Tests review and potentials of on-road commercial vehicles testing with towing trailer

Haraldo Rehder
Rehder Consultoria de Engenharia, Inovação e Gestão

Gustavo P. Rehder
Laboratory of Microelectronics – University of São Paulo

ABSTRACT

For on-road testing of commercial vehicles it is suggested the application of towing trailers with electromagnetic brake. Description of a prototype developed based on a sugarcane trailer and the tests carried out has already been presented by the authors in several Automotive Seminars. Truck tests have been reported, such as cooling system evaluation, accelerated powertrain durability, fuel consumption and evaluation of transmissions and vehicular performance. Easy-to-run and reproducibility programs for emissions and consumption assessment can be carried out with a towing trailer on flat roads or test tracks even at various altitudes. We believe that these methodologies should be better developed and for the continuity of developments and tests with emphasis on emissions and fuel consumption. Support and partnership of automotive, oil and fuel companies are needed, as well as Universities, Institutes and other Government Institutions. Development of a semitrailer for testing commercial vehicles up to 600 HP is being planned.

INTRODUCTION

The problems of global warming and energy efficiency are well known, discussed worldwide and subject of numerous conferences and treaties. The European Commission defined in the EU “Climate strategies, targets for 2030 a climate & energy framework” [1], which was adopted by EU leaders in October 2014. It was defined at least 40% cuts in greenhouse gas emissions (from 1990 levels), at least 27% share for renewable energy and at least 27% improvement in energy efficiency.

In the United States, the Energy Department Announces $ 137 Million Investment in Commercial and Passenger Vehicle Efficiency [2], The National Highway Traffic Safety Administration (NHTSA) and US Environmental Protection Agency (EPA) [3] aim also to the reduction of CO2 emissions and increase the energy efficiency of medium and heavy vehicles. In one initiative, SuperTruck II, the Energy Department has selected and will fund projects of $20 million to develop and to demonstrate cost-effective technologies which more than double the freight efficiency of Class 8 trucks.

Presently in Brazil, there are several Programs promoting the development of vehicles involving emissions, energy efficiency and biofuels, as shown in Figure 1.

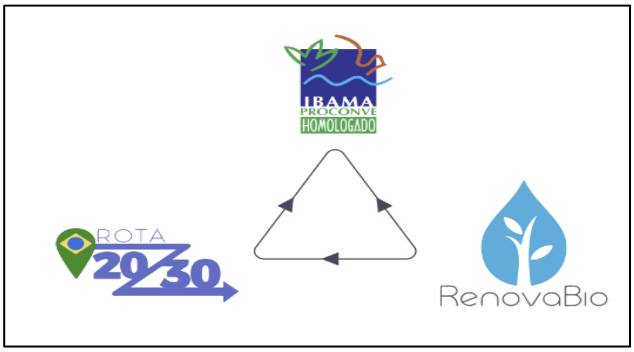

Fig.1. Government Programs ROTA 2030, IBAMA and RenovaBio , concerning vehicles emissions, energy efficiency and Biofuels (source Ricardo Abreu)

The “Programa ROTA 2030” [4], which follows the InovarAuto Program, proposed by the Government, aims to a new industrial policy for the automotive sector, which includes gaseous emissions and energy efficiency for light and heavy vehicles. The Rota 2030 Program will be developed according to the Public Notice (Edital) Desafios Automotivos [5] ALIANÇA INDUSTRIAL (SENAI) – FASE COMPLEMENTAR, last review 2019, and considers:

- SENAI. Industrial Alliance in ROTA 2030 – EMPREENDEDORISMO INDUSTRIAL, POR MEIO DE ALIANÇA INDUSTRIAL page 53 [6]
- SENAI. Innovation challenges in ROTA 2030: EMPREENDEDORISMO INDUSTRIAL, POR MEIO DE DESAFIOS (SENAI) page 57 [7]

A new Public Notice by SENAI concerning those Programs is ongoing.

TESTING METHODOLOGIES

Automotive test methodologies in general, use electronic calculations and simulations, stationary tests with engine or chassis dynamometers, and on road and track field tests. Each test methodology has its advantages and disadvantages.

In Brazil, there isn't chassis dynamometer for testing heavy commercial vehicles such as that one from Mahle [8] with aerodynamic (wind) simulation, presented in Figure 2. Worldwide there are only a few of those installations.

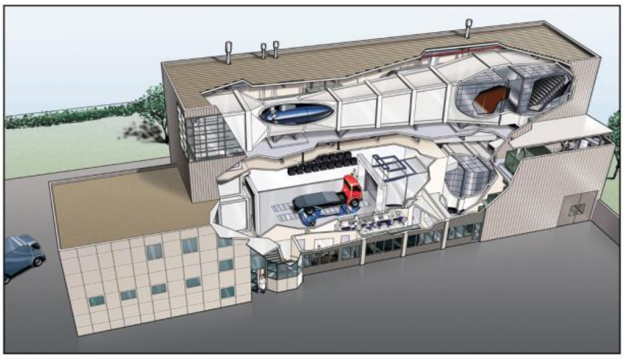

Fig. 2. Mahle, previous Behr AG, Germany, stationary chassis dynamometer.

The commercial vehicles on-road tests in real application conditions are normally extensive, take long time and therefore have high costs. The results depend on many variables such as: application mode, the road topography characteristics, traffic, driver and his way of driving, the convoy weight, among others. The tendency of on-road simulation tests to replace the real application is being pointed out, with emphasis on fuel consumption and emissions, as showed in some of the following examples.

The Standard SAE J1321 has defined since 2002 [9], fuel consumption tests of the complete heavy trucks with GVWR over 10,000 pounds performed on public road or on testing track. Those tests show however, problems of repeatability on public road due to changings of test conditions, specially road traffic. The results of consumption depend on the selection of the testing road and are restricted to this test site. Therefore, the results of these tests are not easily comparable due to the different road topography, traffic condition and the driver way of driving.

Procedures are discussed and proposed in the USA by UCS – UNION OF CONCERNET SCIENTIST in "Brief History of U.S. Fuel Efficiency Standards: "Where we are and where we're going" [10]. Test Procedure for Measuring Fuel Economy and Emissions of Trucks Equipped with Aftermarket Devices is proposed in U.S by the Low Carbon Vehicle Partnership [11].

The European Committee for Standardization [12] created the CEN Workshop Agreement "General guideline on real drive test methodology for compiling comparable emission data". Standard EN CEN/WS 090 has defined since September 2017 with "Real drive test method for collecting emission" [13] for the type approval of all new introduced cars. This includes on-road testing as part of the latest emissions standard known as RDE (Real Driving Emissions). 17379:2019: "A new CEN Workshop Agreement helps make our air cleaner" [14].

AVL Handbook 2016 presents Real Driving Emission Test, page 41 [15]: "PEMS (on-board-portable-measurements-devices) testing will be used by US environmental protection agencies for in-use scanning, in that case also CH4 measurement will be beneficial. EU is discussing to change from PM (particulate mass) to PN (particulate number) for heavy duty".

AVL Handbook 2016 presents also "TYPE APPROVAL: EMISSION", page 24 [16] and "HEAVY DUTY VEHICLES – CERTIFICATION" page 68, [17].

There is therefore a tendency of increasing the on-road testing with PEMS and other on-board-portable-instruments. The on-road testing shows however the problem of repeatability due to the traffic and difficulty of reaching the diverse test places. Measurements of the critical test conditions and simulating them in a plane road with towing trailer can simplify the test which can be reproduced.

ON ROAD TESTS WITH TOWING TRAILER

Worldwide, there are examples of Towing Trailers used to test on-road commercial vehicles such as those offered by Taylor [18] and Mustang [19] in the USA. BLOM, M. [20] presented the ATP Push-Pull Trailer, applied up to 4.6 t, see figure 3.

Fig. 3. Push Pull Trailer from ATP Germany

In Australia bus cooling tests were presented in the AARC Proving Ground Cooling Circuit, 600 m long x 7,3m [21]. Mercedes Benz do Brasil showed a towing trailer to perform bus cooling tests, Padua and all [22].

Truck and other heavy commercial vehicles on road simulation tests with easy execution and reproductivity will be very important in future and the methodology using Towing Trailer for diverse applications should be enhanced.

DEVELOPMENT OF A TOWING TRAILER IN BRAZIL

A Towing Trailer Prototype with electromagnetic brake (EMB), shown in Figs. 3 and 4, was built by the authors based on a sugar cane crop transport trailer with the central lowered chassis. with 2 axles, the rear one with differential.

This Towing Trailer is authorized for circulating on public roads by the Brazilian Traffic Authority DETRAN [23], last License 2020, for maximum trailer weight of 20 t. The technical weight is however much higher due to the previous usage of the trailer. It received the support of FAPESP in a PIPE I Project [24]: “Testes de caminhões leves até semipesados com um reboque de arrasto inovador com freio eletromagnético para simulações on-road de aclives”. A Patent is under evaluation by INPI- Instituto Brasileiro de Propriedade Intelectual RPI Number 2213, on July 2013 [25].

The Trailer body with doors and windows, is covered with aluminum sheets, including recently the roof. In the Trailer front is placed the electro electronic cabin. In the back, over the rear axle is placed the ballast.

Fig. 3. Towing Trailer Prototype side view with truck tractor, parked before test begin.

Fig. 4. Towing Trailer Prototype back view with truck tractor.

The electromagnetic brake is placed in the trailer interior (EMB) shown in Fig. 5, which acts on the rear axle through a drive shaft, braking the convoy through the tires. This EMB is cooled by 3 electric ventilators, to dissipate the generated heat during de electromagnetic braking. The energy supply system for the EMB is also in this cabin.

In the electro electronic cabin are placed the energy supply system for the EMB as well as the central data acquisition of the towing trailer. Control data for the EMB as temperatures, rotation, braking current, voltage is measured, controlled and sent Wi-Fi wireless to the lap top placed in the track cab. The braking current control of the EMB is still by wire.

Fig. 5. Inside Towing Trailer with electromagnetic brake and cooling ventilators in front view. Electro electronic cabin on back view.

Truck tests have been reported, such as cooling system evaluation [26], accelerated powertrain durability tests [26], fuel consumption [27], [28], [29], [30] and evaluation of transmissions and vehicular performance [31], [32]. Those papers will be present and discussed in the next chapters in this present Paper [33], with tests review as well as suggestions for tests and future methodologies.

CONTROLS IN THE TRUCK CABIN.

LAPTOP – In the truck tractor cabin the driver operates normally the truck / convoy. Beside him sits the test engineer/ technician who controls the test program and test results in a laptop, placed on the instrument panel as shown in figure 6.

Fig. 6. Laptop on truck cab instrument truck panel, only for localization view.

Measured Data are shown and controlled in the laptop screen as curves in function of the test time or as instantaneous values, as shown in Fig. 7. All data are stored in the laptop in function of test time. Diagrams or tables can be obtained and registered, as the example in Table 1.

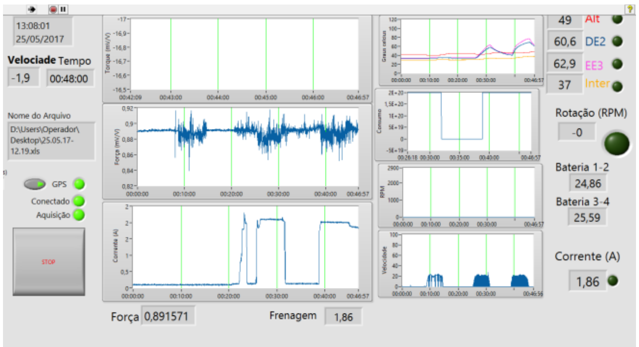

Fig. 7. Lap top screen showing an example of measured present values and diagrams of measured data during the test. Data discussion in following Chapters.

Table 1. Example (extract) of measured data. Variables in function of Test time [s]

Test Time [s]	Temp.1 [°] EMB	Temp.2 [°] EMB	Temp.3 [ª] EMP	Temp.4 [°] EMP	Current [A] EMP	Batteries 1 [VDC]	Batteries 2 [VDC]
0	73,37587	56,81209	64,17355	96,60286	0,19414	24,83308	25,79791
0,01527	73,37363	56,80421	64,16433	96,60172	0,197531	24,15597	25,9387
0,035173	73,36788	56,79229	64,14858	96,59356	0,200295	23,72372	25,99266
0,118304	73,37329	56,8008	64,16108	96,60097	0,219783	24,16548	25,95421
0,132302	73,38086	56,81441	64,17121	96,61036	0,185148	24,78332	25,76348

GPS - A GPS placed on the cabin roof supplies the laptop with latitude, longitude and convoy speed which are stored in the laptop, as shown in Table 2. and the curves in Figs. 8, 9 and 10.

Table 2. Example of GPS meassured data.

Test Time [S]	Latitude [°]	Longitude [°]	Speed [km/h)
0	-22,4253	-47,3624	0,1852
0,01527	-22,4253	-47,3624	0,1852
0,035173	-22,4253	-47,3624	1,852
0,118304	-22,4253	-47,3624	3,3336
0,132302	-22,4253	-47,3624	4,4448

Examples of Latitude and Longitude are shown in Figs. 8 and 9. Test Route calculated from Latitude and Longitude is shown in Fig. 10.

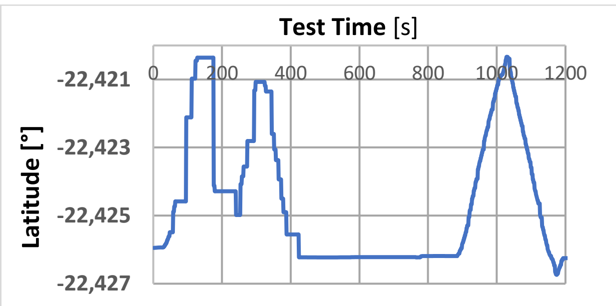

Fig. 8. Example of GPS measurement: Latitude [°] x Test time [s]. 02.02.18-16.55

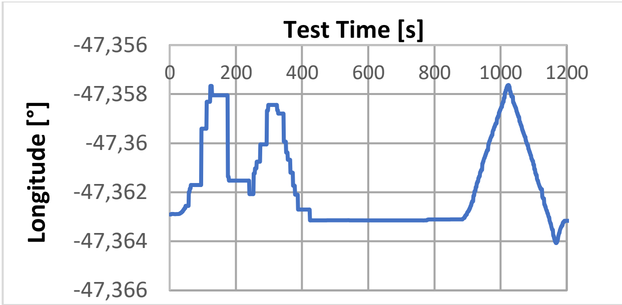

Fig. 9. Example of GPS measurement: Longitude [°] x Test time [s]. 02.02.18-16.55

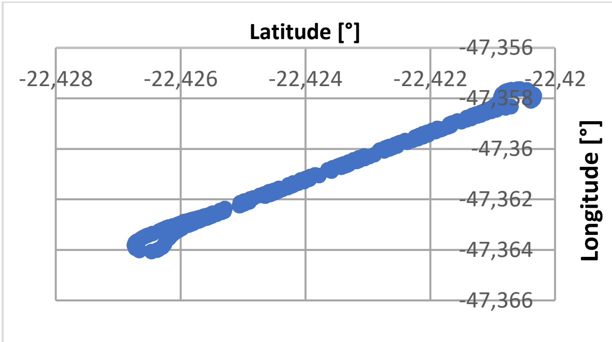

Fig. 10. Test route calculated from Longitude and Latitude. 02.02.18-16.55

Based on GPS measured data, test distance (calculated through longitude and latitude) is shown in figures 11 in function of the Test time.

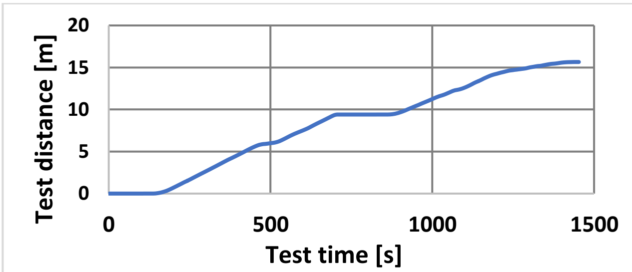

Fig. 11. Example of Test distance [km] in function of test time [s].

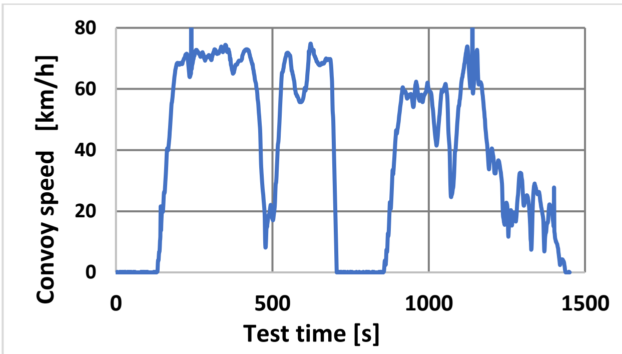

Fig. 12. Example of convoy speed [km/h] in function of test time.

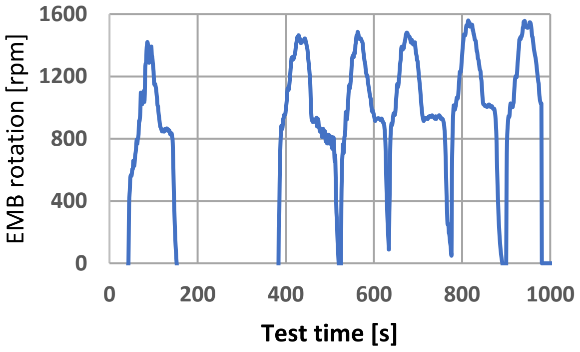

Fig. 13. Example of EMB rotation [rpm] in function of test time [s]. 16.03.18-16.49

EMB CURRENT - The EMB current causes the electromagnetic braking forces of the convoy through the rear tires of the towing trailer, simulating uphills. The current level and consequently the uphill simulations are controlled easily in the truck cabin by the test engineer with a potentiometer. The current control is still performed by wire between trailer and truck. Example of the measured current data stored in the laptop and shown in the diagram are in Fig. 14. It is possible therefore to simulate uphill programs.

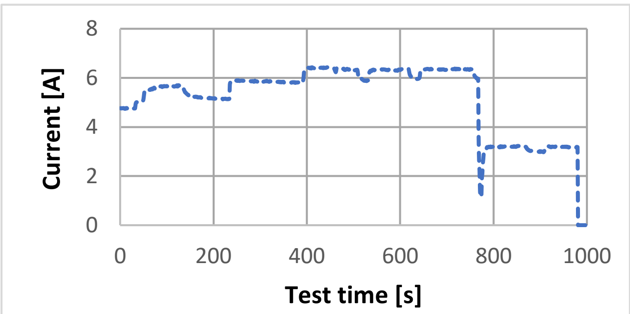

Fig.14. Example of EMB current program in function of test time, to simulate uphills.

EMB TEMPERATURES - EMB current causes heating of the electromagnetic brake. To avoid overheating, temperatures inside EMB and air output are measured and controlled as shown in Fig.15.

Two alternators supply the energy for EMB current and for the EMB cooling (3) ventilators. The temperature measurements indicate the load levels of the alternators. The inside (intern) from de EMB is for this test very low, the air output rises however rapidly.

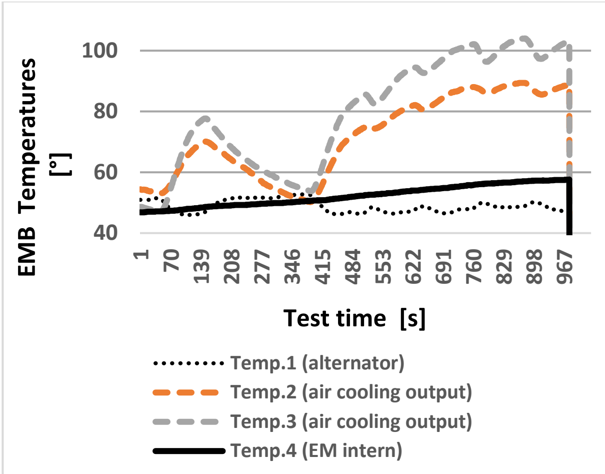

Fig. 15. Example of EMB and alternator temperature measurement.

ELECTRIC SUPPLY - Figure 16 shows the current influence on the battery voltages. The batteries 1 charge the EMB cooling ventilators and the Batteries 2 charge the EMB braking current. The charging of the batteries is enough to supply the EMB current when convoy is moving and consequently with the EMB rotating. When convoy is standstill, the Batteries 1 have a limited capacity of charging the ventilators and the test program should be adapted to their limit. In future, a generator should be run by an independent combustion motor for guarantee the charging when standstill.

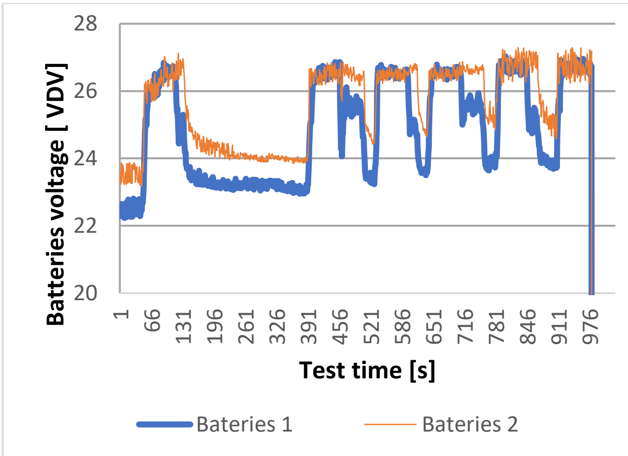

Figure 16. Measurement of Batteries Tension in function of test time [s] during test of Fig. 13. Good charging during convoy movement.

VARIABLES CORRELATIONS – In figure 17 the variables were multiplied by convenient factors to better visualize the relations between them.

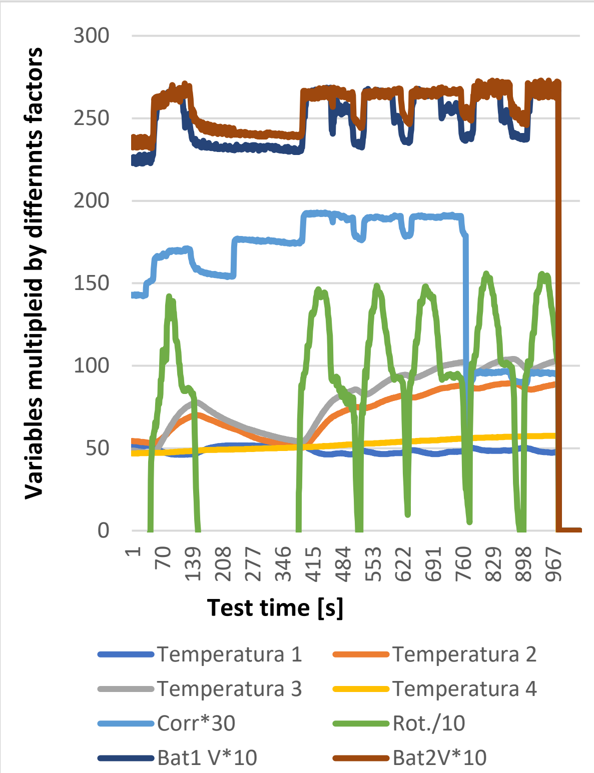

Fig. 17. Variables Correlation during Stop and Go Test on 16.03.18-16.49, test program as in Fig. 14. max. 60 km/h. Extract of almost 1.000 s.
Forces measured in mV/V, between traction truck and Towing Trailer.

TOWING FORCES AND BRAKING TORQUE - The forces between tractor truck and trailer are measured by a specially developed sensor with strain gauges attached/ glued on the traction rod as shown in Figure 18. System based on strain-gauges was also developed for measuring the electromagnetic braking torque, example in Figure 19. The force and the torque are statically calibrated before tests.

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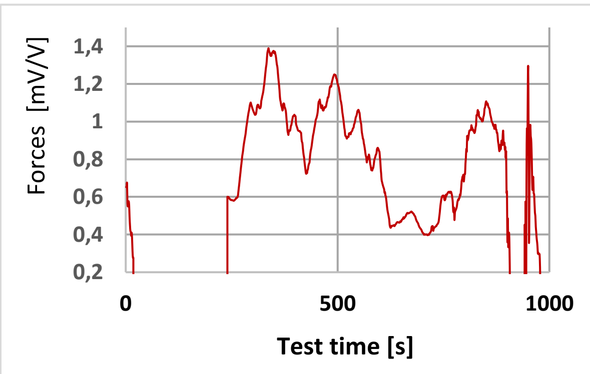


Figure 18. Electromagnetic brake (EMB) , measured in mV/V in function of test time [s].

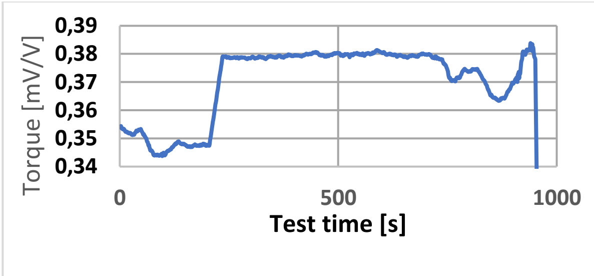


Figure 19. Electromagnetic brake (EMB) torque, measured in mV/V in function of test time [s].

FUEL LEVEL AND FUEL CONSUMPTION - The fuel level can be measured as presented in previous papers [28] and [29]. A small tank was used for short distances, in order to get higher consumption measurement precision, (Figure 20). In this case, 40 cm fuel level. corresponds to 10 liters fuel, 4 cm/liter. Considered a consumption of 2 liters/km, the auxiliary tank will be enough for 5 km test. If considered the original fuel tank of 300 liters and the same 40 cm fuel level, the value will be 0,13 cm/liter and the maximal test distance will reach 150 km and measurements according SAE Standard j1321 can be performed.

The fuel level can be measured directly in a scale or by a capacitive fuel level sensor on the fuel tank filler neck. The present measured data with the convoy standstill, are sent to the laptop and presented on the desktop of the laptop, as shown in a static calibration in Figure 21.

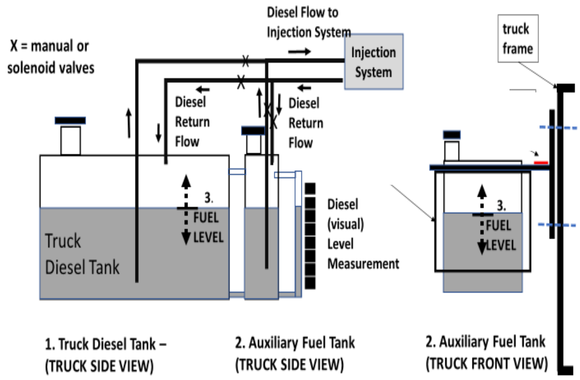


Figure 20. Schematic view of auxiliary tank and truck fuel tank for short (only auxiliary tank) and larger distances fuel measurements.

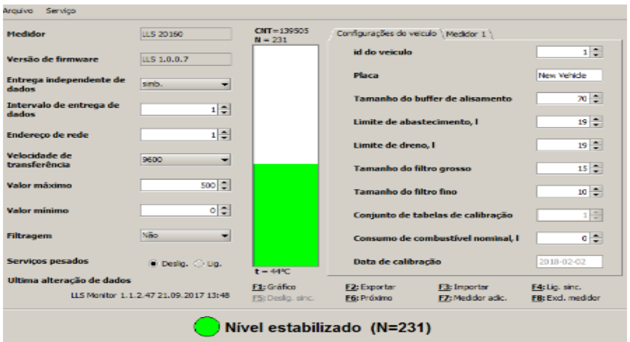


Figure 21. Desktop view. Example of LLS 20160 fuel static level calibration in function of Test time.

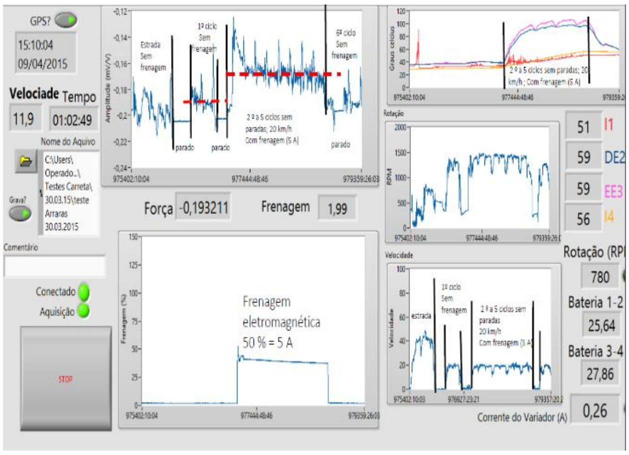
Other measurement methodologies, like the use of CAN data or fuel flow meters can be used in future simulations tests.

REVIEW TOWING TRAILER TESTS

Since 2013, different developments, tests and papers concerning towing trailer have been presented by the authors in several Automotive Seminars. This present Paper reviews the truck tests that have been reported, such as cooling system evaluation, accelerated powertrain durability, fuel consumption and evaluation of transmissions and vehicular performance. Below a description of the main subjects for each paper and possible potentials of the methodologies.

COOLING TESTS - Cooling tests of heavy trucks are performed abroad on stationary devices as shown before with a chassis dynamometer such as that one from Mahle [8] with aerodynamic wind simulation, presented in Figure 2. Worldwide there are only a few of those installations, not existent in Brazil. The cooling tests of trucks were historically performed in Brazil on flat roads and later on testing track, by towing one or more trucks. The development of the Towing Trailer Prototype was first carried out to perform cooling tests of trucks up to 250 HP.

In Symposium SIMEA 2015, Rehder,H and Rehder,GP [26] reported cooling test simulations with a 6x4 Truck and the Towing Trailer Prototype as shown on a laptop screen in Figure 22. It was performed on a flat road at 20 km/h by maximum engine torque (maximum acceleration pedal position).



Fig, 22. Cooling test simulation on flat road at 20 km/h. Laptop screen showing 6 cycles of a cooling test simulation (31.03.2015).

One test takes about one hour or more and are normally carried out until the truck cooling system reaches temperature balance or reaches the truck cooling system limit. The EMB current is defined before the test beginning, in order to reach the maximum of the Engine torque by 20 km/h. Maximum truck testing torque / power depends on the EMB current and the EMB temperatures.

Figure 23 shows an extract of the test data, including the forces between truck and towing trailer.

Cycle	1		2		3		4 / 5		6		7	8 / 9	10	11 / 12	13
Speed [km/h]	20	0	20	0	20	0	max 80	0	max 80	0	max 80	max 80	max 80	max 80	max 80
Current [A]	0	0	4.5	0	4.5	0	0	0	3.0	0	0	5.0	8.0	0	5.0
Force [mV/V]	0.19		0.17		0.17		0.195		0.188		0.195	0.185	0.185	0.195	0.185
Force [kgf]	882		2058		2058		588		1000		588	1176	1176	588	1176

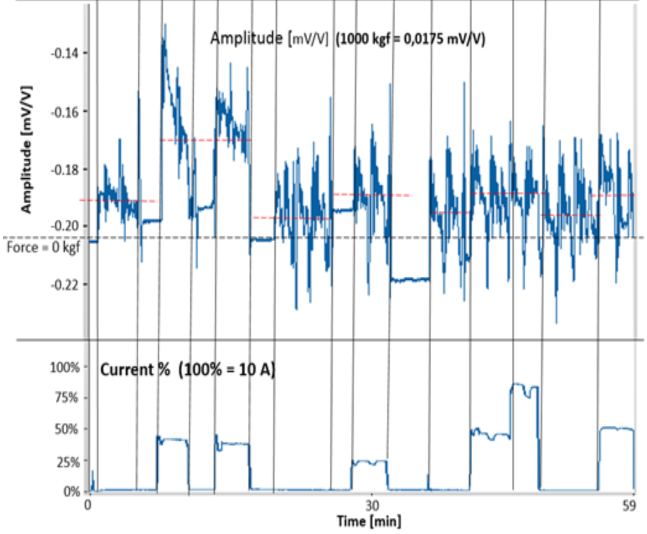


Fig. 23. Influence of the braking current on the traction force, measured in mV/V. Cycle 1 to 3 at constant speed of 20 km/h. Cycles 3 to 13, on-road measurements by maximal 80 km/h.

Advantages of using towing trailer are the preparation and test easiness, reproducibility and lower costs due to the need of only one driver, testing track lower costs due to the lower quantities of convoy axles involved, among others.

In future transformation of the trailer in semitrailer will allow simplification of tests with truck tractors. For testing trucks up to 600 HP, a semitrailer could be developed in future. Tests of trucks up to this power could be performed using the present trailer prototype and a supplementary towed truck. This configuration has the advantage of using the Towing Trailer Prototype to regulate the needed braking torque.

Busses and agricultural tractors tests can be performed by lowering the rod traction system and adapting the testing speed to 10, 25 or even 60 km/h through the mechanical transmission placed before the EMB.

ACCELERETED POWERTRAIN DURABILITY TEST ON PUBLIC ROAD UP TO 90 km/h - In Congress SAE 2015, Rehder, H and Rehder, GP [27] presented an example of tests performed on a public road with up and down hills, characteristic of the Brazilian Central Plateau roads The tests were performed up to 90 km/h, with the towing trailer prototype with several EMB currents (0A , 2A and 5,5A). The forces between truck and towing trailer were measured. For comparations, tests at 20 km/h were performed with 0A and 4,4A.

The laptop screen in Fig. 24 shows the present measured data of time, testing time, EMB temperatures, traction forces, braking and current level, batteries voltages and others. Curves of EMB temperatures, traction forces and speed along the whole test are also shown. The traction forces are measured in mV/V.

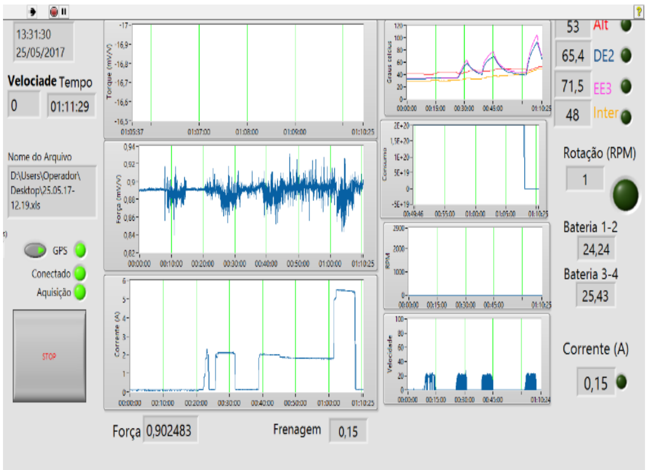


Fig. 24. Tests performed on a public road with up and down hills, characteristic of the Brazilian Central Plateau roads at speeds up to 90 km/h.

This methodology can be used in future for real road condition tastings of the power train in heavier applications and consequently in shorter test time. Not only for the whole system but also for real performance and durability of power train components such as seals, bearings, lubricants and greases under real heavy road conditions. Cost savings by using the Towing Trailer occur due to shorter test time and toll costs (convoys with lower axles quantities), among other characteristics. Tests up to 350 HP trucks can be expected

Presentation tests to evaluate accelerated durability tests on road with a tire manufacturer were performed and indicated the possibilities to use this methodology. Tires can be evaluated in traction (truck) and in braking (trailer). Those tests could be performed also in flat roads and gathering different companies to test different components at the same time.

FUEL CONSUMPTION TESTS ON FLAT ROAD AT 20 km/h - In Symposium SIMEA 2017, Rehder,H and Rehder, GP [28] presented fuel consumption tests with a 6x4 heavy truck and the Towing Trailer Prototype, performed at constant speed of 20 km/h and at several electromagnetic braking levels

Those fuel consumption measurements, performed in short distances, used the auxiliary tank of circa 10 liters and is hydraulically independent of the main (s) truck fuel tank (s) as shown in Fig. 20. Table 3 shows the EMB braking influence (simulating uphills) on fuel consumption.

Table 3: Results of the on-road fuel consumption measurements, speed 20 km/h, 1,7 km each lap, brake currents of 0 A, 2A and 5,5 A.

LAPS	1 to 3	4	5	Remarks
Brake current	0 A	2 A	5,5 A	
TEST Time [min]	6	6	6	
LAP Consumption [cm] Consumption [liters]	LAP 1 4,4 0,978	LAP4] 5,8 1,289	LAP5 10 2,22	Each LAP= 1,7 km. 1 l = 4,5 cm
LAP Consumption [cm] Consumption [liters]	2 3,9 0,867			LAP2 Repetition of LAP1
LAP Consumption [cm] Consumption [liters]	3 3,9 0,867			LAP3 Repetition of LAP1 and 2
Consumption [l/km]	LAP1 to 3 0,541	LAP4 0,746	LAP5 1,30	Testing metho-dology OK

For longer distances, test of fuel level measurements of the truck tank with a capacitive sensor was also performed. This methodology can be also used for simulation of fuel consumption on flat road based on Standard SAE J1321, Testing on flat testing track can simulate varied slope programs and are repetitive in all testing grounds. Automatized test programs can in future be developed.

Other fuel measurement methodologies as fuel on-board-portable-measurements-devices or CAN from the testing truck can be used for this simulation.

ON-ROAD FUEL CONSUMPTION TESTS, SPEEDS UP TO 90 km/h - In Congress SAE 2017, Rehder, H and Rehder, GP [29], presented truck fuel consumption measurements performed with speeds up to 90 km/h on a road with successive segments of uphill and downhills, representative of Brazilian Central Plateau, with electromagnetic braking simulating higher uphill slopes and/or higher weight of the convoy. Laps with varied speeds, maximum 75 km/h and 90 km/h were performed under different electromagnetic braking (uphill slope simulation) conditions (0A, 2 A and 4 A) and tire pressures (110 and 90 psi). The fuel consumption was measured with the auxiliary fuel tank, rigidly fixed on the truck frame as shown in Figure 20. Real-time measurements of the fuel consumption by using a capacitive fuel lever sensor was also possible.

The developed system was able to measure consumption for small distances (10-20 km) and showed the slope uphill simulation and tire pressure effect. These results show a good possibility to perform on flat road a controlled, reproducible and forced uphill simulations up to 90km/h.

Table 4: Results of the on-road fuel consumption tests, maximum speed 75 km/h and 90 km/h, 17,1 km each lap.

Step	1	2		3	4
Max. speed [km/h]	75	90		90	90
Brake current	0 A	2 A		4 A	0 A
EMB Torque: [mV/V]	0	-		4,88	0
Tire pressure [psi]	110	110		110	90
Laps	2	1		1	1
Distance [km]	34,2	17,1		17,1	17,1
Time [min]	41,0	20,04		19,37	
Consumption level [cm]	3,0	2,5		3,0	2,3
Consumption volume [liters]	21,43	17,86		21,43	16,42
Autonomy [km/l]	1,59	0.95		O,79	1,04
Consumption [l/km]	0,629	1,053		1,266	0,962
Consumption [%]	100	167,4		201,3	152,9

FUEL CONSUMPTION TESTS ON FLAT ROAD, SPEEDS UP TO 80 km/h - In Congress SIMEA 2018, fuel consumption test methodology were presented by Rehder, H and Rehder, GP [30], performed with speeds up to 80 km/h on an almost flat public road. On this road, it was simulated testing´s on Brazilian Central Plateau roads with uphill's and downhills.

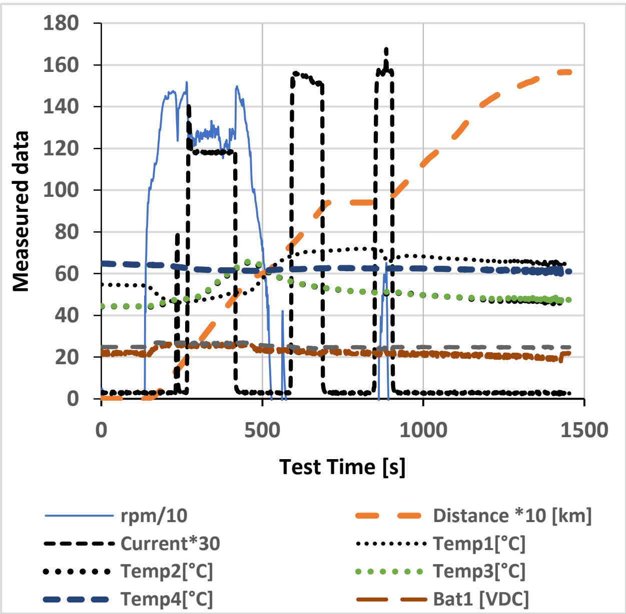


Fig 25. Relations between variables: EMB rotation, EMB current, EMP temperatures, Batteries Voltage, Test distance

The tests were performed with successive varied electromagnetic braking level simulating 2 km uphill and 2 km with zero braking, replacing the downhills, because the Towing Trailer does not push the truck. It is proposed to perform on (flat) test tracks, fuel consumption tests based on SAE J1321 Standard with the Towing Trailer, avoiding traffic and using reproductive varied programs.

Data measured during this simulation are shown in Fig. 25 using a factor for each variable, to better compare them.

In this test program, the fuel level was measured with a capacitive fuel level sensor LLS. Figure 26 shows an extract of the fuel level and the current. Measurements methodology should be enhanced to avoid oscillation during movement of the convoy.

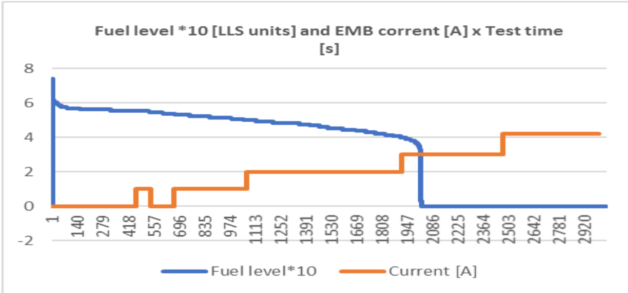


Fig. 26. Fuel level*10 of LLS capacitive sensor (until 2000s) and EMB current

FUEL CONSUMPTION IN STOP AND GO TESTS, ON FLAT ROAD AND SPEEDS UP TO 60 km/h - Presented in AEA 2018 Symposium by Rehder, H and Rehder, GP [31] fuel consumption simulation tests of heavy commercial vehicle in city application performed on flat road, with speeds up to 60 km/h and successive stops and go. Different convoy weight and uphill slopes can be simulated by the electromagnetic brake level. Reproducible tests without traffic influences can be performed on flat testing tracks, with trucks, buses, even with alternative fuels. This simulation test program can be used in future for emissions testing with a PEMS devices.

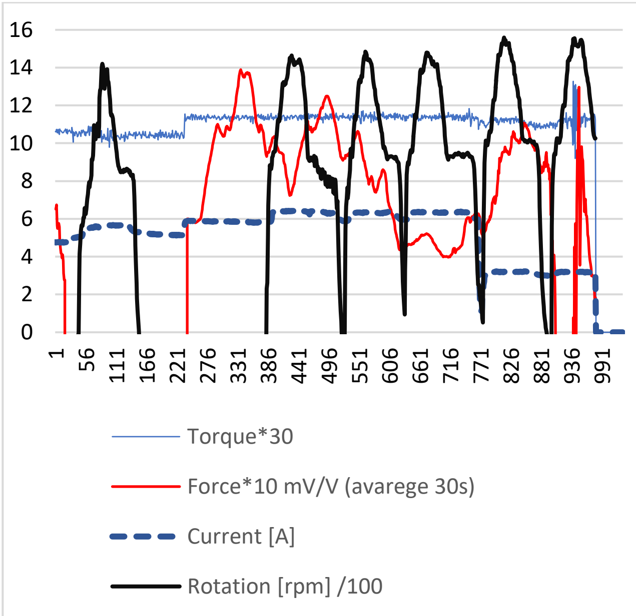


Figure 27. Variables Correlation of Stop and Go Test on 16.03.18-16.49. Max. 60 km/h. Extract of almost 1.000 s.

TRUCK PERFORMANCE ON FLAT ROAD, ACCELERATION UP TO 60 km/h - Presented in SIMEA 2019 Symposium by Rehder, H and Rehder, GP [32], tests were performed to evaluate the power train and the truck/ convoy performance of a heavy truck 6 x 4 with 440 HP and a 16 gear semi-automatic transmission. It was shown the feasibility of evaluations on flat roads during successive accelerations from 0 km/h or 20 km/h until the convoy reach almost 60 km/h, simulating several uphill levels performed by the electromagnetic brake. Figures 28 to 30 show the measured 9 cycles data, during the acceleration on flat road, with the electromagnetic brake.

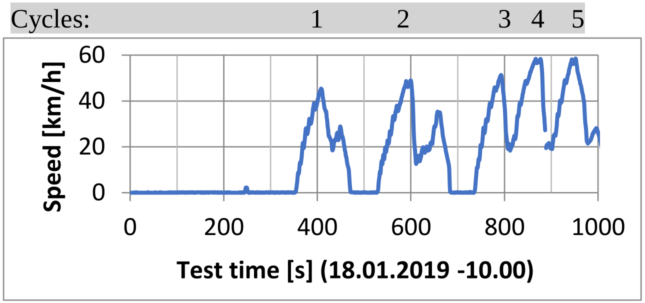


Fig. 28. Accelerations from 0 km/h or 20 km/h until 60 km/h during Cycles 1 to 5

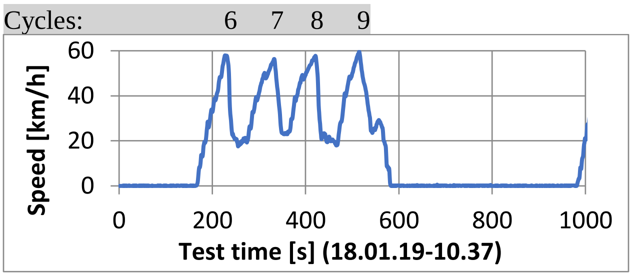


Fig. 29. Accelerations from 0 km/h or 20 km/h until 60 km/h during Cycles 6 to 9 .

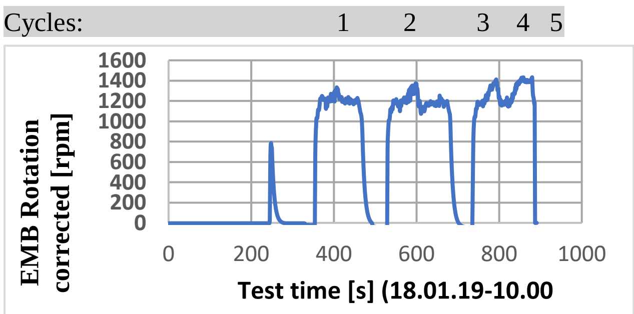


Fig. 30. EMB Rotation during Cycle 1 to 5.

The tests show mechanical behavior, such as gear changes, noise and driver feeling. Besides this, acceleration curves give the power train performance, simulating on a flat road, various uphills and convoy weights caused by the electromagnetic brake as shown in Figures 32 and 33.

In Figure 34 it was shown the temperatures behavior of the EMB. In Figure 35 it was shown the torque behavior. Study of measurements of torque should be enhanced in next works. Relationship between forces and torque caused by the EMB and the higher dynamic forces caused by the convoy dynamic could be evaluated in future

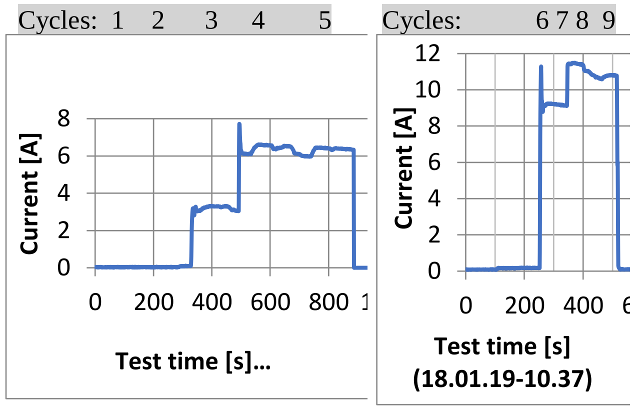


Fig 31. Current Test program in Cycles 1 to 9.

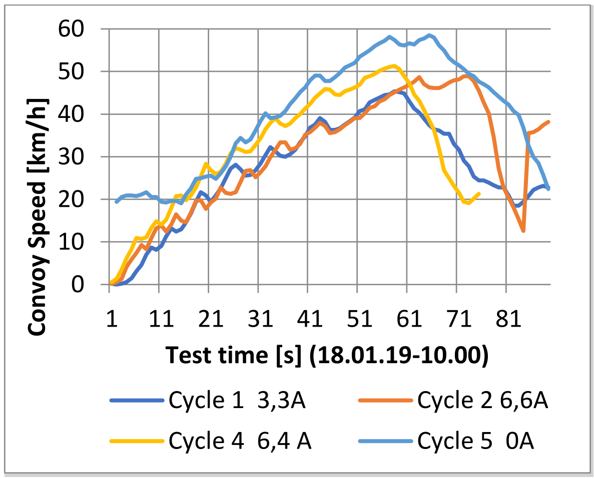


Fig. 32. Speed curves. Cycle 5 with 0 Amperes reaches almost the task of 60 km/h.
Cycles 1, 2 and 4 with braking current of 3,3A , 6,6A and 6,4A reach 45 to 50 km/h.

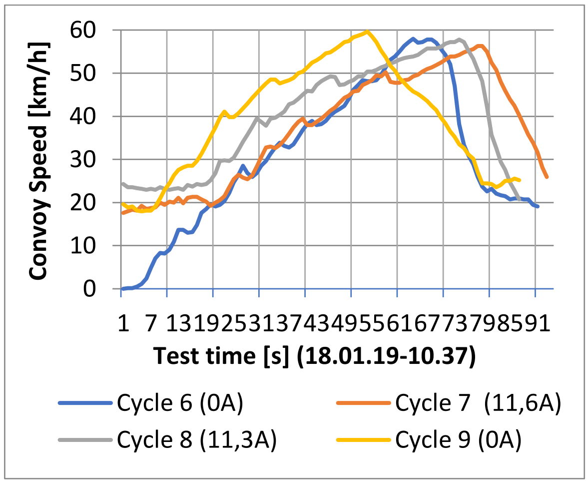


Fig. 33. Speed curves. Cycles 6 and 9 with 0 Amperes reach almost the task of 60 km/h.
Cycles 6 and 7 with 11,3 and 11,6A takes longer time to reach this speed.

The tests show that it is possible to evaluate on flat roads, truck transmission performance with a Towing Trailer during the acceleration and uphills simulations up to 60 km/h, possible to be extended up to 80 or 90 k. The mechanical behavior, such as gear changes, noise and driver feeling can be evaluated. Acceleration curves give the power train performance, simulated on a flat road various uphills and convoy weights.

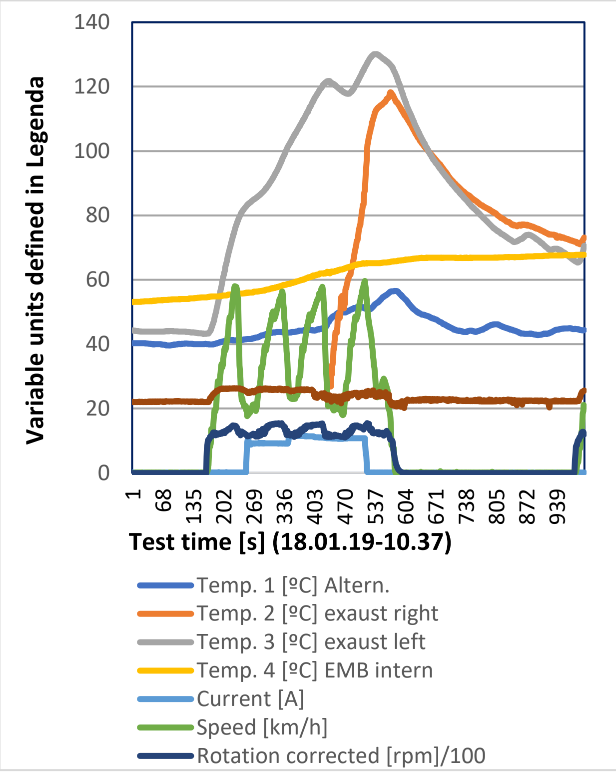


Fig.34. Temperature and battery voltage behavior during Cycles 6 to 9. Temperature 2 measurement failure up to 608 s

Fig. 35 shows the variables correlations in function of test time

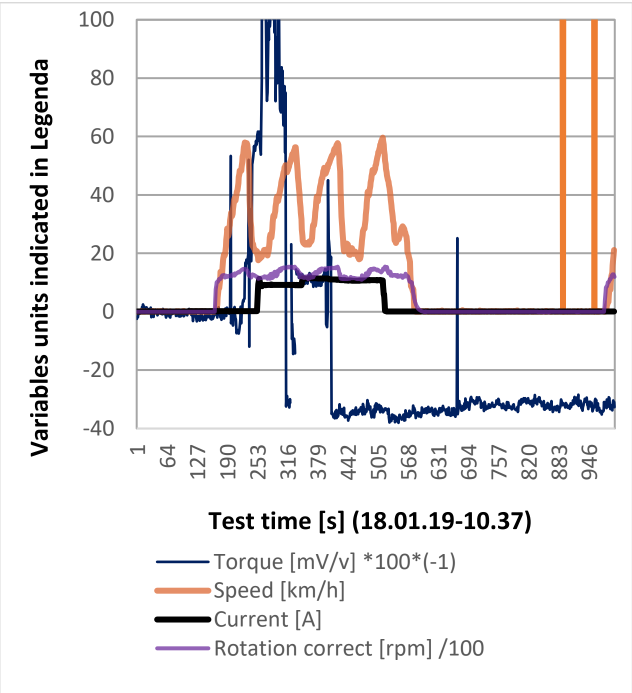


Fig. 35. Cycles 1 to 5. Current, Speed, Torque and Force in function of Test time.

TRUCK PERFORMANCE ON FLAT ROAD, DESCELERATION FROM 80 km/h – Tests by Rehder, H and Rehder, GP [33] were performed to evaluate the power train and the truck/ convoy performance of a heavy truck 6 x 4 with 440 HP and a 16 gear semi-automatic transmission. Deceleration from 80 km/h caused by the EMB braking were performed.

Fig. 36 shows the testing program during 15 cycles, considered the speed and the EMB braking current.

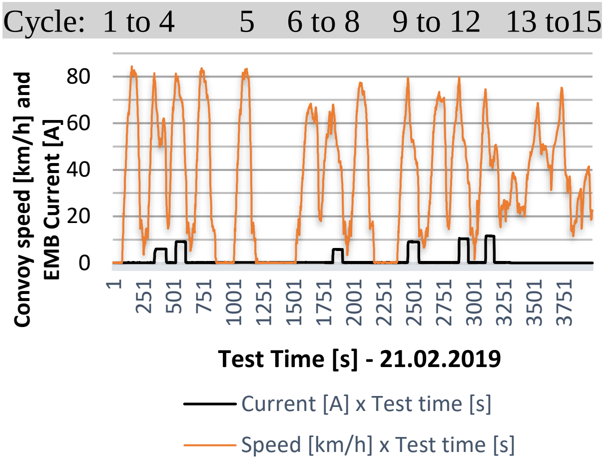


Fig. 36. Testing program, speed and EMB current.

Figure 37 shows the relation among EMB torque, current, rotation and convoy speed. Study of relationship between forces and torque caused by the EMB and the higher forces caused by the convoy dynamic should be in future enhanced. The convoy dynamic forces are very high and with rapid variation in relation to the EMB torque and forces. Measurements to define and separate them will be possible by stationary events.

Test results will be presented in a Paper in 2021.

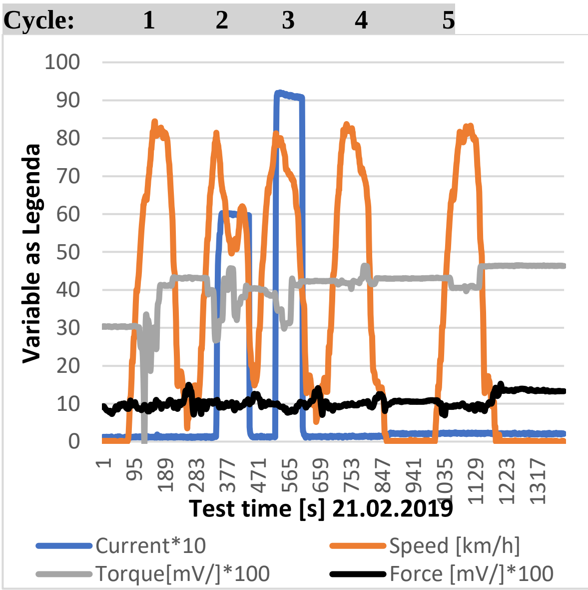


Fig. 37. Variables correlation: Current, Speed, Torque and Force in function of Test time.

CONCLUSIONS

Different reproducible simulation programs using a Towing Trailer on public roads, on flat roads and test tracks can be used in the future to enhance the developments of commercial vehicles It should be defined reproductive methodologies for cooling evaluation, fuel consumption, truck and powertrain performance, energy efficiency and emission evaluations. Tests for accelerated durability of the power train should be enhanced. Tests can be carried out with trucks, buses and tractors, even with alternative fuels, and in variable levels in relation to the sea. We believe that these methodologies should be enhanced in Brazil with emphasis on emissions and fuel consumption. Development of a semitrailer for testing commercial vehicles up to 600 HP is being planned. Support, partnership and alliances of automotive, oil and fuel companies will be needed, as well as Universities, Institutes and other Government Institutions.

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CONTACT INFORMATION

Haraldo Rehder
Engineer, MSc
Rehder Consultoria de Engenharia, Inovação e Gestão
rehder.consult@gmail.com

Phone: +55 11 3815 0930
WhatsApp: +55 11 99592 9872