

# HORIZON AeroSolfd: Retrofit Filtration Devices for Cleaner Urban Mobility - Focus on highly efficient filter systems for petrol engine retrofit

# AeroSolfd

filtration devices

L. Rubino<sup>1)</sup>, A. Mayer<sup>1)</sup>, J. Czerwinski<sup>1)</sup>, Th. Lutz<sup>1)</sup>, L. Larsen<sup>1)</sup>, V. Hensel<sup>2)</sup>, M. Lehmann<sup>3)</sup>, D. Engelmann<sup>4)</sup>

(1) VERT Association, (2) Aurigna, (3) Mann+Hummel, (4) University of Applied Science Biel

## ABSTRACT

HORIZON AeroSolfd is an EU co-funded project that will deliver affordable, adaptable, and environmentally friendly retrofit solutions to reduce tailpipe emissions, brake emissions and pollution in semi-closed environments. VERT, according to the long experience on retrofit and nanoparticle emissions reduction strategies and filtration, will focus on reducing emissions at tailpipe of gasoline vehicles by using the best available retrofit technology. VERT will use demo retrofit systems using the latest available GPF technology in three high mileage vehicle fleets, in Germany, Switzerland and Israel. The project will also serve as a platform to continue research on PN emissions and gaseous secondary emissions from GDI as well as PFI Petrol engines. In addition, the "high emitter phenomena" will be further analyzed with a NPPTI testing campaign of 1000 gasoline vehicles, including GDI, PFI and GPF equipped vehicles.

## BACKGROUND & OBJECTIVES

Solid sub-100 nm particles from traffic emissions pose high risks to human health due to their high lung deposition efficiency and potentially harmful chemical composition [1].

Several studies have shown that petrol engines are of concern as they emit high PN and high secondary emissions (i.e. PAHs).

### High PN emissions

The number concentration of solid particles in the size range of 10-500 nm is generally low in many petrol engines, but in some cases it exceeds 10 million P/cc, reaches 100 million P/cc; this is the case of GDI but also port fuel injection PFI engines [2]. It should be noted that, according to current legislation, PFI engines do not have to comply with EU-PN limit values.

### Secondary Emissions & High Polycyclic aromatic hydrocarbons PAHs

The PAH content of the petrol engines can be much greater than that of the compared diesel engine with particulate filter, and in particular the highly toxic benz(a)pyrenes are also dominantly represented [3]

### High-emission engines - the "dirty tail" of every vehicle fleet

PTI inspections show that a not to be underestimated proportion of vehicles exceed the limits by a large margin, including petrol engines [4].

**Retrofit solutions could address and reduce air pollution.** AeroSolfd is a Horizon Europe project focusing as an innovation action on developing market-ready retrofit solutions to immediately decrease the harmful effects on health and the environment of transport-related emissions with effective filtration devices. The name AeroSolfd stands for cleaner, healthier urban environment, free from toxic aerosols, by market-ready retrofit solutions as shown in Fig.1 for:

Tailpipe (1), Brake systems (2), and (semi)Closed environments (3)



Figure 1: AeroSolfd Retrofit System Applications.

- (1) VERT is in charge of GPF retrofit of petrol engines and will develop and demonstrate cost-efficient tailpipe retrofit filters for petrol engines, both GDI and PFI.
- (2) An existing and proven passive brake dust particle filter (BDPF) concept developed by MANN+HUMMEL for passenger vehicles will be modified for bus and commercial vehicle brake applications. Eco-friendly circular design approaches will be used;
- (3) An optimized version of a stationary air filter will be developed by MANN+HUMMEL for railway, metro companies or operators. By combining the latest technologies and simulation tools for smart applications, the exposure level will be lowered and as a result, the air gets cleaner.

AeroSolfd (36 months duration) consists of two pillars (Fig. 2):

- (A) Development to bring existing retrofit technologies from TRL 4-7 to TRL 8; (TRL: Technical Readiness Level);
- (B) Market preparation including sustainability assessment, raising public awareness, stakeholder engagement and proposal of incentive schemes

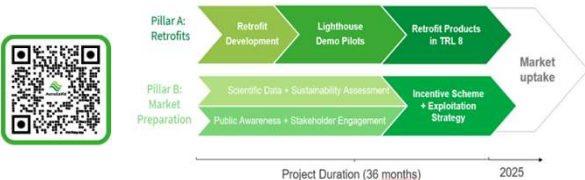


Figure 2: AeroSolfd Pillars - (A) Retrofit, (B) Market Preparation.

- References:
- (1) Lilian Calderin-Garciduenas, Alberto Ayala Environ. Sci. Technol. 2022, 56, 11, 6847-6856. [acs.est.1c04706](https://doi.org/10.1021/acs.est.1c04706), PMBrainpublication.pdf
  - (2) Czerwinski, J., Comte, et al., "PN-Emissions of Gasoline Cars MPI and Potentials of GPF," SAE Technical Paper 2018-01-0363, 2018. <https://doi.org/10.4271/2018-01-0363>.
  - (3) Muñoz M. /EMPA et al., Effects of four gasoline particle filters on nanoparticles and genotoxic PAH emissions of a gasoline direct injection vehicle; Env.Sci.and Technology, Aug. 2018
  - (4) Butcher H. /FRW et al., A new periodic technical inspection of particle emissions of vehicles; Emission Control.
  - (5) Boger, T., Glasson, T., Rose, D., Ingram-Ogunwami, R. et al., "Next Generation Gasoline Particulate Filters for Uncatalyzed Applications and Lowest Particulate Emissions," SAE Int. J. Adv. & Cur. Prac. in Mobility 3(5):2452-2461, 2021. <https://doi.org/10.4271/2021-01-0584>
  - (6) Thonstein Boger, Dominik Rose, Sabine He. -Ameyo Joshi; Developments for future EU7 regulations and the path to zero impact emissions - a catalyst substrate and filter supplier's perspective; Transportation Engineering 10, 2022. <https://doi.org/10.1016/j.treng.2022.100129>.

**SUMMARY:** AeroSolfd is a Horizon Europe project focusing as an innovation action on developing market-ready retrofit solutions to immediately decrease the harmful effects on health and the environment of transport-related emissions with effective cost-effective filtration devices. VERT has a long research history in the field of nanoparticle emissions and filtration and is in charge of reducing emissions at tailpipe of gasoline vehicles by using best available retrofit technology (BAT). VERT received fundings from the Swiss State Secretariat for Education, Research and Innovation for the AeroSolfd project. VERT will apply the latest high-efficient GPF technology in three high mileage fleets, in Germany, Switzerland and Israel. The project will also serve as a platform to continue research on PN emissions as well as secondary emissions from GDI and PFI petrol engines. In addition, the "high emitter phenomena" will be further analyzed with a NPPTI testing campaign of 1000 gasoline vehicles, including GDI, PFI and GPF equipped vehicles. Limiting the harmful effects of transport-related emissions by retrofit solutions is urgently needed in the transition towards cleaner mobility. The project progress can be followed at <https://aerosolfd-project.eu/2023/03/15/filters-for-cleaner-air/>



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

**Acknowledgements:** VERT would like to express its sincere thanks to the Swiss Federal Agencies FOEN, FEDRO and SERI for their financial support with AeroSolfd.

**Contact:** Dr. Lauretta Rubino, VERT Association, Email: [lauretta.rubino@vert-dpf.eu](mailto:lauretta.rubino@vert-dpf.eu), Mob: +49 1732382852 - <https://www.vert-dpf.eu/>

## VERT GPF-RETROFIT APPROACH

### Retrofit with High Efficiency GPF

Two paths have now been taken to improve the collection efficiencies of nanoscale particles, without soot cake formation and with no impact on filter backpressure; both were investigated by VERT. These are membrane filter and hierarchic pore structure [5,6]; Within the AeroSolfd project, 50 vehicles from 4 vehicle families will be equipped with GPF retrofit, CORNING GPF GC 2,0 (200/8) uncoated and tested in everyday use for 8 months. A schematic of the overall exhaust system and retrofit is reported in Fig. 3. The GPF will be placed underfloor in the location of the muffler, pressure will be monitored upstream and downstream the filter as well as temperature upstream and at the outer surface.

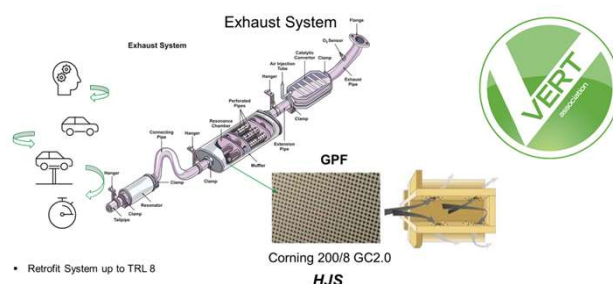


Figure 3: GPF-Retrofit schematic, both GDI & PFI (HJS retrofit system).



Figure 4: VERT GPF-retrofit Fleet demonstration sites.

### VERT GPF-retrofit approach & Vehicle Fleet:

- Selection of high-efficient GPF for petrol engine retrofit with filtration efficiency above 95% for solid particles in the size range (10-500 nm);
- Development of a cost-effective retrofit system with no secondary toxic emissions or noise;
- Selection of four engine families which represent the highest market penetration;
- Investigation of PN emissions behavior, both GDI and PFI, with and without filter;
- Investigation of secondary emissions both GDI and PFI, with /without filter;
- Endurance testing of 50 vehicles, in three different countries (Germany, Switzerland, Israel) with continuous monitoring of retrofit performance (i.e. regeneration, etc.) and NPPTI testing
- Benefit /cost analysis to prove the justification of the use of a retrofit system to cut significantly PN emissions with only a cost equal to 10% of the market value of the vehicle;
- NPPTI testing of 1000 petrol vehicles to establish a statistical information on the emissions quality of today's in-use petrol fleet;
- Team-up with Cities and Municipalities to prepare the implementation rules and regulation of GPF retrofit of in-use petrol engines & dissemination and exploitation of the AeroSolfd project results;
- This retrofit approach will be significant to ensure cleaner urban areas and provide support for future incentives and legislation.