 2020 and May 2021:

Table 4. Database from 21 trucks

```
-------------------------------------------------------------------------------
  Truck # days mileage consumption cons. at v = 0 mileage/a consumption/a
                  [km]    [l/100km]       [l/100km]  [km/year]       [l/year]
-------------------------------------------------------------------------------
CZ279SN    289   58299         34.1             2.2      73630          25093
CZ433SM    285   50716         29.2             0.5      64952          18970
DP048ZY    433   74389         29.0             0.3      62707          18168
DQ082ML    317   54074         29.6             0.3      62262          18434
EP099NZ    446   78970         26.1             0.2      64628          16879
ER295LC    466   97834         26.5             0.1      76630          20320
EV525GJ    229   30167         35.0             5.7      48082          16837
FD623RG    229   33130         30.6             1.6      52805          16156
FF636YZ    232   51450         28.3             0.3      80945          22870
FG082NA    227   50018         26.3             0.5      80426          21173
FK044GY    229   33804         28.8             2.0      53880          15509
FK236DD    229   49987         39.0            12.8      79674          31107
FL501KV    229   65308         29.7             1.7     104094          30951
FN004SD    229   54787         34.4             8.9      87325          30023
FN120DX    229   53560         31.0             4.2      85369          26425
FN393BJ    228   38420         29.0             0.2      61506          17847
FP399KR    290   72187         31.9             4.2      90856          28956
FQ243FD    300   90981         32.8             3.8     110694          36332
FQ618DQ    299   71489         30.9             5.1      87269          26924
FX294TD      4    1793         24.4             0.4     163649          39859
FX430TD     19    1479         30.3             1.3      28417           8621
    All   5438 1112845         30.4             2.7      74694          22704
-------------------------------------------------------------------------------
```

The Table 4 contains data from 21 trucks with a total mileage of more than 1.1 Mio km. The yearly mileage ranges from approx. 50,000 km to 110,000 km, on average we have 75,000 km. The consumption ranges from 26 l/100km to 39l/100km. The latter is high and due to high consumption at speed below 0.5 km/h (idling). The average of the consumption over all trucks is 30.4 l/100km resulting in 22,700 l per year and truck. These observations are used in section D1 to extrapolate potential savings on selected routes to SAMAT's schedule as a whole.

The work described next gives insight into the size of the influence of different vehicles or drivers on the fuel consumption and on driver behaviour. Since the real-life data exhibits large variations due to different traffic situations, varying payload, different mix of road types and slopes, dedicated statistical methods need to be applied to be able to estimate the effect of those factors.

We analyse public road measurement data from the period between June 2, 2020, and June 16, 2021, and try to understand and explain how consumption is influenced by various factors such as type of roads, altitude profile, traffic, as well as driver and vehicle. Since in SAMAT's operation, one driver mostly runs the same truck, we cannot distinguish between a truck or a driver effect and considered the combined effect only.

Although different trucks and drivers are operating on different types of roads (due to different missions), a non-biased comparison of the consumption of the truck-driver combinations could successfully be established based on a suitable regression model. We used this model to subtract the route and traffic effects from the consumption and to interpret the result as the remaining combined effect of truck and driver. The effects are high, up to 9.5%. If we presume that trucks of the same type have the same engine efficiency, we must interpret the differences in consumption between those combinations primarily as driver effects. This applies to the trucks DQ082ML, DP048ZY, and EP099NZ, which are all Mercedes Actros.

In addition to consumption, we also analysed acceleration as well as brake and clutch count as measures for driving behaviour. Using a prediction model to get rid of the route-based effects on those measures did not work. Thus, we used a standard 2-way ANOVA, where the factor city share was introduced to neutralise the major route-based effects. The observations we made are in accordance with the consumption analysis results. The truck DP048ZY is operated in the most economical way.

Next, we optimised the parameters of a consumption prediction model to fit the measured data and we saw, that besides driver effects, the engine efficiency also varies.

The work performed within action C1 on model calibration has been based on fully simulating the trips which are part of the measured data and comparing predicted against measured consumption. This is the straightforward approach to fit all parameters in the prediction model in a single calibration procedure. So far, deviations between measured and predicted consumption cannot be assigned to a single sub-model such as the driver model or the traffic model or the vehicle model.

To eliminate the effects of driver and traffic modelling in another calibration attempt, we did not fully simulate a measured trip, but projected the measured speed and acceleration to the VMC road representation using the map matching results. Then, we only applied the consumption model, which is a part of the vehicle simulation model, and compared the results to the measured consumption values.

This complements action C1.2 towards model calibration and fine tuning. The idea is that replacing simulated speed and acceleration by the measured data leads to a separation of the impact of vehicle parameters on the one hand and driver and traffic parameters on the other hand. Hence, this approach excludes driver and traffic effect and lets us concentrate on the following:

- Checking the quality of altitude and slope data;
- Checking the engine efficiency model (scalar or matrix);
- Optimising vehicle parameters.

Regarding the first topic, we compared data from the VMC database with measured altitude resp. slope data from the HERE database. As already stated in the reports on action C1, the latter is more accurate in detail than smoothened satellite data, but the impact on the calibration process and the consumption prediction model is small.

Regarding the second topic, we also have seen that the more complex efficiency matrix model has a small impact on calibration results and consumption prediction on routes.

With respect to the third topic, we made some attempts to reduce the uncertainty in the mass information and finally worked with a simple mass model, which can easily be used during the transport planning phase. The required information is the mass of the empty truck-trailer combination and the expected payload. The remaining vehicle parameters have been determined by optimisation on a selected subset of routes. As the main result, we found the vehicle parameters as stated in the Table 5 below.

Table 5. Recap of the vehicle parameters

Vehicle parameter	Unit	Initial value	Final value	Description	Determination
R_wheel	m	0.495	0.495	wheel radius	Samat specification
lambdaMax		1.2	1.2	Coefficient for drivetrain losses	Fitting
vEndMax	m/s	27.78	30	Coefficient for drivetrain losses	Fitting
Pmax	kW	330 resp. 338	330 resp. 338	maximum engine power	Samat specification
Paux	kW	2	3	average power of auxiliary consumers	Fitting
PmaxBrake	W	10*Pmax	10*Pmax	maximum brake power	Default
cW (‘Carburant’)		0.7	0.68	air resistance (front area = 9 m^2)	Fitting
cW (‘Bitume’)		0.7	0.55	air resistance (front area = 9 m^2)	Fitting
A	m^2	9	9	front area	Samat specification
m	kg	Median of data	Simple model	total mass of truck and trailer	Simple model
fRoll (high mass)		0.005	0.004	rolling resistance	Fitting
fRoll (low mass)		0.006	0.007	rolling resistance	Fitting
muk		0.8	0.8	coefficient of friction	Default: 0.8
driveaxles		1	1	number of driven axles	Samat specification
n_axles		5	5	number of axles	Samat specification
aymax_veh	m/s^2	5	5	maximum lateral acceleration	Default: 5 m/s^2
engine_efficiency		0.43	0.427 resp. 0.399 resp. 0.434	engine output power over fuel energy	Fitting

Since the remaining deviations between predicted and measured consumption are still large, we finally tried to explain them by checking the impact of the unknown power of auxiliary consumers as well as the potential impact of environmental factors such as temperature on the engine efficiency. We fitted various models and found, that based on the predictors available, there is only a limited potential of explaining the gap.

C.5 Ensuring the long-term sustainability, replication and transferability

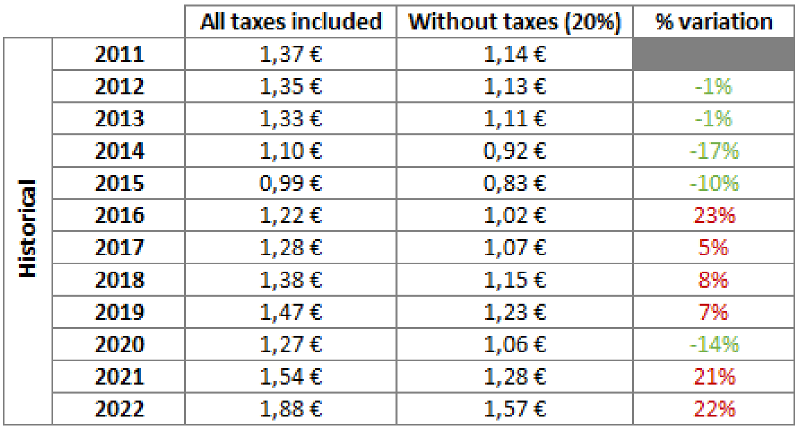
C5.1: Business models definition in case of replicability or transferability

Following the current business model of the grand majority of Telematic service suppliers, potential customers would pay both the terminal cost and the installation service, as well as a monthly subscription to access all platform functions. Including the VMC solution as a supplementary module would encourage the product acknowledgement and awareness in the market. Likewise, it would be stablished an extra fee in the monthly subscription to quantify VMC profits.

Considering the obtained results with SAMAT's vehicle fleet, the 3.5% of fuel savings would be an important asset in the TCO of fleet management's current clients. As it is well known, around 30% of the vehicle's TCO comes from fuel consumption, yet it is not an easy task to master it. VMC solution would both help to increase efficiency and at the same time, reduce companies' carbon footprint regarding their commercial activities.

We have developed 3 different scenarios considering the fuel price variations. Diesel price evolution in the last 10 years has been stable, with increases and decreases that have kept the price in a moderate range of variation. As it is shown below, the two consecutive years with the highest variations were 2020 and 2021, years where the COVID 19 crisis had the biggest economic impacts[2].

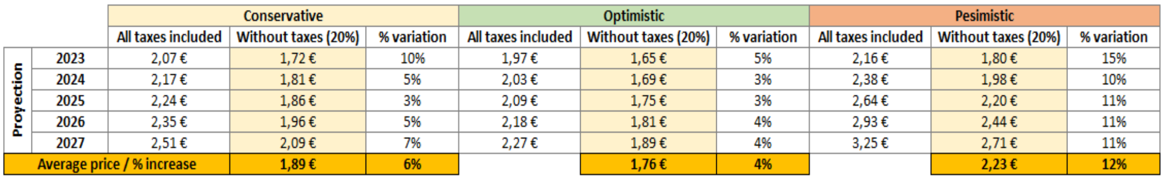
Table 6. Fuel prices' variation



		All taxes included	Without taxes (20%)	% variation
Historical	**2011**	1,37 €	1,14 €	
	2012	1,35 €	1,13 €	-1%
	2013	1,33 €	1,11 €	-1%
	2014	1,10 €	0,92 €	-17%
	2015	0,99 €	0,83 €	-10%
	2016	1,22 €	1,02 €	23%
	2017	1,28 €	1,07 €	5%
	2018	1,38 €	1,15 €	8%
	2019	1,47 €	1,23 €	7%
	2020	1,27 €	1,06 €	-14%
	2021	1,54 €	1,28 €	21%
	2022	1,88 €	1,57 €	22%

Following the historical data, we have built three scenarios of fuel price behaviour: a conservative one, an optimistic one and finally a pessimistic one. It is important to remark that all the other variables rest the same. As to the average vehicle information (mileage per year, rides per year, active days per year, total fuel consumption, etc.), the data was provided by SAMAT as well.

Table 7. Scenarios based on the fuel price



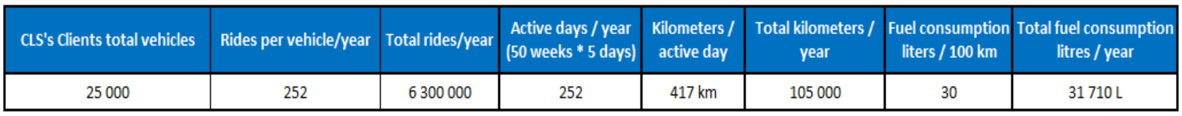
		Conservative			Optimistic			Pesimistic		
		All taxes included	Without taxes (20%)	% variation	All taxes included	Without taxes (20%)	% variation	All taxes included	Without taxes (20%)	% variation
Proyection	**2023**	2,07 €	1,72 €	10%	1,97 €	1,65 €	5%	2,16 €	1,80 €	15%
	2024	2,17 €	1,81 €	5%	2,03 €	1,69 €	3%	2,38 €	1,98 €	10%
	2025	2,24 €	1,86 €	3%	2,09 €	1,75 €	3%	2,64 €	2,20 €	11%
	2026	2,35 €	1,96 €	5%	2,18 €	1,81 €	4%	2,93 €	2,44 €	11%
	2027	2,51 €	2,09 €	7%	2,27 €	1,89 €	4%	3,25 €	2,71 €	11%
Average price / % increase			**1,89 €**	**6%**		**1,76 €**	**4%**		**2,23 €**	**12%**

---

[2] https://www.lefigaro.fr/conso/carburants-debut-2022-les-prix-a-la-pompe-atteignent-de-nouveau-des-niveaux-records-20220111

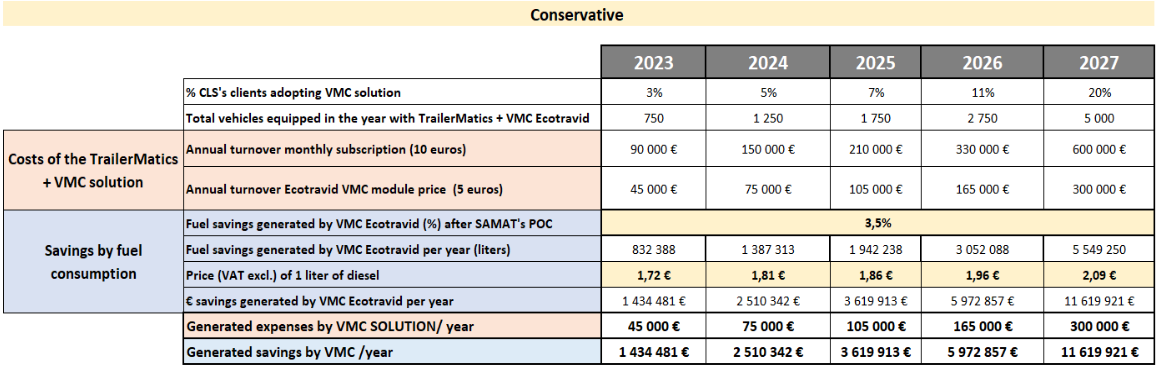
Conservative scenario:
In this scenario, average increase annual rate of 6% has been settled regarding the fuel price. With a commercial deployment horizon of 5 years, the number of customers consuming the VMC solution is growing progressively every year. However, it is evident that the cost of VMC solution (considering the telematic platform cost also) is significantly lower than the incurred cost of fuel (regarding an average price of 1.89 €). In that sense, with a fuel saving rate of 3.5% we can extrapolate a saving of 1.4 M euros for a vehicle fleet of 750 vehicles in 2023. If we are talking about an average fleet of 60 vehicle per client, we would be facing an annual fuel saving that reach 125 K euros per client. Considering the 2.68 Kg of C02 in every diesel litter, we would be saving around 2974 kg de CO2 per year, 178 K kg per client annually.

Table 8. Clients' savings in a conservative scenario



CLS's Clients total vehicles	Rides per vehicle/year	Total rides/year	Active days / year (50 weeks * 5 days)	Kilometers / active day	Total kilometers / year	Fuel consumption liters / 100 km	Total fuel consumption litres / year
25 000	252	6 300 000	252	417 km	105 000	30	31 710 L

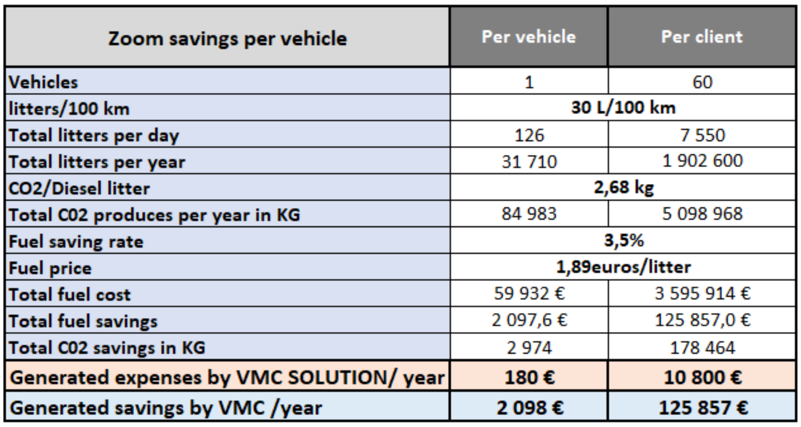
Table 9. Costs and savings in a conservative scenario



Conservative

		2023	2024	2025	2026	2027
	% CLS's clients adopting VMC solution	3%	5%	7%	11%	20%
	Total vehicles equipped in the year with TrailerMatics + VMC Ecotravid	750	1 250	1 750	2 750	5 000
Costs of the TrailerMatics + VMC solution	Annual turnover monthly subscription (10 euros)	90 000 €	150 000 €	210 000 €	330 000 €	600 000 €
	Annual turnover Ecotravid VMC module price (5 euros)	45 000 €	75 000 €	105 000 €	165 000 €	300 000 €
Savings by fuel consumption	Fuel savings generated by VMC Ecotravid (%) after SAMAT's POC	**3,5%**				
	Fuel savings generated by VMC Ecotravid per year (liters)	832 388	1 387 313	1 942 238	3 052 088	5 549 250
	Price (VAT excl.) of 1 liter of diesel	**1,72 €**	**1,81 €**	**1,86 €**	**1,96 €**	**2,09 €**
	€ savings generated by VMC Ecotravid per year	1 434 481 €	2 510 342 €	3 619 913 €	5 972 857 €	11 619 921 €
	Generated expenses by VMC SOLUTION/ year	**45 000 €**	**75 000 €**	**105 000 €**	**165 000 €**	**300 000 €**
	Generated savings by VMC /year	**1 434 481 €**	**2 510 342 €**	**3 619 913 €**	**5 972 857 €**	**11 619 921 €**

Table 10. Savings per vehicle and client in a conservative scenario

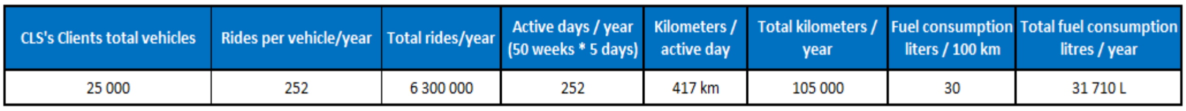


Zoom savings per vehicle	Per vehicle	Per client
Vehicles	1	60
litters/100 km	**30 L/100 km**	
Total litters per day	126	7 550
Total litters per year	31 710	1 902 600
CO2/Diesel litter	**2,68 kg**	
Total C02 produces per year in KG	84 983	5 098 968
Fuel saving rate	**3,5%**	
Fuel price	**1,89euros/litter**	
Total fuel cost	59 932 €	3 595 914 €
Total fuel savings	2 097,6 €	125 857,0 €
Total C02 savings in KG	2 974	178 464
Generated expenses by VMC SOLUTION/ year	**180 €**	**10 800 €**
Generated savings by VMC /year	**2 098 €**	**125 857 €**

Optimistic scenario:
In an optimistic forecast, fuel prices variation would be about 4% average in the following 5 years. Regarding the most important milestones, Ukraine's war has a remarkable impact in price fluctuations. As we can see in the chart below, total

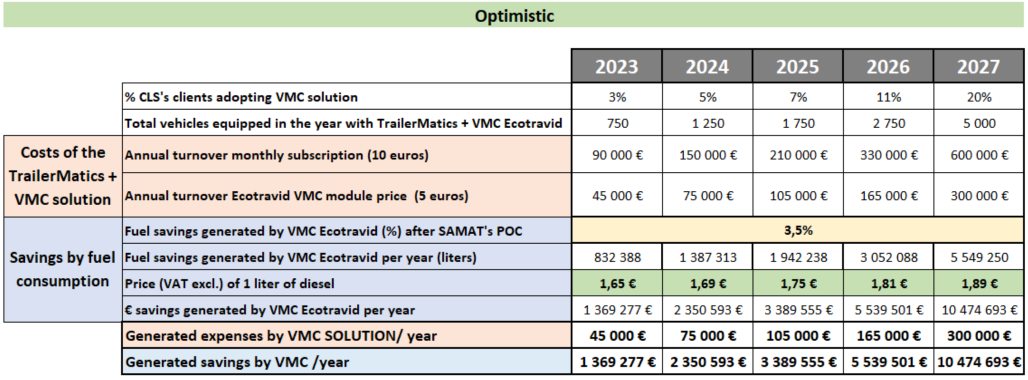
investment in VMC solution would remain the same regardless the fuel price. In the same away, the total CO2's saving would remain unaffected. On the contrary, the total savings amount would decrease, but still would be more significant than the total solution's investment.
Assuming these theorical context could be risky in terms of viability, since for the last two recent years the increase rate has been of 20% average.

Table 11. Clients' savings in an optimistic scenario



CLS's Clients total vehicles	Rides per vehicle/year	Total rides/year	Active days / year (50 weeks * 5 days)	Kilometers / active day	Total kilometers / year	Fuel consumption liters / 100 km	Total fuel consumption litres / year
25 000	252	6 300 000	252	417 km	105 000	30	31 710 L

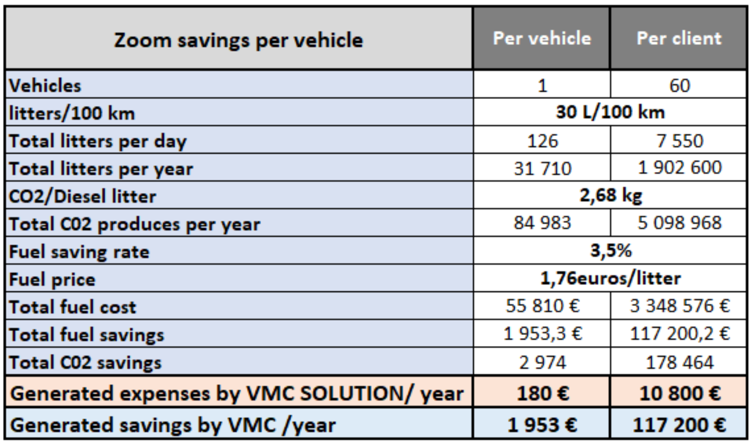
Table 12. Costs and savings in an optimistic scenario



Optimistic

		2023	2024	2025	2026	2027
	% CLS's clients adopting VMC solution	3%	5%	7%	11%	20%
	Total vehicles equipped in the year with TrailerMatics + VMC Ecotravid	750	1 250	1 750	2 750	5 000
Costs of the TrailerMatics + VMC solution	**Annual turnover monthly subscription (10 euros)**	90 000 €	150 000 €	210 000 €	330 000 €	600 000 €
	Annual turnover Ecotravid VMC module price (5 euros)	45 000 €	75 000 €	105 000 €	165 000 €	300 000 €
Savings by fuel consumption	**Fuel savings generated by VMC Ecotravid (%) after SAMAT's POC**	**3,5%**				
	Fuel savings generated by VMC Ecotravid per year (liters)	832 388	1 387 313	1 942 238	3 052 088	5 549 250
	Price (VAT excl.) of 1 liter of diesel	**1,65 €**	**1,69 €**	**1,75 €**	**1,81 €**	**1,89 €**
	€ savings generated by VMC Ecotravid per year	1 369 277 €	2 350 593 €	3 389 555 €	5 539 501 €	10 474 693 €
	Generated expenses by VMC SOLUTION/ year	**45 000 €**	**75 000 €**	**105 000 €**	**165 000 €**	**300 000 €**
	Generated savings by VMC /year	**1 369 277 €**	**2 350 593 €**	**3 389 555 €**	**5 539 501 €**	**10 474 693 €**

Table 13. Savings per vehicle and client in an optimistic scenario

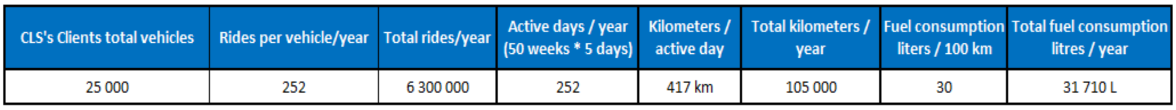


Zoom savings per vehicle	Per vehicle	Per client
Vehicles	1	60
litters/100 km	**30 L/100 km**	
Total litters per day	126	7 550
Total litters per year	31 710	1 902 600
CO2/Diesel litter	**2,68 kg**	
Total C02 produces per year	84 983	5 098 968
Fuel saving rate	**3,5%**	
Fuel price	**1,76euros/litter**	
Total fuel cost	55 810 €	3 348 576 €
Total fuel savings	1 953,3 €	117 200,2 €
Total C02 savings	2 974	178 464
Generated expenses by VMC SOLUTION/ year	**180 €**	**10 800 €**
Generated savings by VMC /year	**1 953 €**	**117 200 €**

Pessimistic scenario:
In this scenario we are expecting a substantial prolongation of relevant milestones, such as Ukraine's war. An average increase rate of 12% in fuel prices would be harmful for transport enterprises. However, the total saving perceived would be more important regarding the % in the TCO that fuel consumption would represent. This scenario, even if negative in terms of transport enterprise's expenses, it is close to a close future. International conflict and even socio-political discontent regarding the work conditions in the oil sector could have a long-term effect.

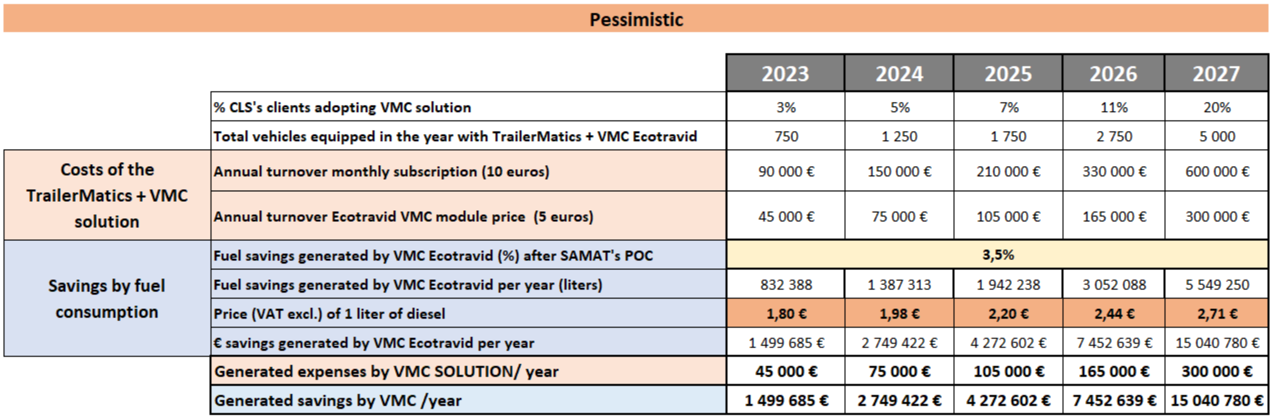
In this context, VMC solution would certainly represent an extremely attractive response to reduce activity's expenses and keep substantial scale economies.

Table 14. Clients' savings in a pessimistic scenario



CLS's Clients total vehicles	Rides per vehicle/year	Total rides/year	Active days / year (50 weeks * 5 days)	Kilometers / active day	Total kilometers / year	Fuel consumption liters / 100 km	Total fuel consumption litres / year
25 000	252	6 300 000	252	417 km	105 000	30	31 710 L

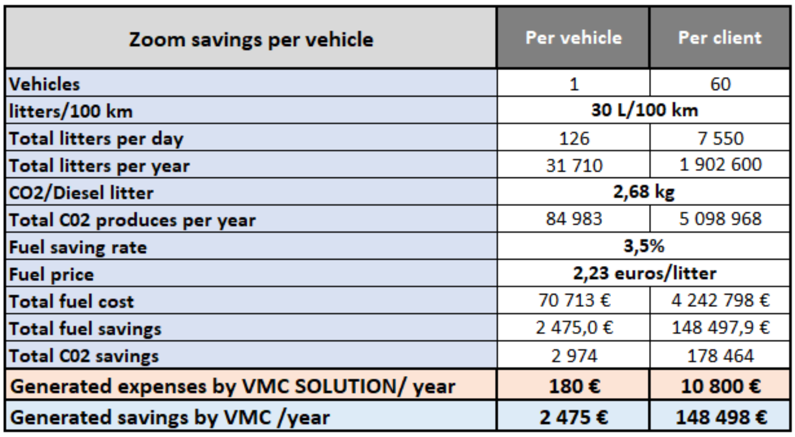
Table 15. Costs and savings in a pessimistic scenario



Pessimistic

		2023	2024	2025	2026	2027
	% CLS's clients adopting VMC solution	3%	5%	7%	11%	20%
	Total vehicles equipped in the year with TrailerMatics + VMC Ecotravid	750	1 250	1 750	2 750	5 000
Costs of the TrailerMatics + VMC solution	**Annual turnover monthly subscription (10 euros)**	90 000 €	150 000 €	210 000 €	330 000 €	600 000 €
	Annual turnover Ecotravid VMC module price (5 euros)	45 000 €	75 000 €	105 000 €	165 000 €	300 000 €
Savings by fuel consumption	**Fuel savings generated by VMC Ecotravid (%) after SAMAT's POC**	**3,5%**				
	Fuel savings generated by VMC Ecotravid per year (liters)	832 388	1 387 313	1 942 238	3 052 088	5 549 250
	Price (VAT excl.) of 1 liter of diesel	**1,80 €**	**1,98 €**	**2,20 €**	**2,44 €**	**2,71 €**
	€ savings generated by VMC Ecotravid per year	1 499 685 €	2 749 422 €	4 272 602 €	7 452 639 €	15 040 780 €
	Generated expenses by VMC SOLUTION/ year	**45 000 €**	**75 000 €**	**105 000 €**	**165 000 €**	**300 000 €**
	Generated savings by VMC /year	**1 499 685 €**	**2 749 422 €**	**4 272 602 €**	**7 452 639 €**	**15 040 780 €**

Table 16. Savings per vehicle and client in a pessimistic scenario



Zoom savings per vehicle	Per vehicle	Per client
Vehicles	1	60
litters/100 km	**30 L/100 km**	
Total litters per day	126	7 550
Total litters per year	31 710	1 902 600
CO2/Diesel litter	**2,68 kg**	
Total C02 produces per year	84 983	5 098 968
Fuel saving rate	**3,5%**	
Fuel price	**2,23 euros/litter**	
Total fuel cost	70 713 €	4 242 798 €
Total fuel savings	2 475,0 €	148 497,9 €
Total C02 savings	2 974	178 464
Generated expenses by VMC SOLUTION/ year	**180 €**	**10 800 €**
Generated savings by VMC /year	**2 475 €**	**148 498 €**

C5.2: Market and competition analysis considering market launch

The European telematics market is moderately competitive and consists of many global players that rely on investments, acquisitions, and partnerships with local fleet manufacturers to capture market share. In addition, manufacturers are focusing on improving product quality by increasing the relevance associated with buyers. Key suppliers include Verizon, WebFleet, Abax, Masternaut and Targa Telematics, among others [3].

---

[3] Mordor Intelligence. European Telematics Market study. https://www.mordorintelligence.com/

a.1 Market Barriers / Drivers

One of the key drivers of market growth is the rising number of accidents on the roads in the EU, with a significant proportion of victims. According to recent data, being involved in work-related road traffic collisions has led government agencies to revise their legislation regarding the security and welfare of employees 4
In that context, after decades as a niche feature, telematics is merging into the automotive mainstream and becoming an asset to reduce costs and assure security. While current adoption rates remain low across markets, they could grow significantly through the first part of the next decade, according to the GSM Association, an organization comprised of mobile-network operators5. Some of the main examples of telematic use cases can include driving-style improvements to boost fuel economy, location-based services such as stolen-vehicle recovery, real-time tracking, vehicle-finder services, vehicle-maintenance alerts, and fuel and routing optimization.
On the other hand, the cost of telematics systems, including installation, maintenance, and feedback provision, continues to be an important investment for the potential customers. However, studies show that the reductions in other costs, such as fuel, and insurance premiums, would be interesting enough to influence telematic demand positively. It is in this context that the VMC solution could become an important tool to tackle enterprises fleet's TCO.

a.2 CLS group profitability study and no-Go decision

After almost 2 years of work on the Ecotravid project, external and internal factors have driven the final decision not to continue with the commercialisation of the VMC solution at the end of the project.
We have addressed the different drivers in relation to the economic, market and strategic objectives of CLS for 2023. Regarding the roadmap projects for 2023, CLS has already committed the annual budget to the different implementations and enhancements of its current portfolio of services and solutions. A large percentage is invested in functionality enhancements of our digital platforms, and the other part in hardware acquisitions and functionality development.
As responsible for three target markets, CLS has prioritised the most urgent needs of its customers with relation to our current solutions. In this regard, the humanitarian and waste market have become the priority in terms of sustainability and financial inflows. Our most important customers and market partners do not include CO2 improvement expenditures among their priorities for the following reasons:

Humanitarian market constraints:

- As far as the humanitarian market is concerned, our main customers are NGOs whose regular missions are in geographically difficult to access areas or even in war zones. In that sense, the paths chosen during missions are not always easy to change. If this is the case, the alternative route is chosen with the highest priority given to the safety of staff and resources.

---

[4] Mordor Inteligencie. European Telematics Market study. https://www.mordorintelligence.com/
[5] Mckinsey. Telematics: Poised for strong global growth | McKinsey

- Many countries and cities where missions take place do not have recognised or established routes. These are rural roads that are sometimes not recognisable on any map, which would make the implementation of the VMC solution even more difficult.

- The most valuable asset for NGOs is their human staff on the ground, and to ensure their safety, they would prioritise short, quick movements rather than increasing risks. In the same way, humanitarian vehicles sometimes must transport perishable resources such as food, medicines, or even high-value resources such as portable heaters, air-conditioning units, etc. To sum up, rapid mission implementation is a key factor in the value chain of humanitarian organisations.

Waste management market constraints:

- As the main clients of this market are the municipal and regional governments, they are intended to manage the city waste collection. In that sense, the main paths of collection are already set up and cannot be changed (thy are formulated regarding the residential areas, industrial areas, etc), so the VMC solution would not be able to propose an alternative collection path. We are talking about the different types of solid waste collection systems (door-to-door collection, block collection, etc.) whose delimitation of routes depends on the geographical position of the inhabitants, companies, etc.

- The main priority of our current customers is to monitor the nature of the waste collected (organic, plastic, batteries, paper, glass, metal, etc.) and to be able to identify and classify it. In addition, they are looking for solutions to have more accurate data on driver behaviour, isolated events that compromise collection, collection measurement data, etc.

- Our main waste management project is TRACITY, which addresses the need to identify bins for user billing based on number of lifts, weight of lifts, etc. This solution must have a 100% accurate and reliable data system. This solution must have a 100% accurate and reliable data system. The context of the development of a circular economy in France is pushing the various players in the waste management market to innovate on this front. In this manner, TRACITY has become our priority for the year 2023 Fraunhofer deployment strategy and preliminary profitability study.

Multimodal (including transport logistics) market constraints:

- As part of CLS's strategic positioning, we will shift our focus from the multimodal market, which caters to all transport and logistics customers. In this sense, we will prioritise humanitarian and waste management developments in our portfolio of solutions and new investments.

- Although we will continue to provide services to our existing multi-modal customers, we will not seek to expand our market share, so we will not seek new customers. Therefore, the VMC solution will not be included in our multimodal platform as there will be no further software updates.

C5.3 Technical and business activities related to the full commercialization of the proposed solution and of its economic feasibility

As it has been detailed and carefully explained above CLS has decided to not go for full commercialization of the proposed solution (based on results and strategic orientation of the company). Therefore during the project the proper full deployment of the solution has not been finalized during the time of the project. Nevertheless as it will be explained in the next task description, Fraunhofer has decided to pursue after the end of the project the commercialization of the solution. To do so as fully described in C5.4 they have performed additional studies to assess the replication and transferability potential of the solution.

C5.4: Preparation of replication and transferability plan

Originally, the fuel consumption and its potential savings for different transport tasks were planned to be analysed based on true missions conducted by SAMAT. The SAMAT business covered by the measurements concentrates on the southwestern part of France and hazardous goods such as carburant or bitumen. Therefore, a limited effort towards extrapolating the corresponding results had been planned. During the project, especially at the beginning of the verification phase (proving savings not only by simulation but by measurements), it turned out that the verification measurements will be limited for several reasons (see also action D1 of this report as well as in the detailed D1 deliverable).

Thus, an additional work package on virtually creating and evaluating reasonable routes, using ITWM’s expertise on usage modelling was added. It includes the modelling, data research and pre-processing, as well as simulation of trips for three additional transport tasks or scenarios, namely hub-to-hub, hub-to-supermarket and fuel supply delivery. The petrol distribution scenario replicates the methodology developed in the Ecotravid project, whereas the supermarket scenarios serve as examples for transferring them.

Objective:

The main objective is to replicate and transfer the fuel saving potentials found in SAMAT’s operation to other applications. The idea is to evaluate the energy savings on a large amount of created routes for different transport tasks conducted all over France. The expected fuel consumption reduction on alternative routes for different scenarios is estimated and compared. This action encompasses four main tasks:

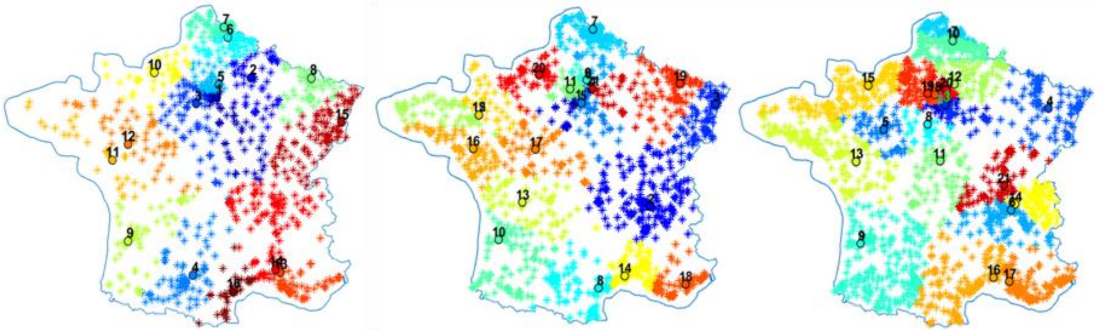
- Identification of relevant transport missions and setting up adequate virtual models.
- Creation of single tasks given by reasonable starting and destination points on the map combined with the mass of the truck-trailer combination including load on the trip.

- Application of the VMC services to compute routes for the different trips, determining speed-profiles and thus travel time as well as fuel consumption of the different alternatives.
- Computation of the possible savings for each mission when using the fuel saving route instead of the fastest or shortest one.

Description of activities:
Available measurements of transport tasks conducted by SAMAT are restricted to the south-western part of France and are biased by customers' demands on materials to be delivered. Applying ITWM's methods for usage modelling allows a well-grounded comparison of results based on a large number of routes for all regions of France.

As exemplary transport missions that generate thousands of tonne-kilometres every day, hub-to-hub and hub-to-supermarket delivery as well as petrol distribution are chosen. The first two allow a comparison of expected fuel saving with and without list mile delivery, the last includes trips with hazardous material. To obtain reliable trips, real locations of supermarkets and their according distribution centres are used. For this purpose, coordinates of warehouses and stores of the three huge chains Aldi, Carrefour and Lidl are looked up from OSM, Google maps and their individual homepages. A shortest distance strategy was applied to assign the stores to their supplying warehouse. The result is given in Figure 11:

Figure 11. Assignment of supermarkets (colored markers) to warehouses (black circles with numbers). From left to right: Aldi, Carrefour, Lidl



For the hub-to-hub delivery, the hubs are connected like shown in the left part of Figure 14. Here, a standard traveling salesperson algorithm on the linear distances is applied to obtain the shortest possible total distance for the complete tour. In case of Carrefour, the distribution hubs in the middle of the country cause a split in three different tours. Hence, links between the tours are added. Including trips in both directions, 150 single transport tasks with full load are generated.

For the supermarket delivery, the number of tours is immense. For some distribution hubs, the nearest neighbour assignment identifies more than 100 supplied stores. Since there is only few information available what strategy the chains apply for their delivery (e.g., minimum number of total trips, minimal costs, maximal freshness of goods...) some realistic assumptions were made and again a traveling salesperson algorithm is used to generate tours with a maximum of four stops. An exemplary result for one hub and one specific tour is given in the middle and right part of Figure 12. For the fuel distribution, a similar process is applied. Here, only one fuel station is approached per trip producing full and empty trailers only.

Figure 12. Exemplary results of traveling salesperson algorithm applied to Lidl location (Left: Connection of warehouses to large tour; Middle: All tours for one warehouse; Right: Routed single delivery trip)

The simulation of transport missions generates thousands of route parts consisting of starting and destination points as well as the expected mass of the loaded truck trailer combination. For the hub-to-hub connections, the mass is always set to the maximum allowed, along the supermarket delivery, the mass is expected to decrease.

All simulated trips are forwarded to the VMC service finally resulting in different routes along the road together with their characteristics like length and expected time and fuel consumption. These results are compared and evaluated in the same way as has been done for the measured transport tasks provided by SAMAT. This means that we applied shortest traveling time routing (standard route) as well as our fuel optimized-routing service and compared the consumption on the standard routes with those on the optimal routes (if any).

To balance travel time and fuel consumption the decision score $r = \frac{c_{orig}}{c_{opt}} * \frac{t_{orig}}{t_{opt}}$ is used. Large values of r are desired, since this means that consumption is decreased without increasing traveling time too much. Since we compare with fastest route, traveling time cannot be decreased. We only look for routes with decreased consumption. Here are the results, depending on which score value is used as threshold ($r > 0$ means that traveling time is not considered):

Table 17. Results of evaluations applying different groups by scenario, operator and region

Scenario	**Operator**	**Region**	**Number of routes analysed**	**Percentage of better alternatives resp. fuel savings**			
				r **> 0**	***r*** **> 1**	***r*** **> 1.05**	***r*** **> 1.1**
Hub-to-hub	**all**	France	155	23.0%, 1.16%	10.8%, 0.90%	5.0%, 0.63%	0.7%, 0.05%
Hub-to-hub	Aldi	France	38	20.0%, 0.79%	16.0%, 0.75%	8.0%, 0.64%	0.0%, 0.00%
Hub-to-hub	Carrefour	France	64	22.2%, 0.65%	7.9%, 0.46%	3.2%, 0.31%	0.0%, 0.00%
Hub-to-hub	Lidl	France	53	25.5%, 1.88%	11.8%, 1.42%	5.9%, 0.95%	2.0%, 0.14%
Hub-to-supermarket	**all**	France	6907	42.1%, 2.48%	18.8%, 1.68%	11.2%, 1.26%	7.0%, 0.87%
Hub-to-supermarket	Aldi	France	1392	41.9%, 2.22%	18.2%, 1.43%	9.9%, 1.23%	7.8%, 0.78%
Hub-to-supermarket	Carrefour	France	3450	43.0% 2.98%	19.5% 2.05%	11.3%, 1.58%	6.6%, 1.10%
Hub-to-supermarket	Lidl	France	2065	41.3%, 2.50%	19.5%, 1.83%	9.9%, 1.23%	5.8%, 0.81%
Cold storage	Carrefour	**France**	3567	37.5%, 1.48%	18.4%, 1.14%	11.9%, 0.73%	8.6%, 0.48%
Cold storage	Carrefour	North	1178	42.0%, 1.87%	21.2%, 1.23%	14.8%, 0.94%	11.0%, 0.55%
Cold storage	Carrefour	East	739	34.6%, 1.12%	17.5%, 0.91%	9.9%, 0.61%	6.3%, 0.27%
Cold storage	Carrefour	Southwest	1650	35.4%, 1.54%	16.8%, 1.21%	10.8%, 0.72%	8.0%, 0.56%
Petrol distribution	TotalEnergies	**France**	2716	43.7%, 2.39%	14.0%, 1.27%	7.6%, 0.78%	4.0%, 0.48%
Petrol distribution	TotalEnergies	Northwest	1482	43.0%, 2.75%	17.4%, 1.62%	9.4%, 0.98%	4.9%, 0.64%
Petrol distribution	TotalEnergies	Southeast	1234	44.7%, 2.02%	9.8%, 0.91%	5.4%, 0.58%	3.0%, 0.33%

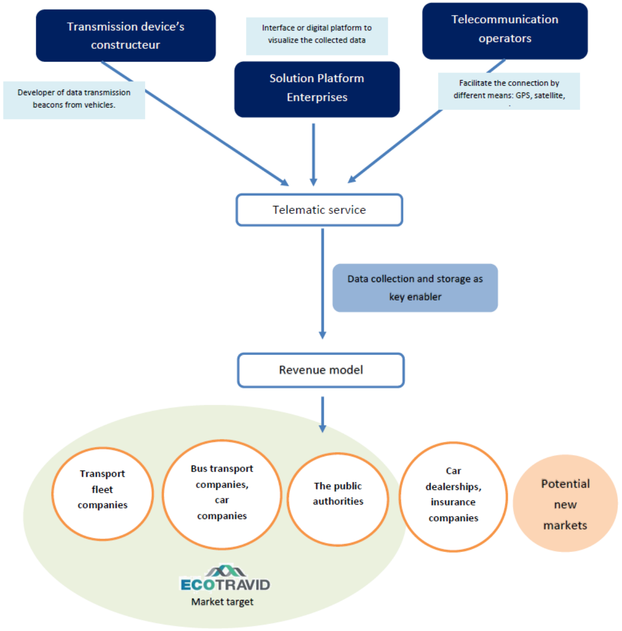
For all scenarios, thousands of single routes combined with the mass of the truck-trailer-load combination were created and analysed. Overall, the savings are a bit smaller than those computed for the SAMAT measurements. Nevertheless, since no time saving was considered, this approach showed that the newly created VMC compute service provides additional better routes than classical routing services.

The results have not only been split by the scenarios, but also by operators and different regions of France. The corresponding groups reveal differences in the obtained fuel saving potentials. In addition to the mean saving potential, the scatter of the results is of interest when talking about further transfer project results to other transport branches, e.g., in different countries and/or transporting different goods with other types of loading and destination locations.

C5.5: Preparation of the Business Plan

The business plans, include first the targeted market and the related value chain as depicted below, as well as market barriers and competition as defined above:

Figure 13. LIFE ECOTRAVID Value chain



Then as detailed within task C5.1, business models and profitability studies have been performed based on various scenarios.

As explained within task C5.2 considering CLS strategic objectives, the company has decided to not pursue the commercialisation of the (see business plan deliverable for more details).

Fraunhofer has decided to pursue the commercial exploitation of the VMC software extensions using a different business model. Indeed Fraunhofer is not a provider of telematics solution but they directly collaborate with truck and trailer manufacturers, for vehicle development. Some of them have their own telematics system, where the VMC solution can be integrated. The additional idea of Fraunhofer is to propose extended services since the new tools derived from LIFE ECOTRAVID could be further applied in the context of vehicle development, for reliability or energy efficiency optimization, as well as for vehicle configuration or for operating fleets. While they cannot predict any specific figures regarding CO2 footprint reduction, they believe that their methods can reduce energy consumption of a given fleet of vehicles and supporting the transformation of conventional drivetrains towards more sustainable ones.

D.1 Monitoring of the environmental impact of the project

To determine the environmental impact of the project, so-called transport tasks on public roads by SAMAT were evaluated. A transport task is defined as a single trip from A to B. This can be a trip in fully loaded condition as a delivery to a customer in B or the empty return trip.

In phase one, transport tasks were determined from measurements using a clustering algorithm on the measured GPS data from use on public roads. For all transport tasks alternative routes were calculated via the VMC services to find potential routes with lower fuel consumption (“theoretical analysis”). In phase two, SAMAT was requested to collect measurement data and measure fuel consumption for selected transport tasks on both routes, the default route and the alternative one, to verify the simulated reduction in fuel consumption (“verification”).

For phase one, a total of 746 different transport tasks were determined from 1,960 measurements. These tasks have different frequencies from 1x to 117x (average 2.6x), lengths from 4 km to 302 km (average 84 km) and add up to a total length of just over 60,000 km (one direction only), all in the southwest of France and only a few in the northeast of Spain.

Figure 10. Map representation of all 1,960 measurements taken on public roads in the southwest of France (and parts of Spain). Base map and data from OpenStreetMap and OpenStreetMap Foundation

For all transport tasks, the route actually driven is available in GPS form (hereinafter "original"). For further processing, the data was projected to the map using map matching, which can lead to slight deviations in case of GPS inaccuracies. In addition, up to 10 routes ("alternatives") were calculated for each transport task via the VMC services. However, for a total of 58% of the transport tasks, no alternative route could be found that differed from the original route. In these cases, the routing consequently does not reduce fuel consumption.

For both the original routes and the alternatives, VMC was used to determine speed profiles and thus the travel time and fuel consumption. In addition to the original, this results in a route with minimum fuel consumption ("fuel-optimal") and a route with the shortest travel time ("shortest") for each transport task. The three variants do not have to be genuinely different.

The possible fuel savings and the associated lower exhaust emissions can be determined by two different comparisons. On the one hand, the fuel-optimal route can be compared with the original route (in the following "original comparison"). However, it is possible that the routing used only finds a better route because temporary restrictions (construction sites, traffic jams, ...) or driving bans for trucks, which are not stored in the map material used, cannot be taken into account. The other option is to compare the fuel-optimal route with the shortest route ("routing comparison").

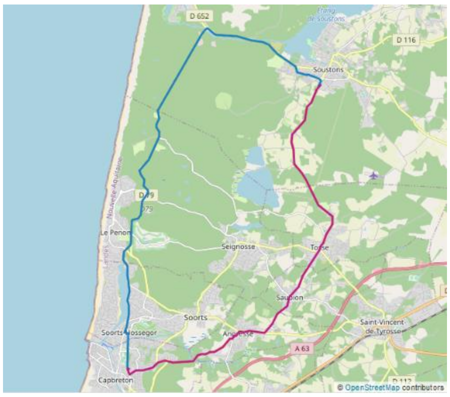


Figure 11. Example Cluster 175: Shortest route (red, 21.1 km, travel time 49:36, 6.1 kg fuel consumption) vs. fuel-optimal route (blue, 18.2 km, 52:43, 5.7 kg). The alternative route has a 5.9% longer travel time, but a 6.7% lower fuel consumption.

In the original comparison, routes with lower fuel consumption are found for approx. 28% of the transport tasks. Taking into account the frequencies and lengths of the tasks, this results in a total fuel saving of 3.5%. In the routing comparison, the result is weaker. Here, better routes are found for approx. 21% of the transport operations, resulting in a fuel saving of 1.7%.

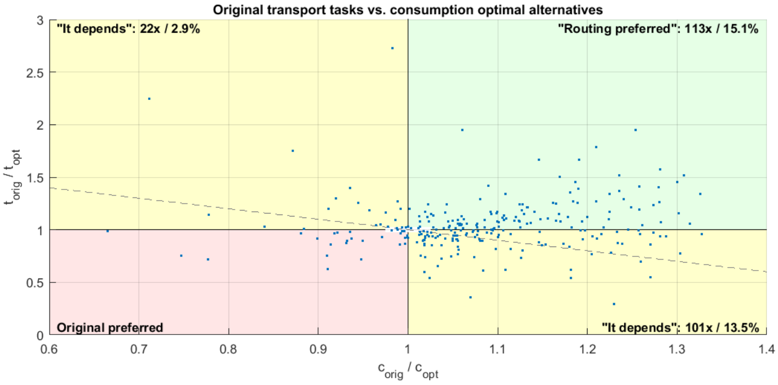


Figure 12.Representation of the consumption-optimal alternative routes in the original comparison. The assessment of whether an alternative route should be preferred depends on both consumption (X axis) and travel time (Y axis). Only transport tasks with permits

This comparison does not take into account that the lower fuel consumption is usually (or in the case of routing comparison always) accompanied by a longer travel time. Whether the longer travel time is worth the lower fuel consumption needs to be decided by the driver (or employer). To balance travel time and fuel consumption the decision score $r = \frac{c_{orig}}{c_{opt}} * \frac{t_{orig}}{t_{opt}}$ is introduced as a possibility to link these two different planning goals for better judgements. For example, if the original route consumes 10% more fuel, the travel time of the fuel-optimal route may also be increased by a maximum of 10% so that $r \geq 1$ applies. Taking into account the decision score, the fuel saving for the original comparison is reduced to 2.4 %, for the routing comparison to 0.3 %.

Table 17. Original and route comparison

	Original comparison		Routing comparison		
Criteria	Frequency	Fuel savings	Frequency	Fuel savings	Time costs
$c_{Best} < c_{Orig}$, $\mathrm{t}_{\mathrm{Best}} < \mathrm{c}_{\mathrm{Orig}}$	15.1%	2.0%	-	-	-
$r > 1.10$	16.6%	2.4%	1.5%	0.3%	0.0%
$r > 1.05$	19.6%	2.6%	3.6%	0.7%	0.3%
$r > 1.00$	22.9%	2.7%	7.6%	1.0%	0.6%
$c_{Best} < c_{Orig}$	28.7%	3.5%	20.9%	1.7%	3.2%

The results presented depend, of course, on the input data used and parameters selected. The measurements on public roads are from the period February 2020 to the end of March 2021 and represent actual transport tasks. The driven distance of the data analysed here is approx. 120,000 km (both directions). The data basis used can therefore be rated as extremely good. Significantly deviating results are only to be expected in areas with deviating topography (and thus greater difference between consumption-optimized and normal routing). The simulation parameters for the determination of travel time and fuel consumption were chosen according to the actual vehicle characteristics. An influence is open if the expected traffic density on the respective routes is taken into account.

In phase two, SAMAT was requested to collect data for selected transport tasks on both routes (default one and alternative proposed by the VMC service) to verify the expected savings on real measurement data. For this purpose, SAMAT transmitted the planned trips on a daily basis. As soon as the measurement data, in particular the actual route taken, was available as a GPS signal, the routes were analysed regarding potential alternative routes with lower fuel consumption. If a suitable alternative route was found, it was transmitted to SAMAT and, if possible, as many measurements as possible were to be taken on both routes.

Planned trips were transmitted in the period from January to February 2023 with a total of 187 planned trips and 110 of them unique. The planned trips up to the end of January were investigated with regard to more fuel-efficient alternative routes, resulting in 16 unique trips with complete and valid measurement data that have been analysed. For 5 routes (31%) an alternative with (simulated) lower fuel consumption could be found, but two of them could not be used for verification because of not enough repetitions. For one route (Ambès – Montayral), two alternatives have been validated.

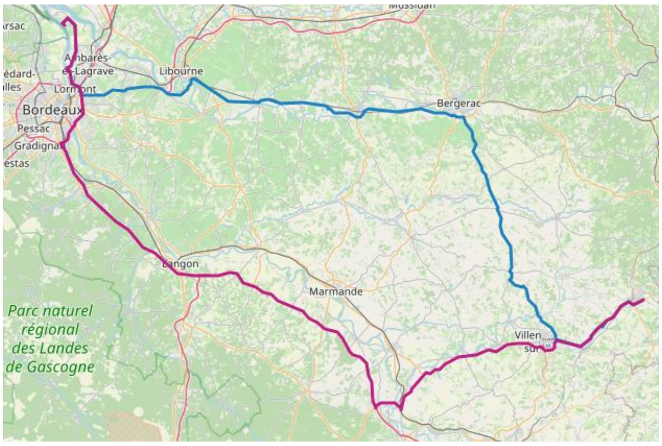


Figure 13. Ambès - Montayral: Default route by SAMAT (blue, 182.8 km) vs. fuel-optimal alternative (red, 195.1 km). The verification showed fuel-savings of 14.1%.

Table 18. Routes' description

Route	Default route	Alternative	Savings	Significant?
Ambès – Montayral (a)	182.8 km, 78.0l +/- 4.4l (4x)	195.1 km, 67.0l +/- 0.7l (2x)	14.1%	Yes ($p = 0.0164$)
Ambès – Montayral (b)	182.8 km, 78.0l +/- 4.4l (4x)	166.2 km, 69.4l +/- 1.6l (3x)	11.0%	Yes ($p = 0.0121$)
Ambès – Libourne	55.0 km, 20.9l +/- 1.6l (6x)	44.4 km, 19.8l +/- 0.4l (4x)	5.3%	No ($p = 0.1169$)
Bassens – Paris	570 km, 245l +/- 9l (2x)	590 km, 251l +/- 16l (2x)	-	No ($p = 0.6556$)

For 3 of the 4 routes, the measurements on the proposed alternative routes had lower fuel consumption, and in two cases this is also significant ($p < 0.05$). Extrapolation of fuel savings is possible based on in total 16 unique transport tasks with 51 measurements in the period considered (9,552 km). Comparing the fuel consumption on the default routes with the consumption on the alternative routes (if available) results in a fuel saving of 4.7%. There are too few data to assess the significance of this result.

Although little measurement data and routes could be used for verification, the results from the theoretical analysis can be verified. In the theoretical analysis, there were 3.5% fuel savings for 28.7% of routes with better alternatives (without taking into account longer driving times), and in the verification 4.7% fuel savings for 31% of routes with better alternatives.

Based on an approx. consumption of 22,700 L of Diesel per truck and year in SAMAT's operation, we expect to save 2,200 kg CO2 per truck and year based on 3.5% fuel savings from phase one resp. 2,950 kg CO2 based on 4.7% fuel savings from phase two. More details on this are in the section on D3.

The firstly reported total fuel saving of 3.5% has been based on simulating consumption on real SAMAT transport tasks. Additional simulation-based saving potentials for other applications are presented in the sub-action C5.4. Here the savings come out a bit smaller. Finally, a real measurement-based verification of the saving potential has been successfully done during the last months of the extension. There, the saving potential of 4.7% comes out even a bit higher. However, the amount of measurements, which could be used is small making this number a bit more uncertain than the simulated results. Nevertheless, the predicted savings are confirmed by real measurements.

D.2 Monitoring of the socio-economic and dissemination impacts

D2.1 Monitoring of the socio-economic impacts

The socio-economic impacts of the ECOTRAVID project have been assessed, focusing on the economic benefits, job creation, and the impact on truck drivers. The economic impact of the project by considering the potential fuel savings with an assumed fuel reduction of 3.5%, based on the more conservative estimate, calculates that each truck can save 795 Liters of diesel per year. This calculation is derived from the average annual Diesel consumption of 22,700 liters per truck in SAMAT's operation and by considering the current price of diesel (without VAT) at €1.10 per liter, the expected fuel savings goes to €875 per truck per year. This analysis, as detailed in action C5.1, demonstrates that the significant cost savings per truck per year can easily contribute to financing the innovative solution and the projected monthly subscription cost of around €5 further emphasizes the economic feasibility of the ECOTRAVID system.

To assess the economic impact for potential end-users, as fully detailed within deliverable “Report on socio-economic impact, including indicators,” three scenarios have been considered (conservative, optimistic and pessimistic). The savings per year and per truck for an end-user are summarized in the table below:

	Generated savings per year, per truck	Generated expenses by VMC / year	% expenses vs. savings
Conservative scenario	2 098 €	180 €	8,6%
Optimistic scenario	1 953 €	180 €	9,2 %
Pessimistic scenario	2 475 €	180 €	7,3 %

During the project's execution, the socio-economic impact has been limited. However, considering replication scenarios in the future, the potential for broader impacts can be assessed. While no direct job creation has been associated with the ECOTRAVID project, it has secured employment in the long term by fostering the development of an innovative product in the road transport sector. The increase in human capital within partner organizations is not an expected outcome of the project, but it remains a possibility.

Regarding the impact on truck drivers, the system's usability and its potential influence on job and driving behaviour have been monitored during the pilot demonstration phase. A survey has been conducted with the truck drivers and feedback from Samat Aquitaine drivers has been positive, emphasizing the user-friendly nature of the "Driver Connect" Android application.

In conclusion, the ECOTRAVID project demonstrates the potential for significant fuel savings and economic benefits in the road transport sector. It has provided valuable insights into the impact on truck drivers and has secured employment opportunities in the long term. Further assessment of the project's socio-economic impacts can be explored through replication and wider implementation of the innovative solution.

D2.2 Monitoring of the dissemination activities

Unfortunately, due to Covid-19 disease, many 2020 dissemination events had been cancelled. With regards to the ones after the pandemic there is the Webinar, which was held on May 30, 2023, and aimed to maximise the visibility of the work done and the results achieved within the project. The team decided to keep the workshop short (two hours) and easy to participate in, by preparing an online meeting.

A specific website was created and informed several thousands of potentially interested addressees via E-mail and direct contact. While the most obvious area of dissemination was the commercial road transport and logistics sector, the team also had telematics providers, vehicle manufacturers and suppliers in their extensive mailing list.

D.3 Monitoring of the project specific indicators

The main specific performance indicators which will be monitored during the project are the fuel consumption and CO_2 emission reductions. In addition, other emissions, regulated by EU norms, have been quantified namely NO_x (nitrogen oxides), CO (carbon monoxide), and PM (particulate matter).

The initial assessment, which has been made for CO_2 emissions, has been the following:

It is assumed that 20 trucks and trailers are rolling 100,000 km per year and consume in average 35 L/100 km. Assuming further that they can achieve 7.5% of reduction fuel consumption, the LIFE ECOTRAVID technology will then lead to a fuel reduction of 52,500 litres or approx. 564,000 kWh (considering the conversion 1 litre of diesel = 10.74 kWh).

Then, based on the fuel consumption reduction calculated, we can calculate the second key performance indicator, the CO_2 emission reduction., as follows: Under the same assumptions as above, the LIFE ECOTRAVID technology will then lead to a reduction of 140,700 kg of CO_2 emissions (2.68 kg of CO_2 /L).

The unit tonne-kilometre (tkm) is a measure for transport volumes. In the following, CO_2 emissions in the unit gramme per tonne-kilometres = g/tkm are reported.

As reported in C4.3 a single truck of SAMAT runs 75000 km per year on average, where approx. half of the drives are performed at full payload and the others are empty return trips. This leads to an average payload of 15 tonnes and a yearly transport volume of approx. 75000 km*15 tonnes = 1,125,000 tkm. Since the consumption is approx. 30.4 litre/100km, a consumption of 75000*30.4/100 = 22800 litre Diesel and 22800*2.68 = 61100 kg CO_2 per year and truck is expected. The CO_2 emissions per transport volume is thus 61100 kg/1.125 Mtkm = 54300kg/Mtkm = 54.5g/tkm.

Note that this number depends on the average consumption (30.4 litre/100km) and on the average transport volume (1,125,000 tkm), which depend on the specific operation. Thus, for applications different to SAMAT's business, the CO_2 emissions per transport volume will differ.

More investigations towards other regulated emissions:

For assessing the CO_2 emissions, the emission factor 2.68 kg of CO_2 /L has been used for converting fuel savings into emission savings so far. In the following, it has been checked if this factor as well as corresponding factors for NO_x, CO, and PM.

We start with looking at the exhaust emission standards EURO 5 and EURO 6. For heavy duty vehicles, the limits are given in mass per engine energy output, e.g., in [mg/kWh]. From the analysis of the measurement data, we know that in SAMAT's operation, the engine efficiency is 0.43, which means that 1 litre Diesel (energy density approx. is 9.912 [kWh/litre]) corresponds to 9.912*0.43 = 4.26 [kWh/litre] engine energy output. Thus, we can approx. convert the numbers in the standard into [mg/litre]. The following tables present the standard (for our list of pollutants and the WHTC, the world harmonised transient cycle) as well as the converted one.

Table 19. Emission standards comparison

Pollutant	Euro 6	Euro 5	Pollutant	Euro 6	Euro 5
NOx [mg/kWh]	460	2000	NOx [g/litre]	1.961	8.524
CO [mg/kWh]	4000	4000	CO [g/litre]	17.049	17.049
PM [mg/kWh]	10	30	PM [g/litre]	0.042	0.128

Next, we checked publicly available sources for road transport emissions. In particular, we used a database provided by the German Umweltbundesamt (UBA) and the Internationales Institut für Nachhaltigkeitsanalysen und -strategien (IINAS) called ProBas to obtain figures about emissions of road transport in Germany (see https://www.probas.umweltbundesamt.de/php/index.php for more details). Among other things, the database provides a process-oriented view on emissions of pollutants. For heavy duty road transport, the input of the process is energy in terms of Diesel fuel and the output is the emission of a pollutant. Since ProBas provides the input as well as the output for various transport scenarios, we can convert the numbers into emission per litre Diesel again using the fuel energy density. A detailed calculation based on Euro 5 vehicle data gives:

Table 20. Emissions based on Euro 5

Pollutant	ProBas (Euro 5)
NO_x [g/litre]	11.092
CO [g/litre]	3.115
PM [g/litre]	0.111
CO_2 [kg/litre]	2.641

Finally, we accessed the database HBEFA (Handbuch für Emissionsfaktoren des Strassenverkehrs, see https://www.hbefa.net/e/index.html). Here we obtain emission factors for various transport scenarios in terms of mass per transport distance, e.g., [g/km]. We checked heavy duty vehicle data estimated for 2015, 2020, and 2025 for

Germany as well as France. Since the database also contains the corresponding average fuel consumption, we again can convert the emissions into mass per litre Diesel. The following table shows the results:

Table 21. Calculations based on HBEFA inputs

Pollutant	HBEFA, D+F, 2015	HBEFA, D+F, 2020	HBEFA, D+F, 2025
NO_x [g/litre]	13.295	6.135	2.790
CO [g/litre]	6.841	3.166	1.262
PM [g/litre]	0.191	0.081	0.033
CO_2 [kg/litre]	2.456	2.389	2.406

As expected, the HBEFA numbers decrease with progressing time. The ProBas factors for the Euro 5 heavy duty vehicles are close to the HBEFA numbers for either 2015 or 2020. The factors for NOx and PM derived from the standards EURO 5 and EURO 6 are close to the corresponding HBEFA factors for 2020 and 2025. The CO factor derived from the EURO standard is much larger than the ones from ProBas or HBEFA.

In view of these results and since we want to conservatively estimate the savings for the future years, we use the HBEFA factors for 2025 in the following.

Applying the fuel saving potentials found in D1 and C5.4:

The following tables summarizes the indicators for fuel, CO_2, NO_x, CO, and PM. First, the emission factors in terms of mass per litre fuel are given as derived above (blue). Then we have the assumptions about mileage and consumption (yellow). The latter numbers are the ones derived from SAMAT's operation. We applied those to the other applications too since we do not have the corresponding average yearly mileage and consumption.

Table 22. Summarize of the fuel indicators

Fuel parameters selected	**HBEFA, D+F, 2025**
CO2 per litre Diesel [kg/litre]	2.41
NOx per litre Diesel [g/litre]	2.790
CO per litre Diesel [g/litre]	1.262
PM per litre Diesel [g/litre]	0.033
Application assumptions	
Yearly milage of a truck [km]	75000
Yearly transport volume of a truck [tkm]	1125000
Average consumption [litre/100km]	30.8
Yearly consumption of a truck [litre/truck&year]	23100

Finally, we have the saving potentials as predicted by simulation or verified by measurements (green). All numbers are given per truck and year.

Table 23. Expected savings for SAMAT routes per truck and year

		Expected savings per truck and year				
Expected savings for SAMAT routes		Diesel [litre]	CO$_2$ [kg]	NO$_x$ [g]	CO [g]	PM [g]
Simulation-based in phase I	3.50%	808.5	1945.3	2256.1	1020,5	26.6
Verification-based in phase II	4.70%	1085.7	2612.3	3029.6	1370,4	35.7

Additionally, the following table contains predictions for other applications achieved by simulation, where the details can be found in the corresponding C5 action report.

Table 24. Expected savings for different applications per truck and year

		Expected savings per truck and year				
Expected savings for various applications		Diesel [litre]	CO2 [kg]	NOx [g]	CO [g]	PM [g]
Sim-based hub-to-supermarket Carrefour	2,98%	688,4	1656,3	1920,9	868,9	22,7
Sim-based hub-to-supermarket Aldi	2,22%	512,8	1233,9	1431,0	647,3	16,9
Sim-based hub-to-supermarket Lidl	2,50%	577,5	1389,5	1611,5	729,0	19,0
Sim-based hub-to-hub Carrefour	0,65%	150,2	361,3	419,0	189,5	4,9
Sim-based hub-to-hub Aldi	0,79%	182,5	439,1	509,2	230,4	6,0
Sim-based hub-to-hub Lidl	1,88%	434,3	1044,9	1211,8	548,2	14,3
Sim-based cold storage Carrefour North	1,87%	432,0	1039,4	1205,4	545,3	14,2
Sim-based cold storage Carrefour East	1,12%	258,7	622,5	721,9	326,6	8,5
Sim-based cold storage Carrefour Southwest	1,54%	355,7	856,0	992,7	449,0	11,7
Sim-based Petro distribution TotalEnergies Northwest	2,75%	635,3	1528,5	1772,6	801,9	20,9
Sim-based Petro distribution TotalEnergies Southeast	2,02%	466,6	1122,7	1302,1	589,0	15,4

E.1 Communication and dissemination

E1.1: Dissemination

Due to COVID-19 pandemic, the original dissemination plan could not be implemented completely.

The **Website of LIFE Ecotravid project** (https://ecotravid.eu) has been created, presenting the project's objectives, the consortium, actions, progress, dissemination activities and results. Easily accessible from web search engines and referenced on the LIFE website, the web address is indicated in all reports and in produced communication material.

A **leaflet and poster** have been designed in order to be exposed and distributed during project's event.

The **leaflet** presents the project, its objectives, its actions and its results to a non-specialist audience.

A **use-case study** (two pages document) has been generated to ease commercial activities about ECOTRAVID by our sales team.

These materials have been used in one major event **SOLUTRANS 2019** (international road transport fair in Lyon, (19-23 Nov 2019).

Due to COVID-19 disease the most part of 2020 and 2021 events have been postponed, as **SITL (transport fair in Paris)** and **IAA (biggest transport fair in Hannover)** exhibitions.
We have been able to participate at the **SOLUTRANS 2021 event** (international road transport fair in Lyon, 16-20 Nov 2020)

An **article about ECOTRAVID** has been submitted in the **newsletter** of the Fraunhofer Transport Alliance FAV (which represents the combined traffic-engineering expertise of different Fraunhofer Institutes).

A **joint research paper** has been published (VDI-Berichte 2380, 2021) and presented at the Commercial Vehicle Conference 7.-8. September 2021 in Linz.

Another **research paper** has been submitted to the CVT 2024 (Commercial Vehicle Technology Symposium in Kaiserslautern).

We have shared different articles on CLS social networks (LinkedIn and Instagram) during the period of 2021 and 2022.

Finally, the three partners organized a FINAL WEBINAR to present the results of the project to the general public. This seminar took place on May 30, 2023.

As part of its scoping activities and with the objective to influence policy recommendations, the ECOTRAVID team participated in LIFE Green Mobility 2022, among other LIFE projects. During the event CLS sought to establish links with other innovative proposals relevant to the project in the field of reducing CO2 emissions. During this event, we identified two projects linked to ECOTRAVID that could potentially become partners: LIFE INTEGREEN and LIFE STRADE.
The first initiative focuses on environmental traffic control. The INTEGREEN system integrates data collected by both fixed monitoring stations and mobile measurement probes to be installed on existing vehicles, such as public transport buses or car-sharing vehicles. Likewise, the LIFE STRADE initiative focuses on a sophisticated new system that simultaneously warns drivers and prevents wild animals from crossing roads.

E1.2: Networking with other projects

As mentioned above networking activities have been initiated with LIFE INTEGREEN and LIFE STRADE.
COVID-19 pandemic had a huge impact on the dissemination activities, nevertheless activities had been intensified in the last phase of the project.

4. Deviations to original plan

An amendment to postpone the project's end date was requested by the partners and got finally approved by the EU which set February 2023 as the end of the project. Indeed, the technical activities have suffered of some delays due to longer execution of some tasks than initially planned and issues encountered for field data measurements caused by lack of synchronisation between GPS and FMS cells. Without such extension the phase II of the field tests could not have been run and implemented.

Additionally with regards to dissemination activities, there have been some short delays due to external factors such as the COVID 19 which had a big impact in cancelling most of the events. These delays were tackled by the revised dissemination strategy (see action E1 description).

As for technical deliverables, some were submitted late due to testing problems experienced by the team, but this did not affect the project's schedule. At the end of the project all key activities have been performed as foreseen.

In terms of environmental results, simulations have demonstrated savings of around 3.5 % of fuel consumption thanks to the innovative LIFE ECOTRAVID concept while phase II tests have demonstrated 4.7% of fuel savings. This is slightly below but close to what was originally expected with savings around 5 to 10%.

Finally with regards to commercialisation as explained in the report, for strategic reasons, CLS has decided to not commercialise the LIFE ECOTRAVID solution. However as detailed within the action C.5 description, Fraunhofer has decided to pursue the commercial exploitation of the VMC software extensions using a different business model. Truck & trailers manufacturer could integrate directly the VMC solution. The additional idea of Fraunhofer is to propose extended services since the new tools derived from LIFE ECOTRAVID could be further applied in the context of vehicle development, for reliability or energy efficiency optimization, as well as for vehicle configuration or for operating fleets.

5. Analysis of benefits

The ECOTRAVID project has created the following achievements with regards to the environmental, social and economic aspects:

Environmental Benefits

The primary focus of the LIFE ECOTRAVID project is to achieve significant environmental benefits by reducing fuel consumption in trucks.

Within the framework of the LIFE ECOTRAVID project, SAMAT trips were selected for demonstration purposes, and initial measurements were conducted to establish the baseline scenario and the results of the field tests. Nevertheless, simulations were also performed, and it was found that for 58% of the total tasks, no alternative routes could be identified for the trips. Taking all parameters into account, simulations performed during phase 1 of the project revealed around 3.5% fuel savings for a truck in the specific case of this project. Although this figure is below expectations, it is mainly due to the fact that a significant portion of the trips already used the optimal route, but for other trips, substantial savings can still be achieved. The verification phase revealed an even higher saving potential with around 4,7%.

Within section 5 you can find more details on project KPIs related to environmental benefits of LIFE ECOTRAVID in terms of CO2

Anticipating a further replication and transfer to VMC tool to a large amount of trucks we have below calculated the LIFE ECOTRAVID environmental benefits.
Assuming in 10 years, 10,000 trucks would be equipped with such system, considering the same as above s as mentioned above but fuel savings of around 2% (more in line with savings calculated within table 24) would be of around 14,926 tCO2 emissions per year and around 17,311 Kg NOx per year, 7,830 Kg of CO & 205 Kg of PM per year.

Economic Benefits

The study successfully integrates and evaluates the impact of the Vehicle Monitoring and Control (VMC) solution within the telematics services market which incorporates the software as a supplementary module and aims to enhance product recognition and quantify VMC profits through an additional fee.

The economic impact of the project was determined by the so-called transport tasks which were determined from measurements collected by SAMAT's vehicle fleet that demonstrates a significant fuel savings of at least 3.5% (worst case scenario phase I, & 4.7% for phase II) and shows an immense potential in positively influencing fleet management clients' Total Cost of Ownership (TCO) since fuel consumption contributes to it. Moreover, integrating the VMC solution improves efficiency in fleet management and reduces companies' carbon footprint associated with their commercial activities.

The study has comprehensively analysed three fuel price scenarios (conservative, optimistic, and pessimistic) to assess the potential benefits of the VMC solution and its results revealed substantial cost savings in fuel expenditures, **with the conservative scenario projecting savings of up to 1.4 million euros for a fleet of 750 vehicles in 2023.** Additionally, “small” clients with an average fleet size of 60 vehicles can expect annual fuel savings of approximately 125,000 euros per client per year. These achievements highlight the VMC solution's viability, significant potential in enhancing fuel efficiency, reducing costs, and promoting sustainability in fleet management operations.

Innovation and demonstration value

The project has focused on demonstrating the effectiveness of an innovative software to reduce truck fleet fuel consumption which has been developed by ITWM. This software aimed to incorporate a highly realistic vehicle model that account for driver influence and encompass a range of potential system modifications together with real-world data that intricately describe the vehicle's environment, encompassing factors such as roads, topography, traffic, and climate conditions.

The project has been divided in two phases:

Phase I focused on collecting data and refining the Vehicle Monitoring and Control (VMC) software where the actual trip and vehicle data were used to improve the software.

Phase II involved integrating the VMC software into the CLS platform and using it to reduce fuel consumption. The effectiveness of the software was evaluated by comparing the data from Phase I and Phase II and the team expects to have a fuel consumption reduction of approximately 4.7%, considering factors such as truck configuration, transport missions, and weather conditions.

Replicability & transferability

In the ECOTRAVID project, fuel consumption and potential savings were analysed for SAMAT's transportation tasks in southwestern France. Verification measurements were limited, so a virtual route evaluation work package was added. This involved creating and analysing routes for different transport scenarios. The results showed slightly smaller savings than observed in SAMAT's measurements but demonstrated that the VMC compute service provided better routes. Variations in savings were observed among different operators and regions.

These findings highlight the potential for replicating and transferring the ECOTRAVID project's methodology and tools to other transport branches.

Considering CLS decision to not commercialize the LIFE ECOTRAVID system, due to internal reasons and despite the effectiveness of the system and its economic viability, Fraunhofer decided to pursue the commercialisation of the innovative algorithm. Fraunhofer will perform the commercial exploitation of the VMC software extensions using a different business model. Truck & trailers manufacturer could integrate directly the VMC solution. The additional idea of Fraunhofer is to propose extended services since the new tools derived from LIFE ECOTRAVID could be further applied in the context of vehicle development, for reliability or energy efficiency optimization, as well as for vehicle configuration or for operating fleets.

To prepare this new commercialisation routes and transfer to other applications / end-users than originally foreseen, Fraunhofer has performed thorough simulations during the last quarter of the project for other applications -> hub-to-hub, hu-to-supermarket, cold storage & petrol distribution.
The savings demonstrated there were lower (~2%) potential savings for such case, but considering the low investment to implement the system, vs. savings achieved with fuel consumption (considering calculations done by CLS) the replicability & transferability to such applications is economically viable.
This will need now to be further investigated by Fraunhofer since this “back-up” solutions has only been envisage at the very end of the project.

Social Benefits, policy implications, best practice lessons

The LIFE ECOTRAVID project has had limited socio-economic impact during its execution but holds potential for future replication. Job creation related to the project has not occurred within the project timeframe, but employment for partner teams has been secured, with the potential for additional workforce if the innovative VMC solution achieves commercial success.

In the context of innovative projects like ECOTRAVID, the driver's role has evolved beyond just driving. They now have additional responsibilities such as loading, unloading, and proof of delivery, with denser missions. Truck drivers already have access to various tools to manage their working hours, find parking spaces for trucks through mobile apps, and communicate through instant messaging platforms. The incorporation of the VMC software tool, which utilizes a screen display work environment, did not negatively impact their current working conditions, as truck drivers are familiar with such technologies.

In summary, the LIFE ECOTRAVID project's social benefits are currently limited but have the potential for future replication and transferability together with Fraunhofer strategy. It has not directly resulted in job creation during its execution, but employment for partner teams has been secured. Feedback from Samat Aquitaine drivers has been positive, emphasizing the user-friendly nature of the "Driver Connect" Android application.

6. Conclusions

In conclusion, the LIFE ECOTRAVID project has successfully advanced the goal of reducing fuel consumption in trucks and promoting environmental sustainability. The integration of the VMC solution into fleet management systems has yielded promising results.

Through the analysis of transport tasks, it was found that a significant proportion of routes had alternative options with lower simulated fuel consumption compared to the original routes. Approximately 28.7% of routes showed potential for reduced fuel consumption when considering alternative options suggested by the VCM tool. Furthermore, around 20.9% of routes indicated the possibility of lower fuel consumption compared to the fastest route, albeit with longer driving durations. Fuel savings of 3.5% were observed when compared to the original routes, and 1.7% when compared to the fastest route, with the potential for additional savings based on subjective decisions by drivers or employers. Measurement data validation confirmed fuel savings of 4.7% for 31% of routes with alternative options. These findings underscore the effectiveness of the VCM tool in optimizing routes and reducing fuel consumption, thereby generating positive environmental impacts in the road transport sector.

The business plan analysis indicates that the VMC solution has the potential to make a significant impact on the telematics services market, enhancing fleet management efficiency and reducing companies' carbon footprint. Conservative scenarios project cost savings of up to 1.4 million euros for a fleet of 750 vehicles in 2023, with an average fleet of 60 vehicles estimated to save 125,000 euros in fuel costs and reduce 2,974 kg of CO2 emissions annually.

Although CLS has decided not to commercialize the VMC solution due to divergent objectives for 2023, the advancements made within the ECOTRAVID project have benefitted Fraunhofer. The tools and methods developed through this project have contributed to vehicle development, energy efficiency optimization, and improved fleet operations.

The achievements of the ECOTRAVID project highlight the practicality and potential of the VMC solution in enhancing fuel efficiency, reducing costs, and fostering sustainability in fleet management operations. The methods and tools developed through this project hold promise for driving the transition towards more sustainable drivetrains and supporting endeavours to curtail energy consumption in vehicle fleets.