LIFE+ Grant agreement reference n° LIFE 09 ENV/IT/000216

GUIDELINES

for the implementation of the hydrogen-methane fuelled bus

SUMMARY

Comune di Perugia

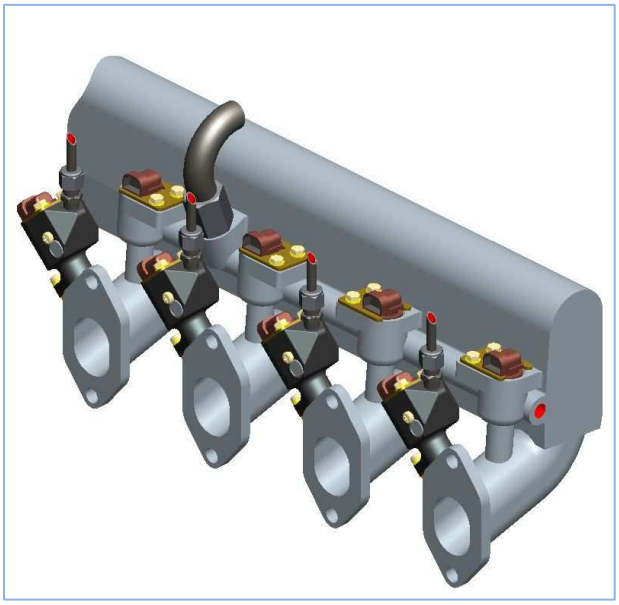
tamat

Cgenera

UMBRIA MOBILITÀ

H2POWER PROJECT GUIDELINES SUMMARY

The project demonstrated the opportunity to use a hydro-methane mixture (30% Hydrogen and 70% Methane) as fuel in an endothermic engine originally powered by methane, reducing emissions and fuel consumption, maintaining the engine performances and vehicle driveability in urban test tracks.
The vehicle used was an IVECO Daily A50C31, equipped with four-cylinder in-line engine, 2800 cc, spark-ignition, Full Methane powered, model 8149 CNG.
The project steps were:
- to develop a power system designed for hydrogen-methane mixture (idrometano);
- to perform engines test bench aiming to realize an appropriate ECU mapping with related engine output data and main exhaust emissions data collection;
- to develop a demonstration bus
-to implement urban road tests.
The design of vehicle devices following the engine bench test results, taking consideration of the technical requirement and available spaces in the bus, produced technical solutions that obtain the project objectives.
In particular the study of the dual intake manifold power line (4+4 injectors) produced a suitable result according to the small area available on the vehicle and guaranteed the efficient work of the used extra injectors.



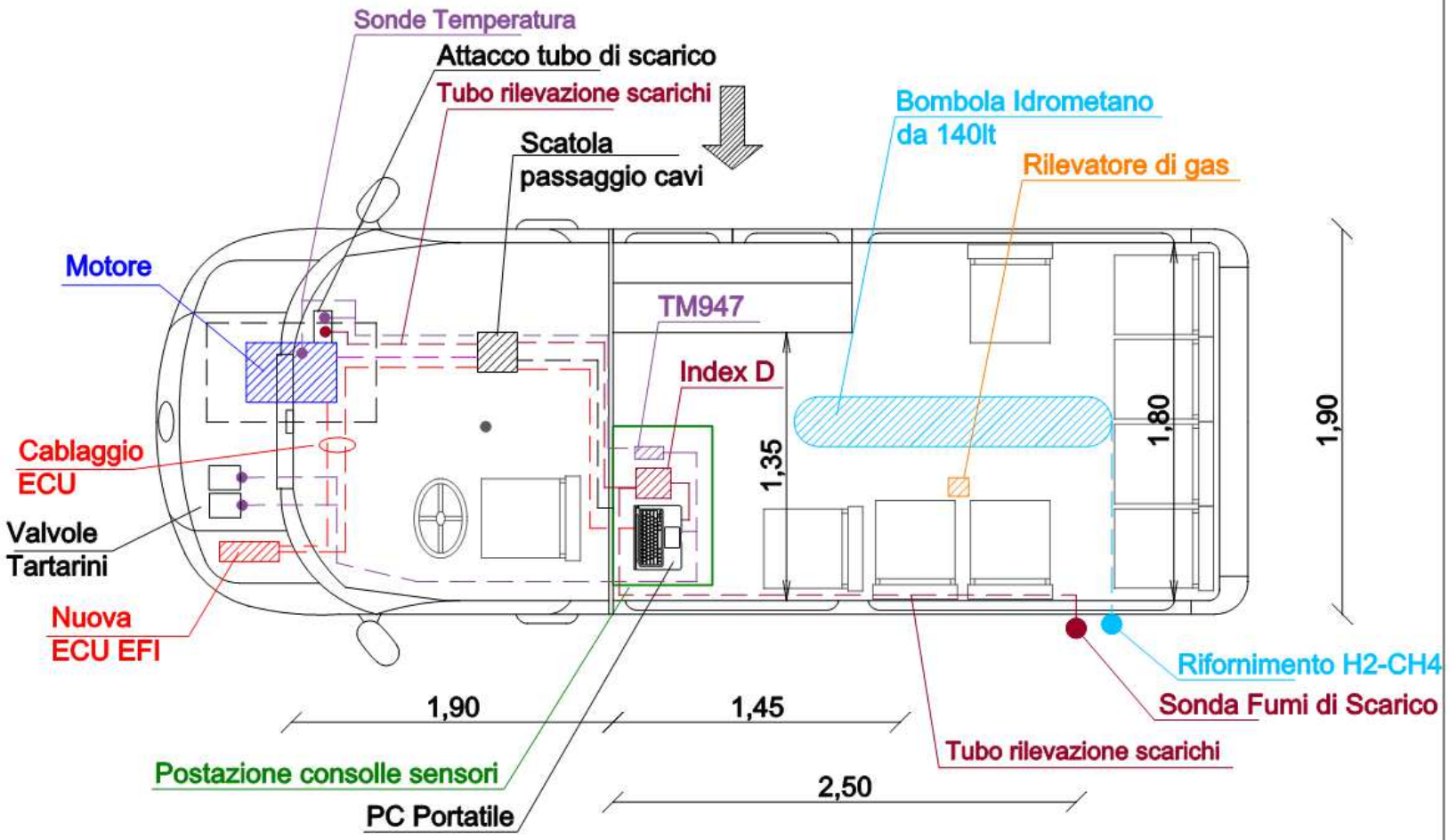
In order to control all parameters of the engine was necessary to replace the original ECU Magneti Marelli with a more efficient one totally configurable; for this scope it was adopted an EURO4 ECU performed by EFI Technology.
Further investigations were carried out at the level of design concerning material choices, monitoring and sampling devices.
Two types of fuel were tested:

- Methane (CH4 100%)
- Hydrogen-methane mixture 35% H2 in volume (equal to 6.3% in mass)

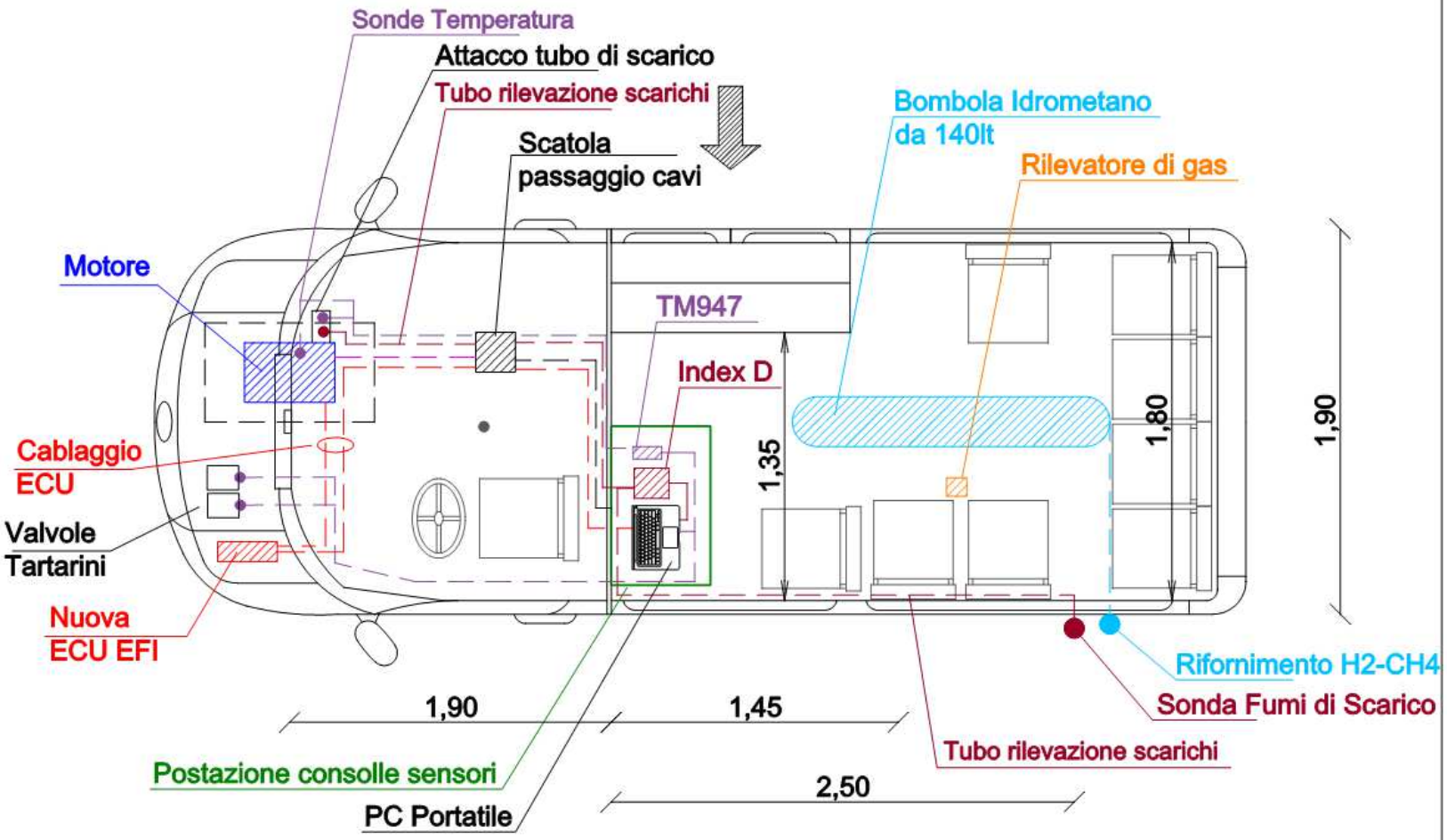
The blend ratio was varied from $\lambda = 1$ (stoichiometric conditions) up to the maximum sustainable by the engine related to the fuel used, in particular $\lambda = 1.25$ for methane and $\lambda = 1.70$ for hydro-methane mixture H2 35%.
In order to emphasize the benefits of hydrogen power it was realized an installation ensuring the automatic variation of different gas percentage depending on the power required by the driver. This solution allowed to add the maximum amount of hydrogen depending on instant engine conditions, exploiting the benefits of hydrogen addiction without engine performance reduction (torque and consumption) and preserving the efficiency of the catalyst system.

The retrofit activities on the vehicle were made at the workshop of Umbria Mobilità in Perugia by mechanical staff. The main modifications regarded the fuel tanks allocation, the intake manifold and the injection control system including wires and sensors. The methane power line was maintained in original condition.
A careful study on the gas/cylinder/valve combination, with reference to the norm ISO/TR15916-basic rule for the safety of hydrogen systems – prepared by Tecnhnical Committee ISO/TC 197, confirmed the hydrogen full compatibility of all materials used for cylinders and valves.
The additional power system realized, totally independent and easily inspectionable, consisted of an additional tank of 140 litre capacity, equivalent to about 20 Kg of fuel at 200 bar pressure, that ensures an autonomy of about 6 hours of the demonstrator vehicle allowing reasonable test time based both on average vehicle consumption and full methane condition (about 6.2 Km/Kg).
The following figure shows the vehicle layout after modification:

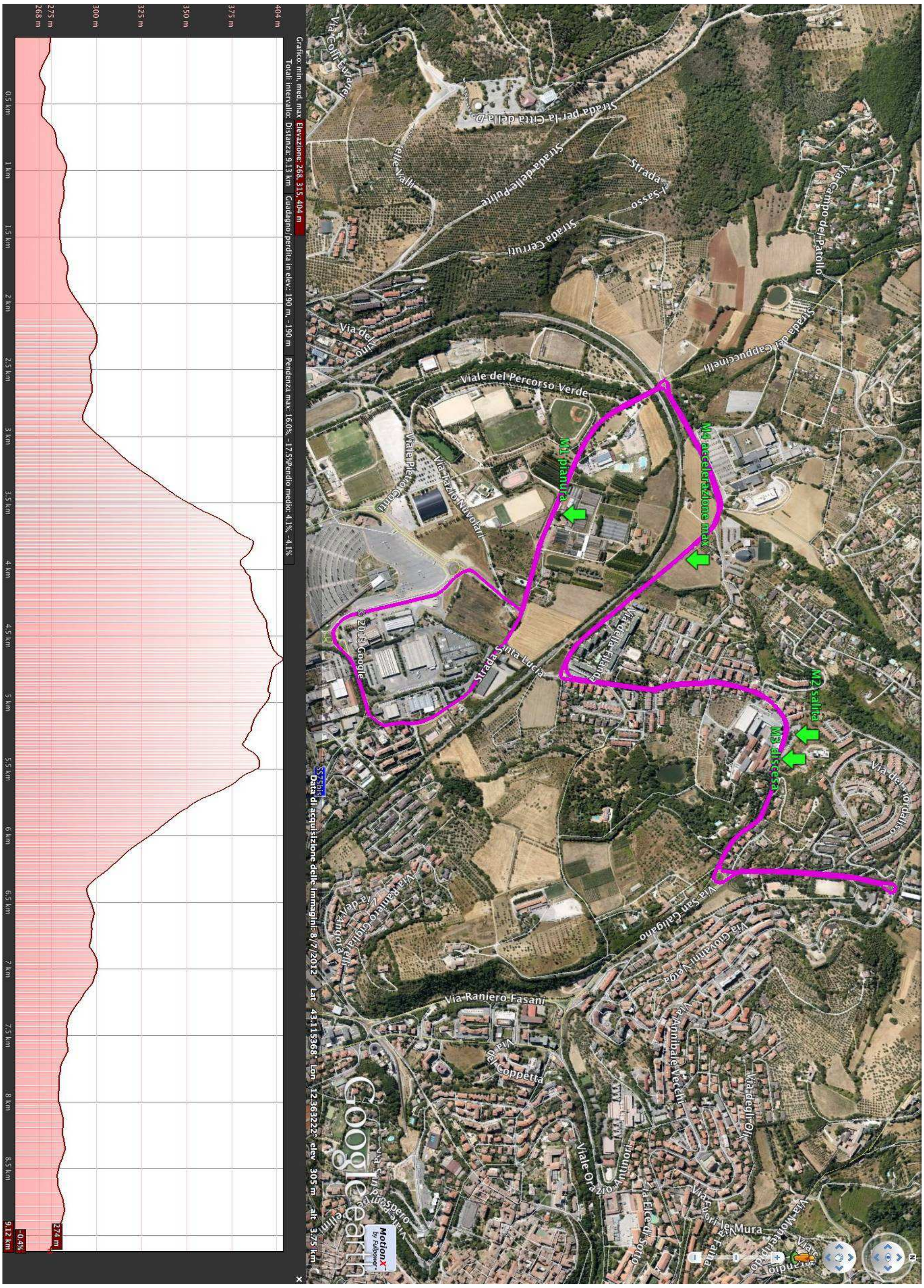
Layout allestimento Iveco



Layout allestimento Iveco



The road tests were performed on a track according to the topography of Perugia city and simulating the urban public service conditions with the presence of passengers on board (load).



The exhaust emissions, were sampled by an Ipex Analyzer through a suction probe positioned at the exit of the catalytic pipe.

The GPS system tracker installed on a tablet device allowed to record the route and altimetry variations in order to evaluate performances in terms of useful torque. Furthermore the tracking system allowed to analyse the system usability in the mixed track mentioned above.
It was also arranged, a security detector H2-CH4 (with reference to visual and acoustic alarm for security against any gas leakage on the tank and tank circuit). A video-cam was positioned in the driver cabin, in order to record the path to evaluate vehicle driveability in relation to the different roughness of the track.
Before to implement the hydro-methane system were made ex-ante vehicle tests to measure the parameters in the original vehicle condition. Test results are shown in the following table:

Ex-ante vehicle configuration. Tab.1

Alimentazione	Metano 100% fisso
Centralina	Magneti Marelli
Collettore aspirazione	4 iniettori
Valvole di espansione	n.1 Tartarini
Lambda	1,00 fisso
Minimo	1000 rpm

The result collected after the implementation of the hydro-methane system are mentioned in table below:

Ex-post vehicle configuration. Tab.2

Alimentazione	Metano 100% + Idrometano (35%H2+65%CH4) variabile
Centralina	EFI Technologies
Collettore aspirazione	4+4 iniettori
Valvole di espansione	n.2 Tartarini
Lambda	Da 1,00 Metano 100% a 1,70 Idrometano (35%H2+65%CH4)
Minimo	1000 rpm

All instruments, including the EFI ECU mapping, were developed by the engineers of Egenera and the Mechanical Engineering Department before the official test with many track trials.

The results obtained on road tests were fully in line with those observed on the engine bench test, this confirmed what initially expected by the project; the mixture of hydrogen with methane led to improved carburetion and to flatten the mixture with an improvement of the overall engine efficiency, reducing fuel consumption and emissions of CO and CO2.
After a deeper experimentation the studies and the technologies obtained by the project will be further developed and transferred to other European realities with the expectation of obtaining good results in terms of emission and low investment cost.
The project demonstrated the possibility to combine in real-time methane and hydrogen in high quantities without modification of the original vehicle performances.