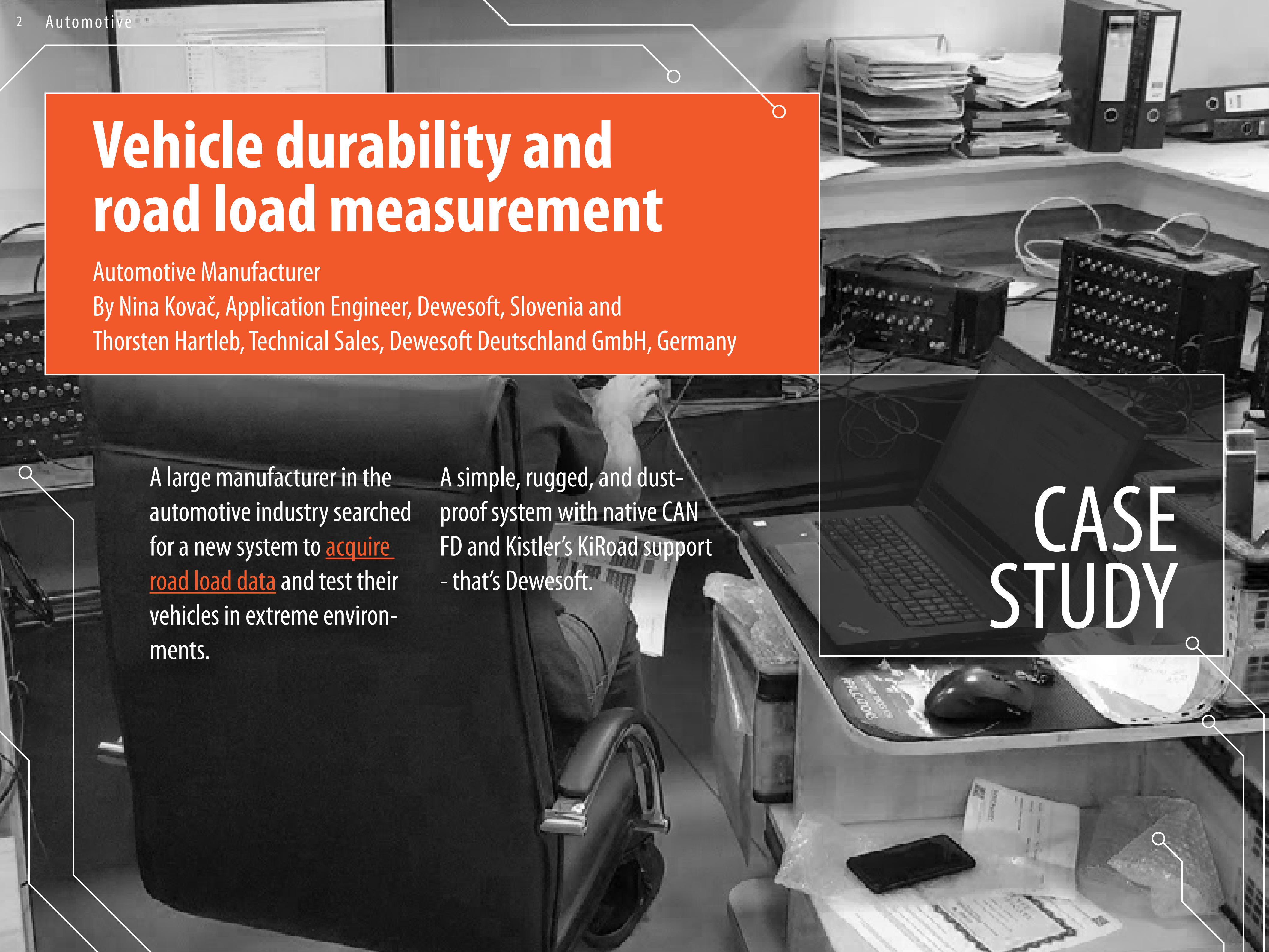
DEWESoft®

AUTOMOTIVE APPLICATIONS

CASE STORIES



Vehicle durability and road load measurement

Automotive Manufacturer
By Nina Kovač, Application Engineer, Dewesoft, Slovenia and
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A large manufacturer in the automotive industry searched for a new system to acquire road load data and test their vehicles in extreme environments.

A simple, rugged, and dust-proof system with native CAN FD and Kistler's KiRoad support - that's Dewesoft.

CASE STUDY

When you need to test full vehicle durability and safety, road load data acquisition is the way to go. It supplies data on the vehicle's response to the road, the loads that the vehicle will undergo during its lifetime. This implies collecting information about the road characteristics and many other driving and vehicle parameters. Road load data acquisition usually requires a large number of input channels.

In this case, the customer is a large automotive manufacturer who is present in the automotive industry for almost a century. With their iconic designs, high-end technology, and extremely efficient production, they are nowadays known all over the world. Vehicle development, testing, and manufacturing are closely related in their business, so every equipment optimization is really important for them as it allows to speed up the production or the development process.

Vehicle durability measurements are done during test drives or on testbeds. Tests are done either for an entire vehicle, a subsystem, or certain components. Road load data measurements are collecting information about the road characteristics and many other driving and vehicle parameters such as vehicle velocity, air, and rolling resistance, engine loads, inertia, mass, and many more.

Customer issues

The engineers in the testing department were for many years working with an older road load data acquisition system to acquire data from the road and test their vehicles in various environments all over the world.

Their main drive to exchange the old system was to have just a single unit for data acquisition, dust-proof, rugged and also supporting standards that have emerged in recent years like CAN FD and Kistler's KiRoad Performance wheels. Additional requirements were to support the automated setup of the measurement based on the export of an existing database and the possibility to use the system on testbeds via EtherCAT.

One DAQ device for all input channels

Having a single simple unit that can handle many analog and digital inputs was the first requirement that our customer had. Cabling and compact sizing of data acquisition systems are important for them when it comes to connecting, mounting, and transferring data acquisition units from one place to another.

The road load data acquisition systems also need to be powered from the car's battery power supply thus having a low power consumption DAQ system is very important. Also having power redundancy with the DAQ system's built-in backup batteries is very important and brings additional measurement security.

Rugged, dustproof, and flexible

Another big issue for the customer was their non-dust-proof units and their connectors. They are testing their vehicles all over the world. The desert testing environment in Nevada, USA is their main concern. Besides the sand that can ruin the unit's amplifiers, Nevada's high temperatures are really problematic for DAQ systems if the cooling is not properly solved.

CAN FD acquisition support

Many older systems nowadays lack CAN FD support, which has become a standard in modern high-performance vehicles. To have all the information from the modern vehicle, the CAN FD data protocol needs to be supported and integrated with the whole DAQ system and used software.

Dewesoft provides a synchronous CAN bus and CAN FD acquisition on their DAQ devices with full software support for visualization and analysis of the acquired CAN bus data.

Kistler KiRoad performance support

The Kistler Group is a market leader for dynamic pressure, force, torque, and acceleration measurement technology, and one of the biggest manufacturers of wheel sensors used exactly for road load data measurement.

To efficiently acquire data from these sensors – and keep them synchronized - support for their systems is indispensable. Not having KiRoad support was a crucial criterion for our customer to exchange the old DAQ system for a new one.

Learn more:
Dewesoft Kistler KiRoad Performance acquisition setup

Customer's specific database support

The customer stores their channel and measurement setups in their specific database. The old DAQ system had automated the creation of the sensor database and setup. This functionality should be continued which means the new data acquisition software needed to support the import format of this external database. Simplifying and automatizing this process would be beneficial for them - they would save a lot of time and avoid manual input adjustment mistakes.

Dewesoft road load data acquisition system

Late in the year 2020, Dewesoft replaced the existing customer's system with the new, optimized system, which was completely synchronized and compatible with the customer's vehicles that used CAN FD and Kistler KiRoad sensors.

The road load data acquisition (RLDA) system delivered to the customer was designed for durability testing methods and road load data analysis of three vehicles. The system included about 200 channels per car, and it was intended to be easily mounted and connected, and be able to work in extreme environments. Therefore, the system needed to be optimized in size and cooling.

Figure 1. A final check of the road load data acquisition system at Dewesoft

The new system delivered by Dewesoft included 8 units of R4rt DAQ devices and 3 units of R2rt DAQ devices. With these, the customer can measure the following parameters on three vehicles:

- Strain gages
- Wheel force transducers (WFT)
- Resistance temperature detectors (RTD)
- Thermocouples (TH)

R4rt units are compact, high-quality data acquisition systems that can handle up to 64 analog inputs, 32 counter inputs, 96 digital channels, and 32 analog outputs and a built-in high-performance, highly reliable data processing computer and SSD data logger.

Such device flexibility enables connecting multiple channels to a single unit. All R4 and R2 devices are completely **dust-proof** and have **optimized cooling** so they can be used in any extreme conditions. Sensors connected on SIRIUS R(x) units are as well connected over **dust-proof LEMO connectors.**

To cover the **CAN-FD** measurement, Dewesoft supplied the customer with 4 additional KRYPTONi-1xCAN-FD devices.

KRYPTON devices are rugged and distributed EtherCAT data acquisition devices for field measurement in extreme and harsh environments. The KRYPTON DAQ systems offer an **IP67 degree of protection** - high shock protection and operation in temperatures ranging from -40 to +85°C.

KRYPTONi-1xCAN-FD has a single CAN FD port and using the EtherCAT data interface several devices can be daisy-chained with a single cable for power, data, and synchronization. This allows the customer to position the CAN FD connection in the car next to the bus to reduce the cable length of CAN FD.

The **full hardware and software support** of **Kistler's KiRoad Performance** system offered by Dewesoft satisfied the customer's needs. All acquired channels can be meaningfully grouped, and all the input channels and amplifiers information can be imported in DewesoftX software from the customer's specific database, which completely automatizes the measurement setup process.

To prepare the system for possible future system integration with a testbed, Dewesoft added a single digital real-time EtherCAT channel output. This addition can feed real-time data to the testbed to a 3rd party control system (like **MTS FlexTest**) and record full-speed data to DewesoftX software in parallel.

Learn more:
Road Load Data Logger and Signal Conditioning for MTS Test Bench

Such a decision can reduce the customer's setup costs vastly as the solution requires only a single cable from Dewesoft's DAQ systems to the test bench controller. It also eliminates the need for a high-level analog input stage on the controller side and eliminates kilometers of cabling.

System configuration

During the outdoor road test and measurement, all of the DAQ hardware is mounted on the back seats of the tested vehicle. For the single vehicle, the **R4rt DAQ system** is used as the **base system** of the whole configuration that has connected a display and a keyboard for the test driver.

The R4 is a compact data acquisition system built around SIRIUS DAQ technology. Systems feature DualCoreADC® analog inputs with 160 dB dynamic range and acquisition speeds of 200 kHz per channel or optional high-speed amplifiers with speeds up to 1 MHz per channel.

As mentioned above SIRIUS R4 chassis can hold up to 4 SIRIUS DAQ slices with up to 64 analog inputs, 32 counter inputs, and 32 analog outputs with a built-in high-performance data processing computer and SSD data logger.

Other hardware devices such as R4rt-HUB, R2rt-HUB, KRYPTONi-8xTH, KRYPTONi-8xRTD, and KRYPTON-1xCAN-FD extensions are added and connected around the base system - see figure 2.

Every single device was properly synced with the whole system, in which the **Kistler KiRoad DAQ unit** was used as a **master clock** for the Dewesoft DAQ system.

DewesoftX software is used to acquire the data from all Dewesoft's data acquisition units and Dewesoft's KiRoad plugin is added to DewesoftX to collect the information from the Kistler sensors and units - see figure 3.

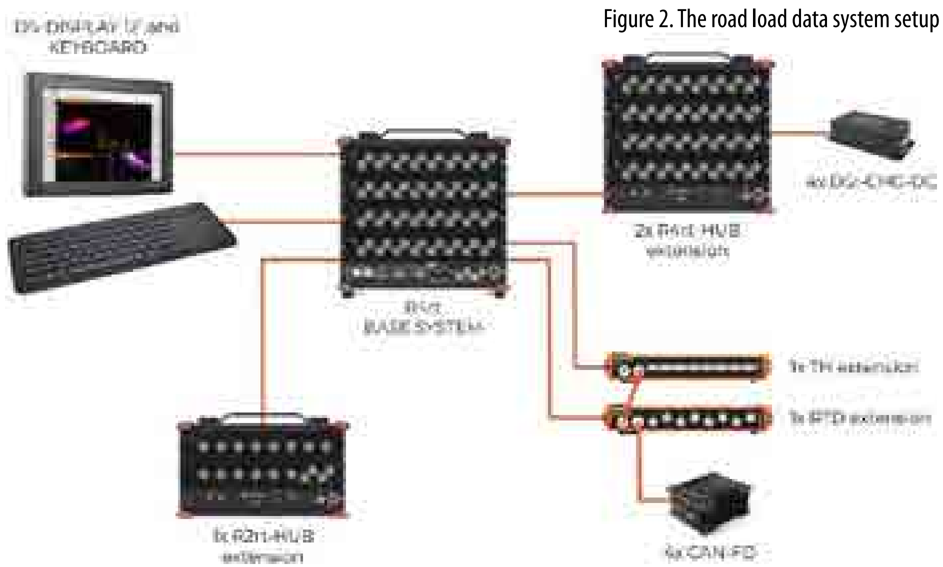


Figure 2. The road load data system setup for a single vehicle

The KiRoad plugin is integrated directly into the DewesoftX and synchronizes all available data from the wheel force transducer system to the Dewesoft analog and GPS data acquisition devices. Channels from these devices will be available in the software as any other channel and can be stored or used directly for further analysis.

Hardware used for a single vehicle

- 1x R4rt Base system
- 2x R4rt-HUB
- 1x R2rt-HUB
- 1x KRYPTONi-8xTH
- 1x KRYPTONi-8xRTD
- 4x KRYPTON-1xCAN-FD
- 4x DSI-CHG-DC
- 1x DS-DISPLAY 12' and a Keyboard
- Kistler KiRoad and wheel force transducers (WFT) - used as a master clock for Dewesoft DAQ

Software

- DewesoftX software
- KiRoad plugin
- CAN
- CAN FD
- XCP / CCP

Third-party and related parts

- Strain gage sensors
- Resistance temperature detectors (RTDs)
- Thermocouples (THs)
- Kistler KiRoad Performance torque wheels

Conclusion

With the new DAQ system, the customer gained CAN FD and native KiRoad support which brings much value to them - regarding the measurement, analysis, and as well on system setup.

Such systems can even be extended to thousands of input channels and are capable of recording analog, digital, counter, video, GPS, and many other data sources, all inside a single box with proper synchronization.

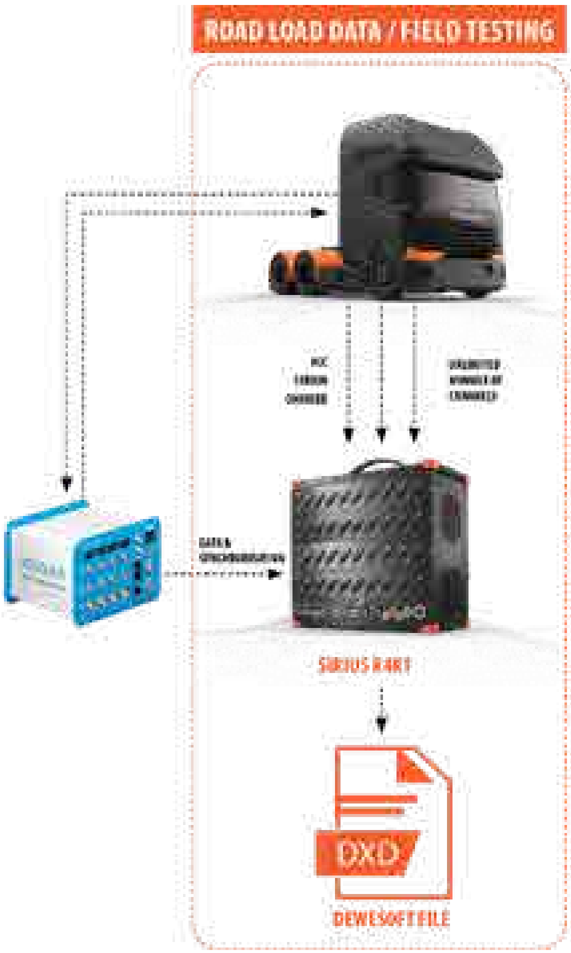
The delivered systems are designed in a rugged and dust-proof fashion with optimized cooling - the customer can use them under any conditions. At the same time, the system is easy to install, configure, and is immediately ready to run when the sensors are mounted. The customer can export their custom channel setup data from their specific database and import it in the DewesoftX software without needing to manually adjust amplifiers or input channels.

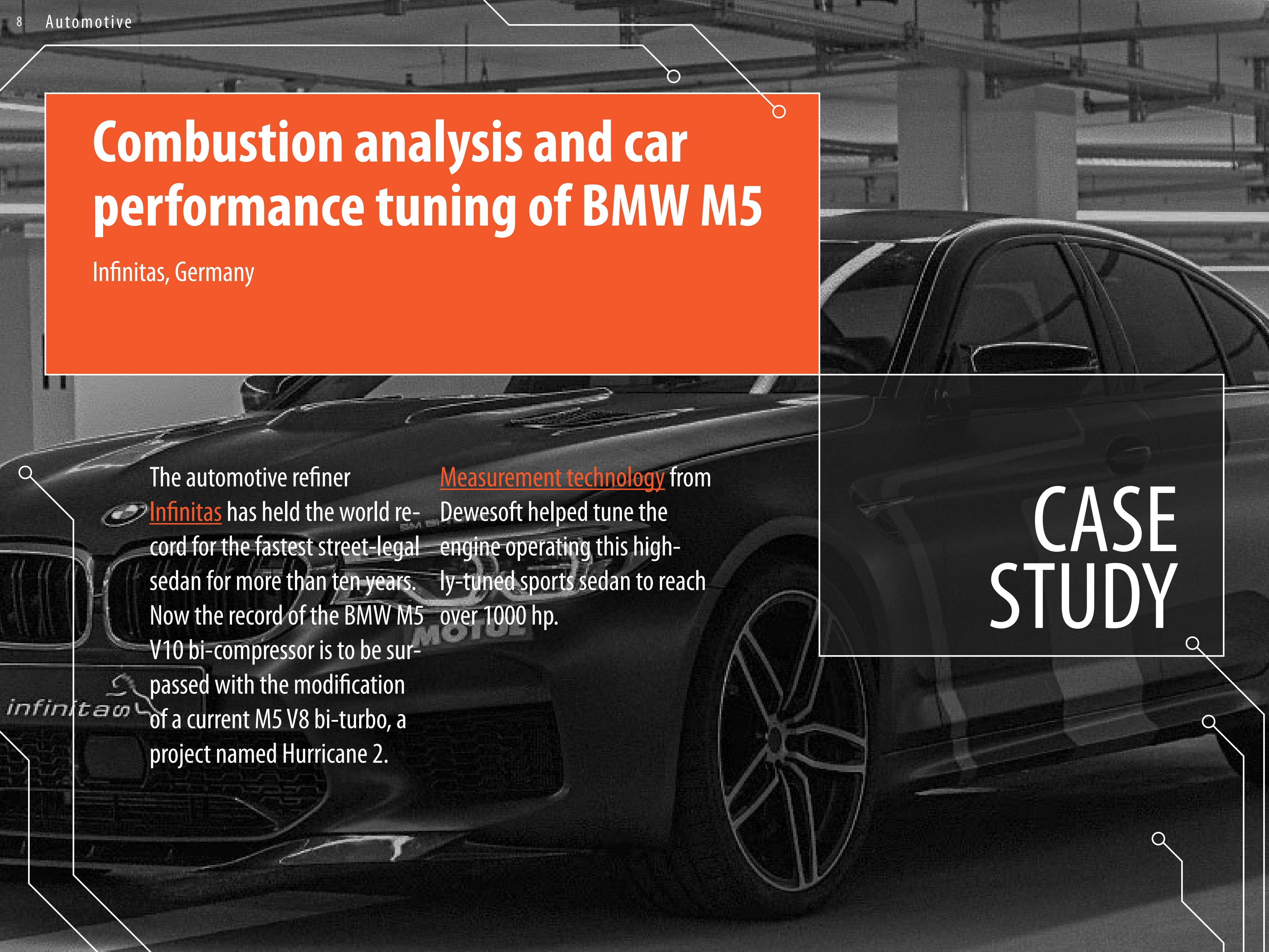
The hardware units are also prepared for testbed integration and real-time control over a single digital EtherCAT channel which the customer may well use in the future.

The same solution is not only suited for automotive vehicles but can be applied in the aerospace and marine industries that need road load data analysis.

Video: Road Load Data analysis - active suspension testing

Figure 3. Road load data measurement with Dewesoft SIRIUS R4RT and Kistler's KiRoad unit with optional RPC III export





Combustion analysis and car performance tuning of BMW M5

Infinitas, Germany

The automotive refiner Infinitas has held the world record for the fastest street-legal sedan for more than ten years. Now the record of the BMW M5 V10 bi-compressor is to be surpassed with the modification of a current M5 V8 bi-turbo, a project named Hurricane 2.

Measurement technology from Dewesoft helped tune the engine operating this highly-tuned sports sedan to reach over 1000 hp.

CASE STUDY

A new world speed record

The family-run German company Infinitas has been perfecting and refining exclusive automobiles for 40 years. Sometimes it's about records on the racetrack, sometimes about optimizing the vehicle for long journeys, or again about setting the engine power to environmentally conscious efficiency. Whether luxury refinement of the extra class, individual technology gadgets, or performance levels beyond the norm – it is individualization without limits.

For the first time, the company from Gachenbach in Bavaria worked together with Dewesoft. The project was sensational - set a new world record with a tuned BMW sedan, which will be named Hurricane 2.

The Hurricane models have set unbeaten records. Driven by a V10 bi-compressor, the Hurricane RR based on a BMW M5 V10 is the fastest sedan driving public streets. In 2010 it set the world record with 372.1 km / h (231 mph) - roughly the same top speed as F1 racing cars.

Watch the YouTube video -> here

Figure 1. The current BMW M5 is modified to a hurricane at GP Infinitas to set new records - measurement technology from Dewesoft helps with development and combustion analysis.

The large superchargers - air compressors or blowers increasing the pressure of the air supplied to the engine - were used to achieve 25-percent more air volume. Furthermore, the car was fitted with a multipart widebody kit, high-performance carbon-ceramic brakes, a fully adjustable suspension kit, and not least oversized 20-inch wheels wrapped with Michelin rubber.

Hurricane RR reached a horsepower output of 800 (588 kW). The car's engine cranked out 800 Nm (590 lb-ft) of torque, allowing it to jump to 100 km/h (62 mph) in 4.35 seconds, and 200 km/h (124 mph) in 9.5 seconds. The car eventually gets to 300 km/h (186 mph) in 25.8 seconds.

Testing with Dewesoft

Dewesoft develops versatile and easy-to-use data acquisition systems for test and measurement engineers. For the M5 tuning project, the company supplied several systems for measuring the drive, adapted to the different conditions and needs, and networked with one another.

The ultra-robust KRYPTON DAQ systems with **protection class IP67** were used for measurements directly in the engine compartment. KRYPTON is an EtherCAT module for **distributed data acquisition** with analog and digital inputs and outputs.

Additional SIRIUS high-speed DAQ modules were in the trunk during the measurements to process and store the test data - see figure 2. The combination of measurement technology with various interfaces and protocols such as **CAN or XCP on Ethernet** as well as the connection of any sensors made it possible to record all relevant data together with the combustion cycle.

For initial testing, Hurricane 2 was on an all-wheel-drive test bench. The individual partial successes were verified and proven again and again in many stages.

"Sometimes these tests are the confirmation of our considerations for adjustments to the setup of the engine," says Infinitas managing director Christian Stöber, explaining the development process, which can take weeks.

"With Dewesoft we now have measurement technology onboard that can relate many different measured values synchronously: combustion analysis, temperatures, air pressures, frequencies - that makes work a lot easier."

Christian Stöber, Infinitas managing director

Figure 5. DewesoftX software offers a simple and very intuitive configuration process

Figure 2. The high-speed DAQ SIRIUS reliably performed excellent services in the trunk of the M5, while robust Krypton modules digitized the engine's sensor signals.

Performance increase of over 1000 horsepowers

Among other things, modern engine tuning includes:

- the adaptation of mechanical components such as the crank
- drive with pistons and connecting rods,
- the fuel supply (fuel injected),
- the two exhaust-gas turbochargers,
- the engine management system, or the exhaust system.

With the additional adaptation of the data status of the two engine control units, Infinitas ultimately achieved more than 1000 hp.

One focus of the development was primarily on combustion engine analysis, for which Dewesoft not only has suitable DAQs but with DewesoftX software also corresponding analysis software.

The overall system is an efficient and highly precise overall solution for engine research and development and is also ideal for optimizing individual components and for testing ignition systems, exhaust systems, and valve controls.
Above all, angle and time-based measurements and highly developed algorithms were used at GP Infinitas.
In addition to the crank angle, measurements included:

- the cylinder pressure,
- various pressures outside the engine such as boost pressure
- and exhaust backpressure,
- various temperatures in the water, oil, air, and
- the speeds of compressors or turbochargers.

"The more data is recorded and intelligently evaluated, the sooner problems and hidden performance potential can be identified," explains Christian Stöber. In concrete terms, this means using the Dewesoft data acquisition system and during the ongoing process on the rolling dynamometer to repeatedly test, introduce changes and validate them - see figures 3 and 4.

From the test bench to the road

The development goal of 1000 hp and more, for which Infinitas has a base of interested customers, represents a significant increase in the current performance of the M5 from BMW. And this performance grade needs to be made safe. Despite the high performance, the vehicle must have a long service life.

The tools from Dewesoft enable the **measurement of a wide variety of parameters.** On the one hand, they compare the simulation and the development goal, but on the other hand, also consider the component load and forecast the service life. A higher engine output means, for example, that the engine has to dissipate more heat, which is why the cooling must be adapted.

Gearboxes and differentials are also only designed for a certain torque. Too much could damage the components, which is why tuning with the accompanying measurement technology always involves a holistic view of the development, Stöber confirms.

The Dewesoft DAQ system is also ideally suited for tests under real conditions and also accompanies the extraordinary vehicle to the final tests on the road. The Infinitas team was particularly enthusiastic about the problem-free installation of the system and the competent support from Dewesoft.

The award-winning DewesoftX software, which offers a simple and very intuitive configuration process, plays a key role in this - see figure 5. “Setting up the measurement technology is usually a challenging task in such development work”, objects Christian Stöber, “but here Dewesoft convinced us. We were pleasantly surprised at how uncomplicated, quick and intuitive the application is.”

Figure 3. Driving at well over 200 km / h in front of a wall - the engine’s measurement data is recorded on a modern all-wheel-drive test bench.

Figure 4. Investigating the status quo safely without the influence of weather and traffic: In the end, the company's world record of 372 km / h for a limousine should be surpassed!

Conclusion

In the end, it is a matter of the finest adjustments before the M5 manages the seemingly impossible. The combustion analysis shows that the work of the engineers at Infinitas' Hurricane manufacturing has paid off. For months, large and small adjusting screws were changed by hand, mechanical changes were made, the software was fine-tuned: It has now been proven that the tuned vehicle delivers what it promises. It is the fastest road-legal sedan in the world that can be driven outside of racetracks, deserts, and dry salt lakes.

Temperature measurement on a racing car

Alpine Elf Matmut Endurance Team

By Loic Siret, CEO, Dewesoft France

Images by: ©DPPI

CASE STUDY

Keep cool! Race cars are state-of-the-art technology and testbeds for automotive technologies. And the temperature is crucial to ensure optimum performance and safety. It's an issue of keeping temperatures down and of monitoring cockpit, tires, motor, electronics, etc. – when racing all systems on the car are being pushed towards their maximum temperatures.

Alpine Elf Matmut Endurance Team taking part in the World Endurance Championship (WEC FIA) needed a solution to monitor cockpit temperatures and locate sources of excessive heat – Dewesoft delivered.

Racing cars are packed with equipment for dedicated in-race measurements. Battling the heat and keeping the drivetrain and other systems of the car cool is a major task for the team, both at the design stage and when at the track. When the engine gets too hot it loses power, heat will expand or weaken e.g., gearbox materials, the oil will lose its lubrication effect, and electronics may fail.

For example, in the wheel assembly, which includes the braking system, the brake discs and pads can reach temperatures of up to 900 deg C while the calipers have a maximum operating temperature of around 260 deg C.

Racing tires have a very narrow tire temperature operating window. In most cases, they are limited to a mere 30°C range for peak performance in terms of grip levels. Too hot or too cold affects driving capability and safety. Even a few degrees variation in the environmental temperature has an influence.

All in all, thermal management is a key to reliability, performance, and safety. To monitor the temperature of the race car components all racing teams and all car manufacturers need to apply multi-physics sensors and data acquisition capable of merging different measures at the maximum precision and speed.

This year, the Alpine Elf Matmut Endurance Team will debut in the Hypercar category with the n°36 Alpine A480. Since its return to endurance racing, Alpine has won two European titles, two world crowns, and three LMP2 victories at Le Mans. Alpine continues this commitment at the pinnacle of motor racing in 2021 in taking on the challenge of the FIA WEC Hypercar category in parallel with its Formula 1 debut.

Figure 1. The Alpine Elf Matmut Endurance Team with the n°36 Alpine A480.

Heat - the challenge

The Alpine team wanted to control the temperature inside the car cockpit to avoid excessive heat. Inside the car, the driver often experiences some problems with high temperatures. The trick is to know what the problem is, and how big it is. Locating the source and performing the temperature readings inside the cockpit. But how to measure and monitor?

And FYI - even the driver is affected. The air temperature inside a Formula 1 cockpit averages 50 deg C (122 deg F). During races that last two and a half hours, drivers can drop 2.5 to 3 kilos just through sweating.

So, the major problem is to have under control the temperature inside the cockpit for the sake of the driver and the built-in electronic devices that can send error or bad information that can force a stop or even break the car engine during a race - see cockpit in figure 2.

Installing a thermocouple or a Pt100 platinum resistance temperature detector (RTD) inside the car is not easy – the space is very tight and accesses are tricky. Furthermore, you need to know exactly where to put the sensor – to know the problem - as such sensors are dedicated to just one point of measurement.

The race car cockpit has very limited space. It doesn't allow you to implement any big devices. You may have similar problems fitting sensors to locations in or on a race car elsewhere; tires, wheels, motors, deflectors, etc.

Figure 3. Using Dewesoft and an Optris infrared camera to measure temperatures inside the cockpit.

Measurements

The most common and popular sensors for temperature measurement today include thermocouples, RTDs, and thermistors, and Dewesoft temperature data loggers support all of them. But, in addition to the standard temperature sensors Dewesoft also supports temperature measurement using infrared thermal cameras from OPTRIS – even combined and synchronized with analog temperature sensors. In this case, the thermal video camera was the only applicable solution.

The Alpine Team used the combination of a thermal camera from Optris and Dewesoft - see figure 3. This enabled the engineers to:

- Measure average, max. and min. value.
- See from where the high temperature is coming
- Modify the airflow to dissipate heat

In DewesoftX data acquisition software video from OPTRIS cameras is synchronized with analog and other data sources down to ~10 ms accuracy.

Dewesoft temperature data loggers and temperature recorders allow accurate temperature logging from any temperature sensor type like thermocouples, RTDs, and thermistors. Temperature loggers are modular by design and can expand from 1 to 1000's of temperature measurement po

Figure 2. A view in the cockpit- space is tight and packed with electronics.

Conclusion

The solution enabled the Alpine development engineers to monitor if the temperature was stable or not. They could locate hotspots, identify the exact component or device causing the heat, and observe the effects of alterations, e.g., dissipation of the airflow.

The Dewesoft solution even offers additional benefits as it can combine infrared thermal cameras with other inputs; standard video, GPS for positioning, speed, CAN information, and more. The equipment and the software can be used to measure and analyze any external or internal component of the car.

Apline racing -> YouTube Video

Airbag ECU bracket inertance measurement

Shanghai Automotive Industrial Corp. (SAIC Motor), China
By Patrick Fu, Application Manager, Dewesoft China

CASE STUDY

Automobile airbags are of lifesaving importance. Such airbags are triggered by an impact sensor, that is intended for detecting the acceleration signal in case of impact. The impact sensor monitors and controls the explosion of the airbag executed by an electronic control unit (ECU) cell.

To function correctly the car bodywork at the mounting position must have sufficient stiffness - the frequency response must be restrained within a critical range. At SAIC Motor the acceleration and frequency response (inertance) are measured and analyzed online using DewesoftX software and DAQ devices.

Introduction

Such inertance measurements are made in order to avert malfunctional explosion and avoid unnecessary hazards and costs. The results are commonly verified complying with criteria set by Continental AG, as the CAE simulation-based methodology cannot replace the real condition testing. When the internal reason of resonance is determined, it may guide further modification of the structures to improve stiffness of bodywork and chassis.

Safety is the priority of modern automotive development, where the airbags play a key role to protect drivers. The controller of airbags, ECU functions rapidly to trigger the airbag for passenger protection as soon as it detects severe collision that exceeds the restraining capability of the safety belt.

Instead, the airbags also hurt passengers severely in case it explodes under minor accidental collision. As a result, the car manufacturer must ensure that the ECU mounting bracket and vehicle bodywork can be working with enough stiffness to resist a certain level of impact.

The success story comes from Shanghai Automotive Industrial Corp. (SAIC Motor), which is the largest auto manufacturer in China's market. SAIC Motor's business covers the research, production, and sales of both passenger and commercial vehicles and is also engaged in the R & D, production, and sales of auto parts. SAIC Motor's affiliated OEMs include SAIC Passenger Vehicle Branch, SAIC Maxus, SAIC Volkswagen, SAIC General Motors, SAIC-IVECO, etc.

In this case, we are working with the Safety Engineering & Virtual Technology Dept. (SMTC) of SAIC, who is responsible for resonance test (inertance) complying with Continental Resonance Test Method and Judge principle. With our award-winning Dewesoft solution the customers can implement resonance tests by themselves.

Dewesoft core philosophy is one software for all applications! DewesoftX data acquisition software is the result of this philosophy. We have been implementing countless features for Automotive, Power analysis, NVH, Aerospace, Industrial, Civil engineering applications, as well as features for general test and measurement. Data recording, analysis, reporting, and everything in between are covered within a single software solution.

Dewesoft features in this case an intuitive turn-key FFT analyzer for NVH tasks based on its versatile SIRIUS® USB data acquisition system. It may greatly save money and time for SAIC with no help from Continental engineers.

Issue and application

The function of an airbag impact sensor is to detect the acceleration signal in impact, which can be used for judging and controlling the explosion of the airbag by SDM. As to avert the airbag error explosion and avoid unnecessary loss, the sensor fixing point inertance must be restrained in the required range.

Industries / Applications
The resonance test is defined as Inertance. The inertance provides a value that stands for the local stiffness at the ECU/G-SAT mounting position, which is important for the acceleration signal quality.

The inertance can always be understood as the ratio of the signal output to input (amplification or damping factor). The calculation of inertance is:

$$Inertance = \frac{\sqrt{Ax^2 + Ay^2 + Az^2}}{F}$$

Where Ax, Ay, Az represents the acceleration of x, y, z-direction, and F is the hammer force. The unit of inertance is g/N.

The resonance test and judge principle were initially released by Continental AG. In general, the inertance falling into the yellow and green zone is acceptable - see Figure 1.

With the development of the Continental algorithm, the following condition is also acceptable:

- If inertance falls into the red zone above 600Hz, the result can be acceptable
- If inertance falls into the red zone between 400 and 600Hz, and inertance<=2, the result is also acceptable. But if conditions allow, modification is needed.

Accordingly, the simulation resonance test (CAE) is always a more cost-effective way to validate preliminarily and CAE is also needed before the experimental test.

The input signal is 0-2000Hz sine wave amplitude of 2g for the whole band, and the band step is 10Hz. The output is injecting sine waves for ECU in the single direction, and collecting the signal output of X, Y, and Z direction. The non-injection direction signal's strength should be less than 20% of the injected signal. And the required direction signal's strength should be similar to the injected signal (80%-120%).

For example, inject 2g signal in the Z direction for ECU, and the signal's strength for X and Y direction should be less than 0.4g (2g*20%). But the signal's strength for the Z direction should be 1.6-2.4g.

To be sure, the CAE result cannot replace the real condition resonance test. It is just for reference, sometimes the result may be different from the resonance test. Because the CAE model is ideal, the real condition may be worse or more difficult than it. Commonly, before the CAE result is acceptable, but the resonance test is not acceptable, or the CAE result is not acceptable, but the resonance test is acceptable.

The resonance test is supposed to comply with the Continental method while Continental provides test certification service. Now it's also allowed by Continental that some customers have their own resonance equipment, and it is recommended to do this resonance test by customer-self.

Because it will save lots of time and money for both. But some requirements should be met and the resonance test result should be sent to Continental for analysis. The whole test process refers to the law and regulation including:

- Continental Resonance Test Method and Judge principle – Continental AG
- GB/T 37474-2019 Methods and requirements of airbag system abuse test for automobile
- GB/T 19949.1 -2005 Hybrid electric vehicles – Power performance – Test method

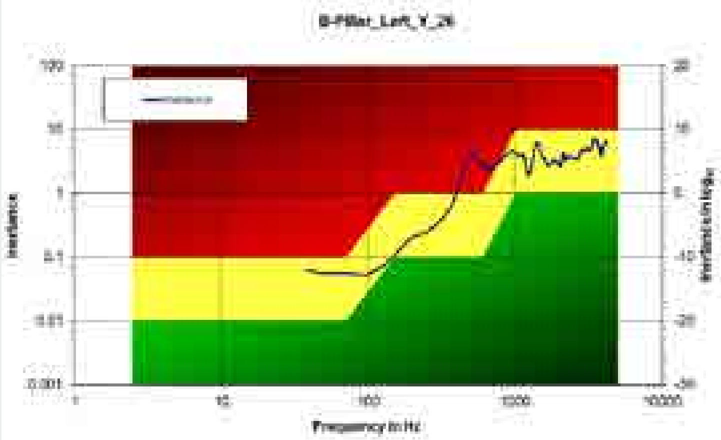


Figure 1. Resonance test and judge principle (Copyright © 2016 Continental AG).

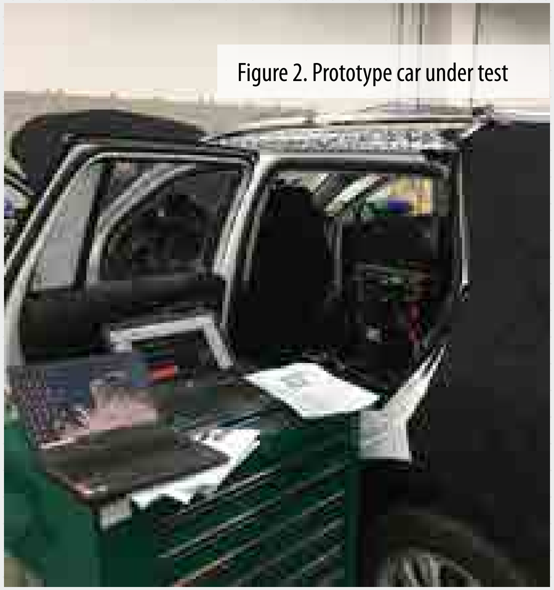


Figure 2. Prototype car under test


Figure 4. SDM fix point to be tested.


Figure 5. The bottom of the B-pillar of the vehicle.

The Dewesoft measurement solution

Measurement setup
The resonance test has been regularly carried out at SAIC's workshop in no need of a road test on proving ground. The vehicle under test is a SAIC ROEWE RX5 SUV prototype - see Figure 2.

The measurement system includes an impulse hammer, acceleration sensors, a data acquisition unit, and a power supply - see Figure 3. All reference sensors should fulfill the following specification:

- No sensor resonances in the measured frequency band (0-5000Hz)
- Sensor mass less than 10g
- Sensor dimension less than 1cm × 1cm
- The sensor has been calibrated before the tests

The DAQ hardware requirements are:

- Dewesoft SIRIUS DAQ system model SIRIUSi-8xACC
- Dytran 5800B5
- The Dytranpulse™ Impulse Hammer is a general-purpose IEPE impulse hammer used to excite structures or machinery with a definable impulse force. The impulse is used to identify resonances, an important measurement parameter for the study.
- Dytran 3333A3 accelerometer
- A miniature IEPE triaxial accelerometer with low-end frequency response, for excellent phase response at low frequencies.

The data acquisition software required:

- DewesoftX DAQ software

Inertance measurements

The end-user SAIC makes a slight improvement on Continental's setup mounting a triaxial accelerometer instead of 3 single sensors to test X, Y, Z direction acceleration signal on the position of SDM (Supplemental Restraint System Diagnostic Module) and the bottom of the B-pillar of the vehicle - see Figures 4 and 5.

The sensor cube can be directly glued to the screw head or nearby floor. And it's preferred to use a specially designed gauge to guarantee the angle of the cube. The gauge will be removed prior to the test's start.

Workflow

The typical sample rate is 20kHz with an anti-aliasing filter of 4kHz.

For each position, at least 3 times hammer hit about 50N to 100N is needed. Ensure hit duration as short as possible and without double click.

The complete sensor data, including 10ms of pre-trigger, should be recorded at least. It's recommended to record a 500ms signal at a 20kHz sample rate.

The inertance measurement is very sensitive to electrical noise, for example, 50Hz from the power supply. It is recommended to record each 250ms pre and post the event to confirm whether there is electronic noise. A Hammer hit (approx. 20N) can be used as a trigger.

Data recording and format requirements

After each test, it is necessary to document the test position, test direction, the test setup, and all the relevant information to analyze or repeat the workflow. After each test, it is highly recommended to record the test description, test number, date, vehicle (VIN number), and test location.

All the test data should be checked directly after the test. The measured data should be 60-95% of the setting range. For all sensors, there should be no obvious noise signal before hammer force.

Following the up-to-date specification, it is also allowed to record 80ms data with a 50% pre-trigger. That can be easily implemented with the turn-key DewesoftX data acquisition software. We just set the threshold to 50N at the rising edge during the test and start acquisition at a sample rate of 25.6kHz, storing fast on the trigger.

Online calculations are needed to enable the SAIC engineer to be aware of the result the first time on site. The frequency domain reference curve is such a sharp tool to get it done. The user has plotted the reference curve as a predefined mask - see Figures 6 and 7.

The algorithm by Continental is to get all spectra of the 3 directions acceleration and force individually, then inertance in the frequency domain is directly calculated - see Figures 8 to 11. To maintain consistency, the users simply copy the algorithm having the spectra by Math Library in Dewesoft X3.

The spectra are operated by FFT Math with a frequency resolution of 12.5Hz. DewesoftX Formula Math is intuitive for users to edit formulas as to how inertance defines - see Figure 12.

Test results

The measurement analysis can be visualized where the inertance spectrum is plotted on DewesoftX Visual Controller - 2D graph. For clear contrast, a predefined tolerance zone (reference curves) is overlapped on the graph as well - and the result is revealed - see Figure 13.

For comparison and validation every test done by the user - the raw data (acceleration, force) - have also been sent to Continental for analysis. The authority's evaluation results were consistent with ours – see Figure 14. In this case, the test point (B-Pillar) as shown is good and will be deemed as qualified by Continental company.

Generally, the ECU mounting bracket and the bottom of B-Pillar are the two mandatory test points instructed by Continental where each point has an average of at least 3 hits. The engineer

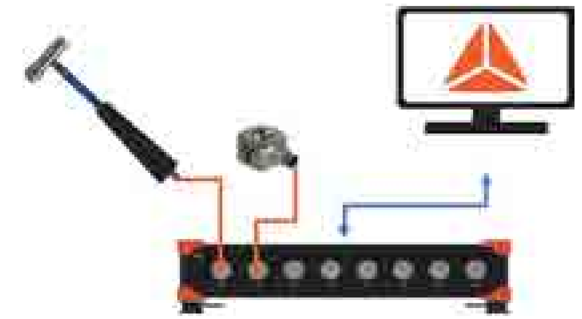


Figure 3. Basic setup diagram for resonance test

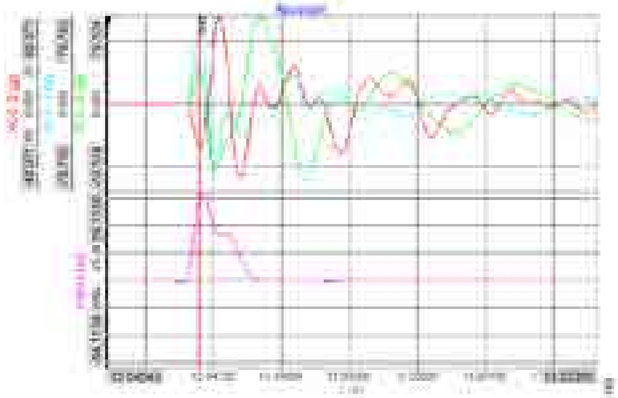


Figure 6. Raw force and acceleration data captured upon trigger

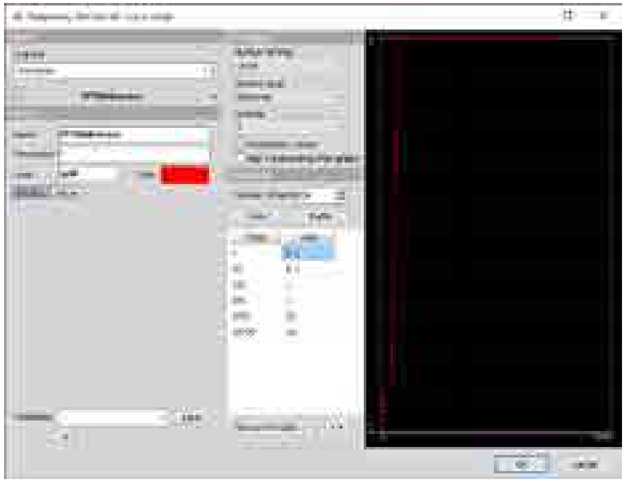


Figure 7. Limit originated from Continental judge principle

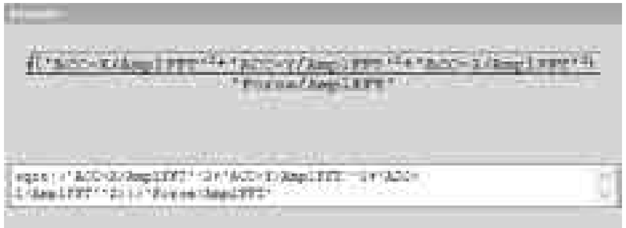


Figure 12. Formula edited by Dewesoft Math.

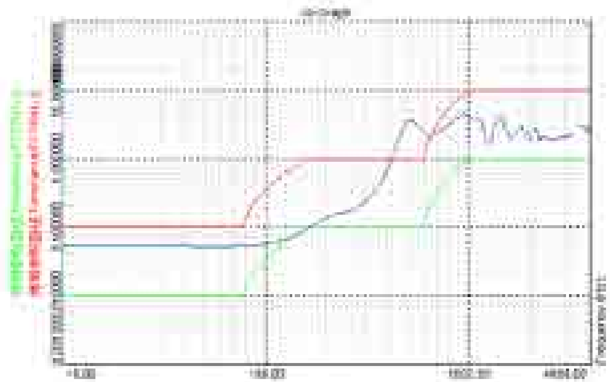


Figure 13. Tolerance zone formed by a reference curve

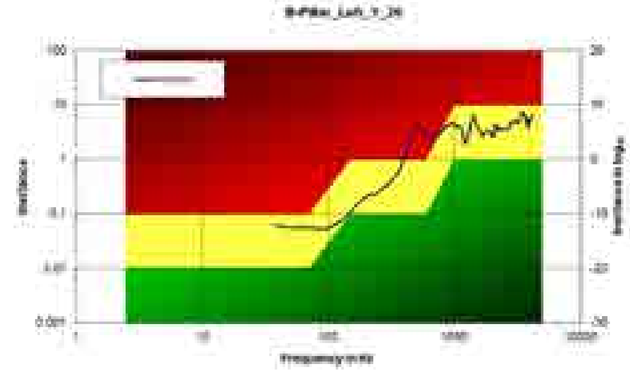


Figure 14. Inertance measured on B-Pillar checked by Continental

would also suggest that a hammer force applied of 20N to 60N could be enough based on a multiple test summary.

Conclusion

Continental reports accordingly that the experiment done and facility used by SAIC customers are approved. Therefore, Dewesoft will be listed as a standard unit for the test while Continental engineers will no longer travel to SAIC on-site afterward.

Alternatively, the raw data and analysis are required to be submitted to Continental authority for validation.

The solution can be widely popularized to car manufacturers since many of them have such requirements. For the resonance test, the SIRIUSm-4×ACC is a basic solution, more economic in case the customer's budget is limited.

SAIC is very pleased to accept Dewesoft quickly since they are not going to spend large amounts of money to ask Continental engineers to come. It frees up a huge budget of the Safety Engineering & Virtual Technology Dept. every year.

Besides, as a versatile data acquisition system, Dewesoft is going to be applied to sound measurement for SAIC as well as saving additional investment. The Dewesoft as a professional FFT spectrum analyzer has it all that includes top performance, advanced cursor functions, high freely selectable line resolution, flexible averaging, and advanced functions for in-depth frequency analysis.

Dewesoft is recognized as a very cost-effective solution for a wide range of automotive NVH tests. It is certainly such a sharp tool and is supposed to be widely accepted by plenty of automotive engineers.

Documentation and external resources

- Dewesoft SIRIUS® Technical Reference Manual
- DewesoftX User Manual
- Continental Resonance Test Method and Judge principle – Continental AG
- GB/T 37474-2019: Methods and requirements of airbag system abuse test for automobile
- Zhang Li, Li Cuixia, Lei Yingfeng: Analysis and optimization of frequency response for airbag impact sensor fixing point.
- Bian Xintao: Automobile safety airbag ECU resonance analysis.

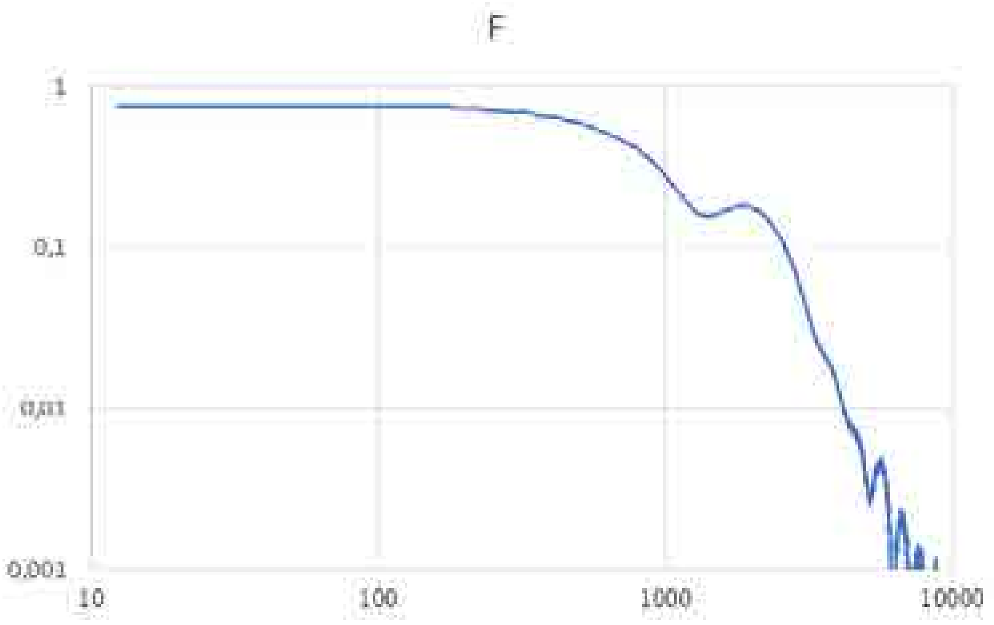


Figure 8. Force spectrum check.

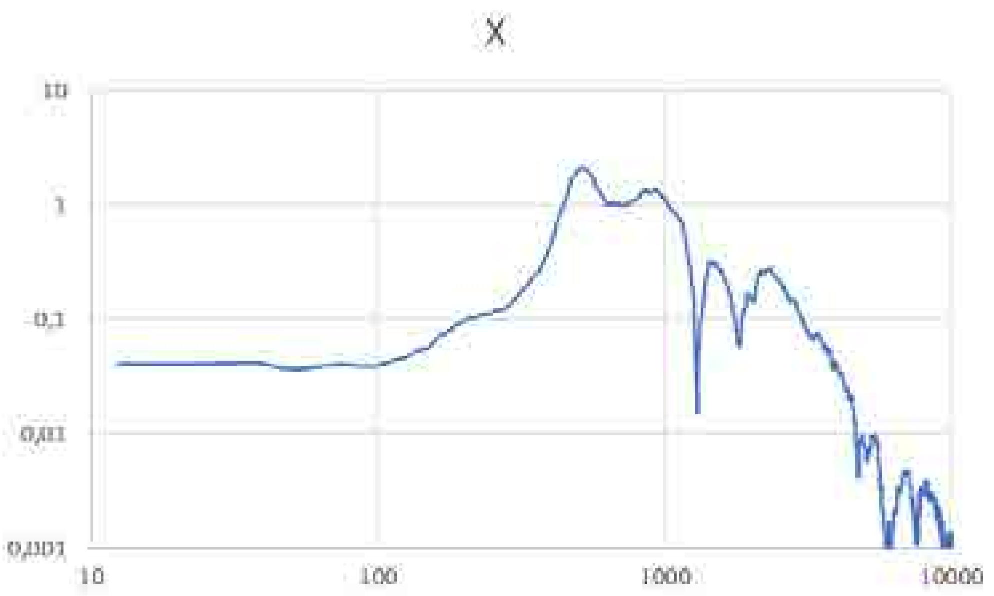


Figure 9. X-directional acceleration spectrum.

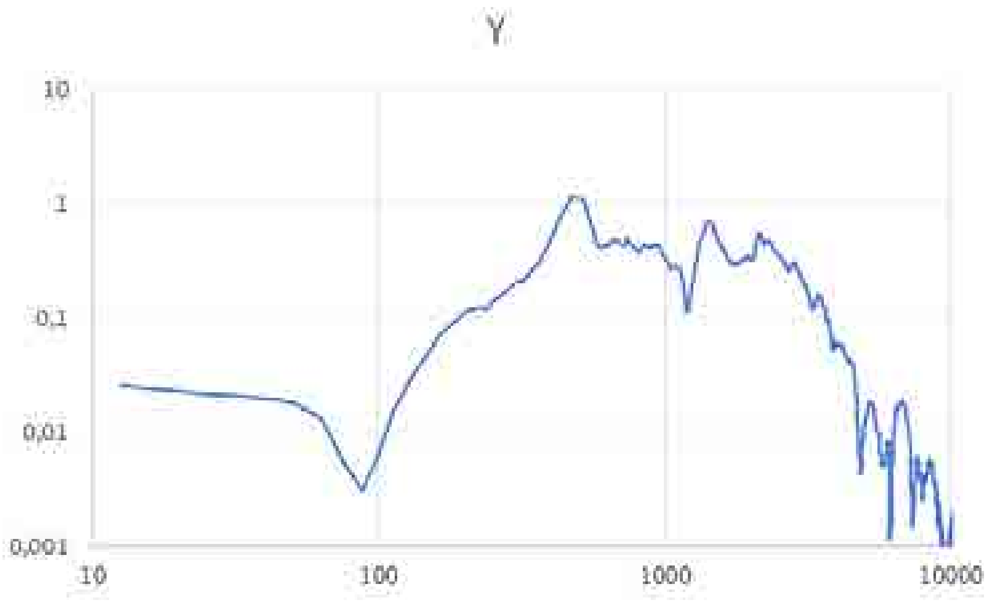


Figure 10. Y-directional acceleration spectrum.

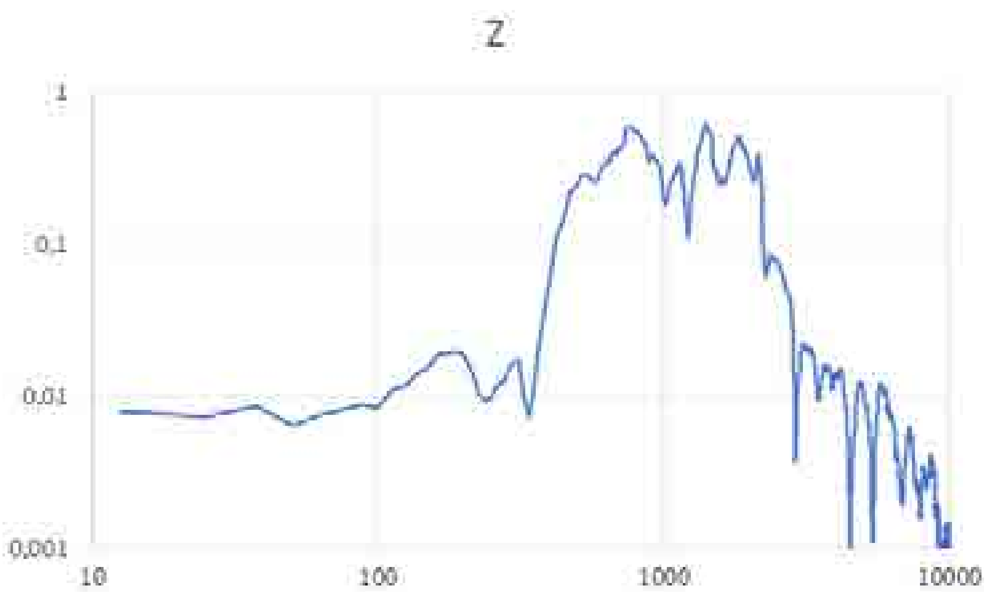


Figure 11. Z-directional acceleration spectrum.

Car seat crash test with a catapult

Dynamics Test Centre CED, Normandy, France

By Nicolas Phan, Sales Engineer, Dewesoft France

CASE STUDY

The Dynamics Test Centre (Centre d'Essais Dynamiques - CED) is a public test laboratory open to any industrial or research organization. Among others, CED provides the test facilities for seat crash testing, including a powerful reverse pneumatic catapult. This is used by manufacturers in the automotive or aerospace industry to evaluate seat behavior during an impact - to guarantee occupant safety in case of an emergency such as a crash.

The engineers wanted to view the test signals in real-time during the test. Now they use software and rugged data acquisition systems from Dewesoft for seat mechanism testing and crash test dummies calibration.

A seat crash test is almost like a rocket launch. A seat and a dummy are placed on the catapult test bench which is then to be released and accelerated - or decelerated - at specific speeds to simulate a frontal collision. Focused and organized technicians meticulously check the test specimen and set up - the test bench, the seat, the test dummy, each mount, cable, and sensor.

When everything is ready, everybody evacuates the test room. Behind a huge armored glass window in the test control room, they wait. Then, the chief operator sounds a loud nerve-racking alarm. People now know that the test is imminent. And BAAANG !!! - you hear the air spring release and feel ground vibration - even in the isolated control room. The dummy takes the hit.

Days or weeks of preparation - and it all happens within less than a second! It is a one-shot measurement. And the seat with the dummy? Have you ever been on a roller coaster or experienced other sensational rides?

Now, imagine this banging into a wall. The test bench of CED is the most powerful in Europe. It is capable of projecting a 4 tons specimen at 90 kph along 1 to 2m which corresponds to the distance covered by a crash (vehicle deformation).

Seat crash testing

For cars, crash testing – or dynamic testing – is a mandatory regulated safety test to homologate vehicles. Automotive seats allow occupants to drive relaxed and safe. Nowadays, the seat can combine many mechatronic functions such as adjusting automation with an electric motor, heating, and even an active sound system or smart driver recognition system.

Figure 1. Vehicle seating is constructed with numerous components. (Photo: Faurecia)

A seat combines hundreds of mechanical components. The most basic ones regarding safety are the anchorage mechanism - the inner track, the locking mechanism, and the bolts - and the seatback, not forgetting essential safety parts such as airbags and belts. Modern seat kinematics is complex. The seat mechanism components must be able to effortlessly recline, lift, adjust and swivel the seat, and then return it smoothly back to the driving position - see figure 1.

To implement a numerical model of resistance to vibrations and shocks, the CED R&D simulation department needs real road load data and accurate extreme mechanical stress in a real crash test situation. The science of materials and the study of surfaces - and contacts between them - are also applied to understand mechanical behavior and potential after-sales issues.

Figure 2. Six-axis vibration table with the climatic chamber.

The dynamics test center - CED

The Dynamics Test Centre CED belongs to the Industrial Campus of Research and Innovation Applied to Materials (CIRIAM) – recently renamed Normand'Innov, and is supported by the regional council of Normandy in France. Based in the city of Caligny, CED includes test facilities such as huge six-axis vibration tables, and installations for climate durability, squeak & rattle testing, as well as the reverse pneumatic catapult.

The test center is equipped with several six-axis vibration tables for durability testing with a wide range of vibrations and loads. E.g., multi-axial simulation such as road, aviation, and seismic. See figure 2 for more details.

Those vibration tests can be combined with a removable climatic chamber for hot, cold, or humidity. Another option is a semi-anechoic chamber for squeak & rattle noise measurement, electric car development, acoustic comfort, and more. With the reverse pneumatic catapult, CED works for companies in the automotive and aerospace industry, like Airbus, Safran, Zodiac Aerospace.

The 61 hectares site in Caligny also comprises the FAURECIA seating mechanism production and a branch of ENSICAEN University. This worldwide R&D center for the design of seat mechanisms excels in internships and training in mechanical engineering and materials science.

Faurecia S.E. is a French global automotive supplier headquartered in Nanterre, in the western suburbs of Paris. It's in the world top-10 of the largest international automotive parts manufacturers and at the absolute top for vehicle interiors and emission control technology. One in three cars worldwide is equipped somehow by Faurecia.

Reverse catapult testing

The powerful pneumatic reverse catapult at the CED test center is used for impact testing and real-time dynamics testing of automotive structures and equipment like dashboards, seats, or child seat restraints. The bench consists of a trolley that is projected by a hydro-pneumatic air spring to reproduce impact/shock situations on mechanical structures and equipment. It enables crash testing with 3.1 Mega Newtons, 90kph, 122 g, and a 3000 kg usable payload - see figures 3 and 4..

The device on which dynamic tests of seats and head restraints are conducted is a steel flatbed sled that runs on fixed rails. The sled is moved to simulate vehicle crash accelerations, re-creating the forces on occupants inside vehicles during real-world crashes. The changing acceleration or deceleration over the time duration of a crash is referred to as a crash pulse, and the key aspect of a sled is that it can be programmed to produce specific crash pulses.

To evaluate rear crash protection, vehicle seats are affixed to the sled. The sled is accelerated to simulate a stationary vehicle that's rear-ended by another vehicle of the same weight going 32 kph (20 mph). To accomplish this, compressed air is pumped into a special cylinder, thrusting a ram forward in a preprogrammed pattern of acceleration (crash pulse).

The catapult guarantees the repeatability of multiple deceleration pulses complying with the constructor's specifications and meeting authority regulations and safety standards - see table 1. The engineers of CED use a dedicated acquisition

Name	Organisation	Description
ECE17	UN/ECE	Regulation No 17 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of vehicles with regard to the seats, their anchorages and any head restraints.
ECE94	UN/ECE	Regulation No 94 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of vehicles with regard to the protection of the occupants in the event of a frontal collision.
ECER44	UN/ECE	Regulation No 44 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of restraining devices for child occupants of power driven vehicles ('child restraint systems')
Whiplash	Euro NCAP	Euro NCAP's whiplash tests are designed to promote best-practice seat and head restraint design i.e. those designs which are known from accident data to provide the most effective protection in the real world.
Euro NCAP	Euro NCAP	The European New Car Assessment Programme is a European voluntary car safety performance assessment programme. The safety rating is determined from a series of vehicle tests, designed and carried out by Euro NCAP.
US NCAP	National Highway Traffic Safety Administration (NHTSA)	A provision of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requires new passenger vehicles to be labeled with safety rating information published by the National Highway Traffic Safety Administration under its New Car Assessment Program (NCAP).
FMVSS (202, 207, 208, 225)	Federal Motor Vehicle Safety Standards	Federal Motor Vehicle Safety Standards (FMVSS) are U.S. federal regulations specifying design, construction, performance, and durability requirements for motor vehicles and regulated Automobile safety-related components, systems, and design features.
AS8049	SAE Aerospace Standard (AS)	Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft.

Table 1. International vehicle safety regulations and standards.

system and software on the catapult from KT Automotive GmbH, an offspring from Kayzer-Threde Gmbh, now part of the Kistler Group. However, with the standard crash test system, they were unable to view the test signals before, during, or immediately after the test. The test worked like a black box

Figure 3. Reverse pneumatic catapult for crash testing.

recording the data in standalone. To view the data and do their calculations the engineers had to go in post-analysis mode and export the data.

To develop the test bench and especially acquire the capability for strain gauge measurements requested by their clients, the engineers of CED were searching for DAQ system supplying:

- 6 channels strain gauge conditioner (full, semi, quarter bridge).
- Compact & robust system to be embedded in the catapult trolley.
- Shockproof from 25 to 60G (with a rate of around 50 tests/year).
- Maximum sample rate 20kHz per channel.
- Digital input to synchronize start acquisition with the catapult system.

Possibility to visualize measurements in real-time or to have test results status immediately at the end of the test. This was not possible with the existing system that works like a black box and needs long post-treatment analysis.

The number of channels used depends on what needs to be analyzed - the structural mechanism of the seat, human behavior on the seat, or both.

Figure 4. Preparing a reverse pneumatic catapult test - the dummy is on the sled.

The solution

The CED engineers chose the hardware solution proposed by Dewesoft - see figure 6:

- **KRYPTON 6xSTG:** 6-channel universal strain gauges data acquisition system.
- **KRYPTON ONE 4xDI:** 4-channel digital input module.
- **ECAT Power Junction:** for injecting power supply.
- Specific 50m flexible EtherCAT cable KAWEFLEX® dedicated for rolling trolley and repetitive mechanical movement.
- Sample rate 20kHz per channel.

The Krypton One 4xDI receives a digital signal from the catapult trolley that triggers the measurement to synchronize the two data acquisition systems. As DewesoftX can start measurement on many conditions and with pre-trigger time, no data is lost and the results can be exported in multiple formats to be compared to any third-party data acquisition system.

Dewesoft hardware comes with the powerful data recording and analysis software - DewesoftX. A large choice of mathematical functions is available: custom formula editor, Integration and double integration, derivation, filtering functions, statistics, reference curves, etc.

As it is easy to use, the engineers of CED can quickly create custom multi-physics displays with real-time calculations - see figures 9 and 10.

The crash test dummies

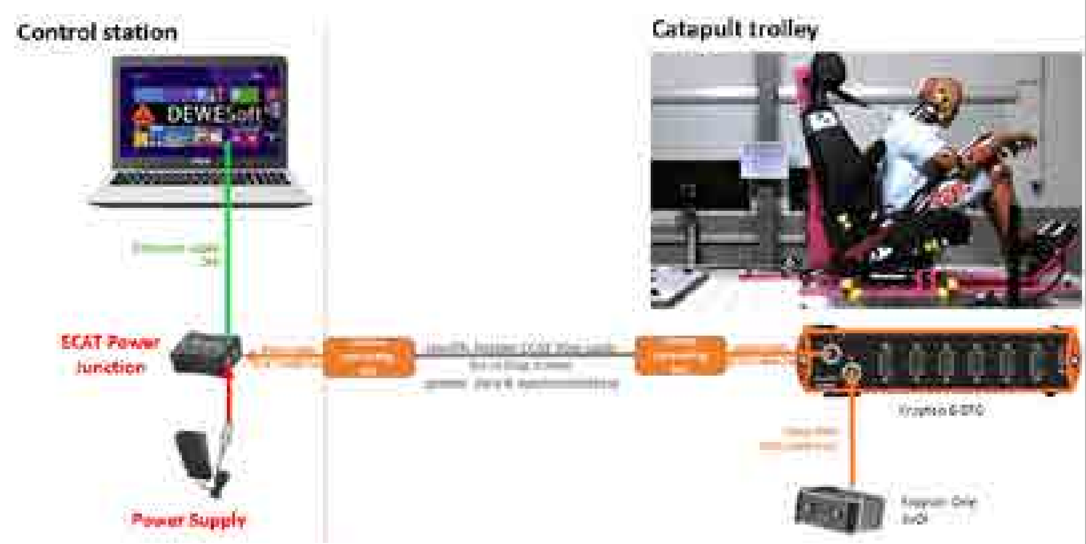
Crash testing involves a crash test dummy. Crash test dummies are designed to simulate the human response to impacts, accelerations, deflections, forces, and moments of inertia generated during a crash. They enable the study and development of crash-worthy structures and restraint systems.

Equipped with multiple built-in or mounted sensors they pick up and record a range of values during the test. The values that are recorded, along with other measurements made during the crash test, allow evaluating whether the test meets standards.

All details – the dummy's clothing, the tension of the harness, the position of the chest clip, the tightness of the vehicle belt – are regulated by standards allowing for tests to be repeated and compared when done at different laboratory facilities.

The instrumented dummies at CED are made by the American manufacturer HUMANETICS, a global leader in the design, manufacture, and supply of crash test dummies faithfully modeling human beings. The company even supplies calibration equipment, crash sensors instrumentation, software modeling, and active safety testing equipment. And such dummies are not cheap toys. The price of one dummy is similar to that of a very nice family car.

Figure 6. Krypton system architecture on the catapult.



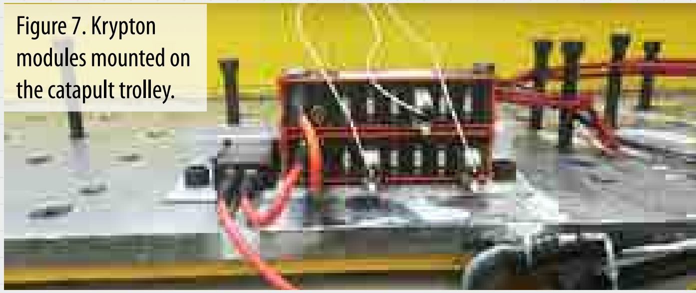


Figure 7. Krypton modules mounted on the catapult trolley.

Figure 8. Custom flexible 50m EtherCAT KAWEFLEX® for Krypton power supply, data, and synchronization.

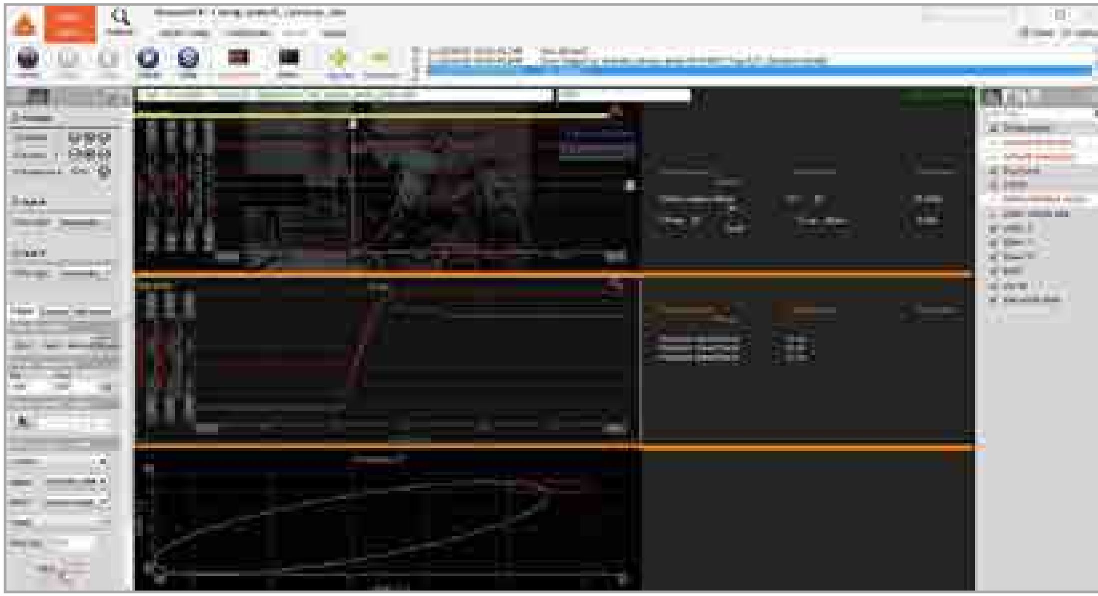


Figure 9. Example of a customized software interface for real-time math calculation.

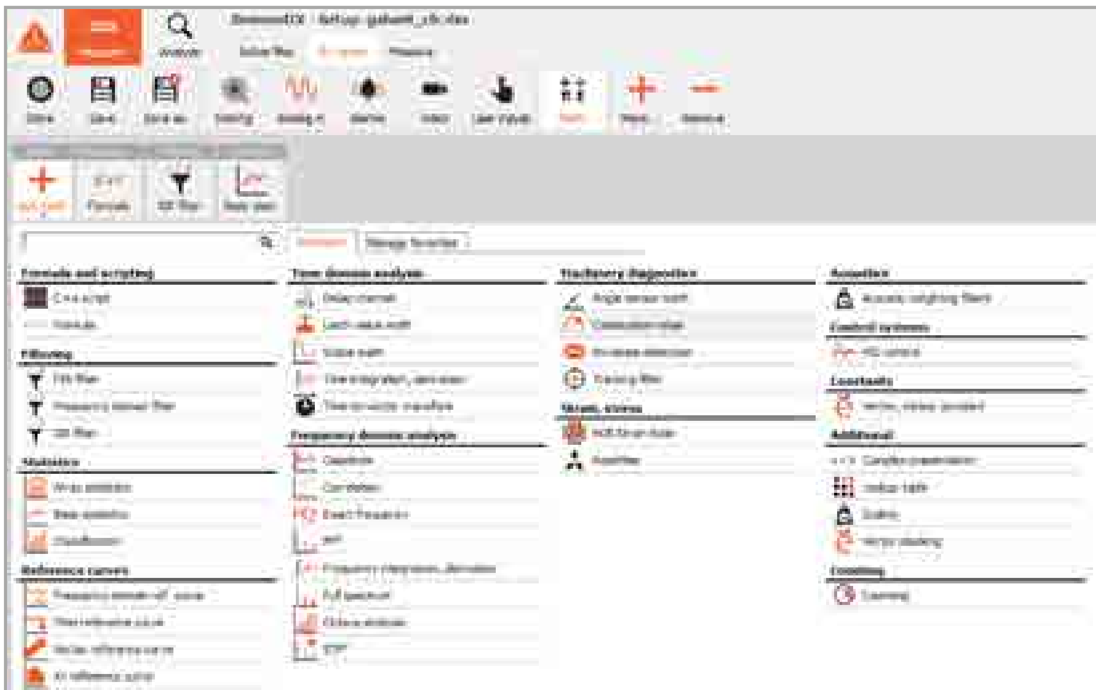


Figure 10. Multiple math functions (including CFC filters for the crash test) are available in DewesoftX software.

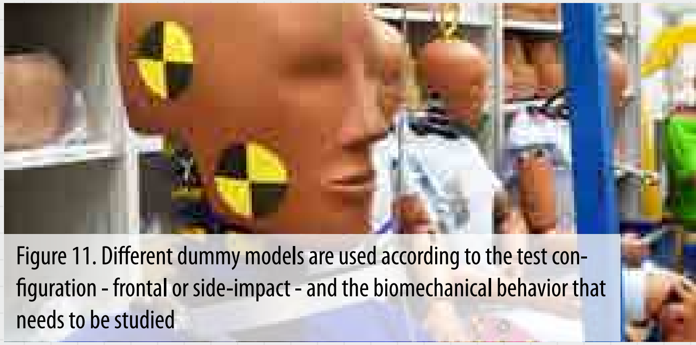


Figure 11. Different dummy models are used according to the test configuration - frontal or side-impact - and the biomechanical behavior that needs to be studied

Figure 12. A dummy mounted and ready for the seat crash test.

Measurements

In all physical crash tests, the dummies are used to measure the forces and assess likely injuries of vehicle drivers and adult or child passengers. A range of destructive crash tests is conducted to simulate the most common types of crashes including frontal impact, side impact, run-off-road, and rear-end.

Per year, the CED test center makes around 600 to 800 crash tests - both frontal-reverse impact and side-impact crash tests - depending on the number of test specimens made. 20 to 30 measurement channels are needed for one dummy only. That is why additional channels such as Krypton are applied.

"Krypton allows us to easily and quickly acquire up to six strain gauges on a test", says Baptiste Fleury, Crash Test Engineer at CED Normandy. "We use these gauges to measure the stresses at different places of the seats. For example, checking a potential weakness that has been identified in the calculation, dimensioning a component according to the measured stresses, or even providing data to the calculation on places that are difficult to model or simulate".

Before a car seat hits the market, more crash tests may be performed. Manufacturers run crash test simulations throughout the design and development of a product. Early crash tests are done for research purposes to help determine what design areas need to be improved or clarify whether a potential product alteration will be beneficial or not. However, in some cases, the first crash tests are only done when the prototype seat is available.

Load cells, accelerometers, displacement transducers are included in the dummies. They help the engineers to evaluate what a real human body goes through in terms of shock and impact force. They are also used to evaluate the efficiency of the seat security systems such as:

- safety belts,
- head supports,
- seat armrests,
- etc.

Also, other transducers such as strain gauges are mounted on the seats. These allow the engineers to see how the materials used will behave in case of crash situations - if they are strong enough to avoid breaking, losing, or deforming.

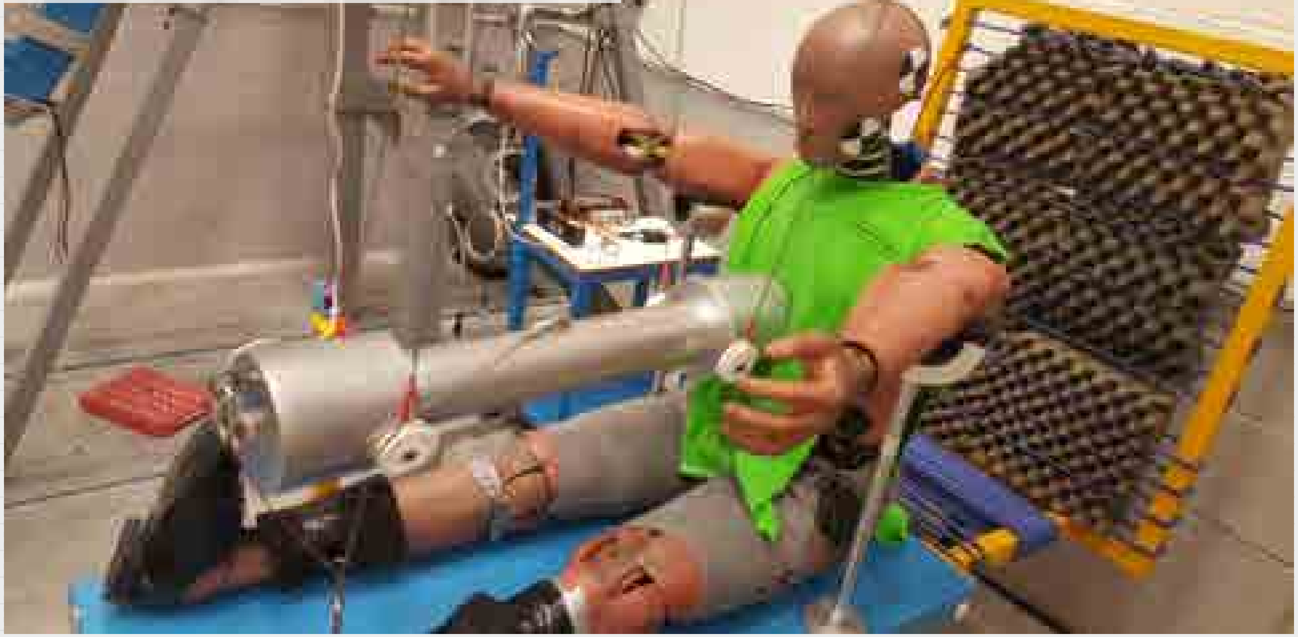


Figure 13. A tension-compression machine with a known displacement setpoint is used to calibrate displacement sensors or strain gauges.

Versatile DAQ modules

The new Dewesoft Krypton modules at CED are not just rugged but also versatile. In their metrology department - the "Dummies Clinic", the engineers now also use these for other measurement tasks such as calibration of sensors and dummy health checks.

As crash test dummies simulate the human response to impacts, accelerations, deflections, forces, and moments of inertia generated during a crash - they take a heavy beating. Throughout their "lifetime" dummies are exposed to high shock levels and all the sensors inside - force, torque, displacement… must be checked regularly. This is done on specific test benches such as impactor test benches or tension-compression

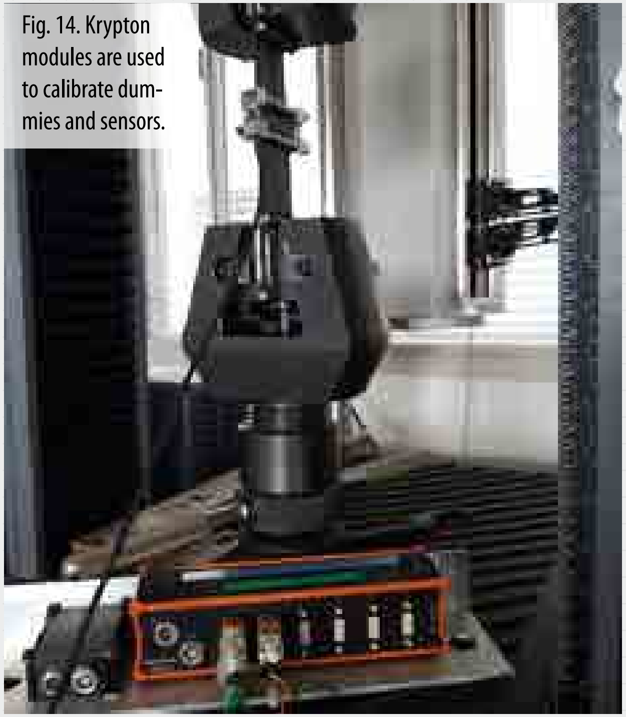


Fig. 14. Krypton modules are used to calibrate dummies and sensors.

machines. The high accuracy and universal inputs of Krypton modules are well-suited for those calibration purposes.

The test procedures for dummies are regulated and described in test standards. The engineers either do a test on a dynamic pendulum impactor or an electromechanical test bench for traction and compression - see figures 13 and 14.

The dynamic pendulum impactor provides data on the behavior of materials or components subjected to rapid loads. It is used to measure the response of an impact on the human Thorax - the chest region between the neck and the abdomen. When testing with the pendulum impactor, a known reference mass bumps into the dummy at a known velocity. The force/deflection response of the dummy's sternum or chest bone is measured.

The electromechanical test bench is used to measure the sensor response curve. It applies a known static load or displacement and the deformation of the sensor itself is checked.

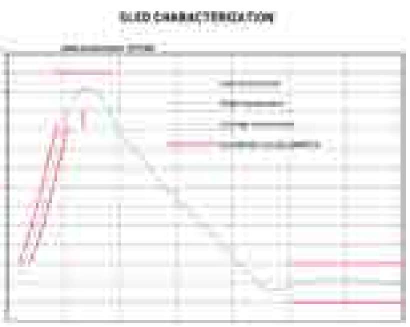
The entire data acquisition measurement chain can also be calibrated with an electrical reference generator signal. Every sensor has an electrical output that is being scaled into a physical unit in the acquisition system. A calibration process is done to check if the data acquisition system itself measures the correct value. A calibrated signal generator is used as a known electrical voltage reference and the signal is sent to the inputs of the data acquisition system.

Conclusion

The Dynamics Test Centre CED in Normandy FRANCE has chosen rugged Dewesoft KRYPTON acquisition modules for their seat crash test catapult. With shockproof up to 100G, strain gauge, and universal STG amplifiers inside, KRYPTON units are suited for extreme vibration environment use and high-resolution measurement range.

"Easy to use and versatile, we use the KRYPTON modules both for crash tests to study the dynamic behavior of structures/materials and for high accuracy calibration operations", says the Crash Test Engineer Baptiste Fleury.

Figure 5. Example of time acceleration profile.



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[Youtube Video]

Video report on CED test center
[Youtube Video]

Crast Test Dummies at CED
[Youtube Video]

Direction stability test of braking vehicle

Military R&D customer

By Glacier Chen, EV industry application manager, Dewesoft China

CASE STUDY

Despite the improvements in car chassis design over the past decades, steering drift during braking where the driver must apply a corrective steering torque to maintain course can still be experienced under certain conditions while driving.

A customer involved in military R&D needs to accurately measure the braking performance of vehicles, specifically how to accurately measure the brake centerline offset. Dewesoft provided a solution based on both the Dewesoft X Brake test plugin and Polygon plug-in in combination with GPS RTK technology.

Introduction

All vehicles show some degree of directional instability during straight-line braking since no real vehicles are truly symmetric.

By today's standards of vehicle performance, handling, and drivability, even minor deviation of this type is unacceptable. If not corrected by the driver, the vehicle may pull to a certain side of the road, the so-called brake pull. There are numerous sources of this behavior:

- kinematical brake steer,
- asymmetric mass distribution, or
- brake imbalance.

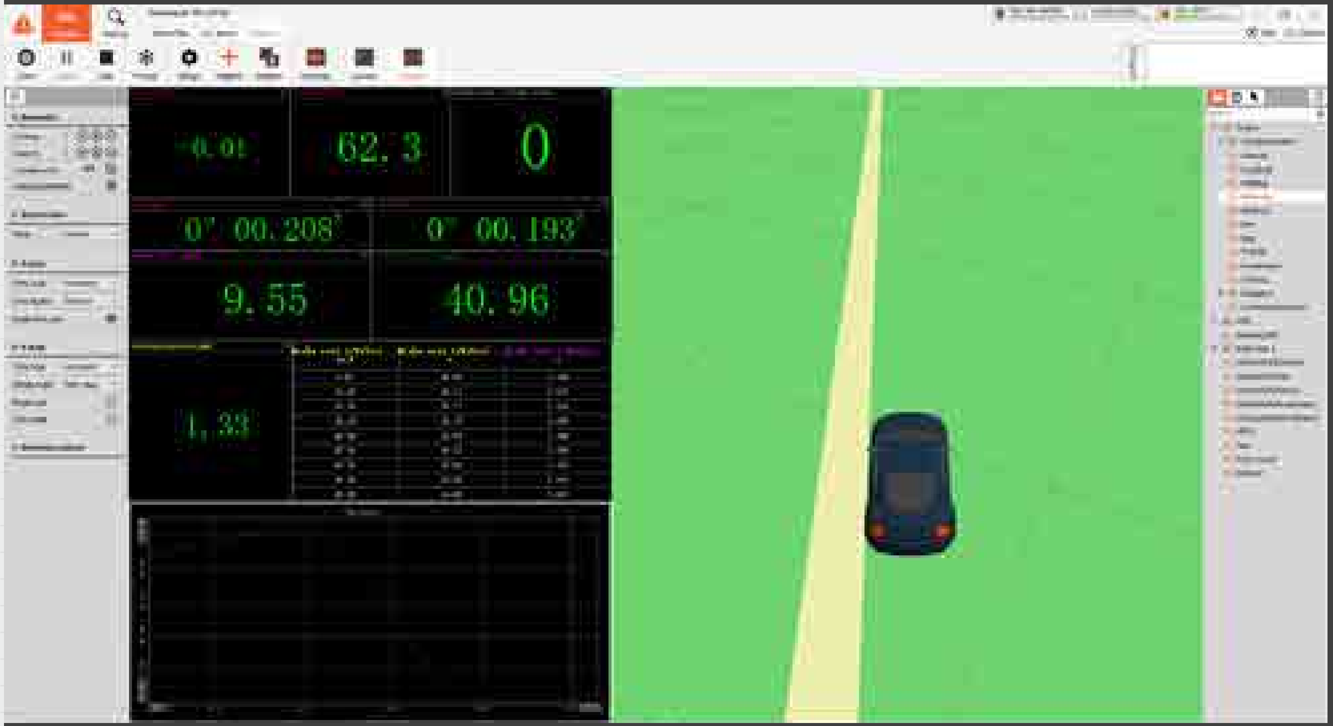
There are three evaluation indicators of vehicle braking performance:

- braking efficiency,
- the constancy of braking efficiency, and
- the directional stability of the braking vehicle.

The directional stability during braking is the performance that the car does not yaw, slip, or even lose its steering ability when braking.

In addition to recording the general brake test parameters like braking distance, initial braking speed, mean fully developed deceleration (MFDD), and other parameters, our customer needed to measure the yaw angle speed during braking, and the brake centerline deviation Shift amount, etc.

The yaw rate can be accurately measured by the gyroscope. How to accurately measure the brake centerline offset was a problem for the customer.



Customer

The causes of steering drift during braking need to be understood at the design stage. The customer in this project is in military R&D and needs a set of equipment that can accurately measure the braking performance of military vehicles.

In the European Standard ECE R13H Annex 3 Braking tests and performance of braking systems, 1.2.7 stipulates that the vehicle must not deviate from the 3.5m test road. Chinese standards GB7258-2017 also have explicit requirements for braking vehicles, stipulating that they cannot deviate from the 2.5m lane when braking.

ECE R13H Annex 3 paragraph 1.2.7. states:

"The prescribed performance shall be obtained without locking of the wheels at speeds exceeding 15 km/h, without deviation of the vehicle from a 3.5 m wide lane, without exceeding a yaw angle of 15° and without abnormal vibrations".

It is therefore necessary to measure both the braking efficiency and the directional stability of the vehicle at the same time during braking.

The customer needs to calculate the following parameters:

- braking distance,
- initial braking speed,
- mean fully developed deceleration (MFDD),
- brake centerline offset, and
- etc.

The brake centerline offset is defined as the vertical distance from the projection point of the test vehicle's center of mass on the ground to the vehicle's straight-line trajectory. How to predict the straight-line trajectory of a vehicle under braking is the key to accurately measuring the offset of the brake centerline.

The measurement challenge

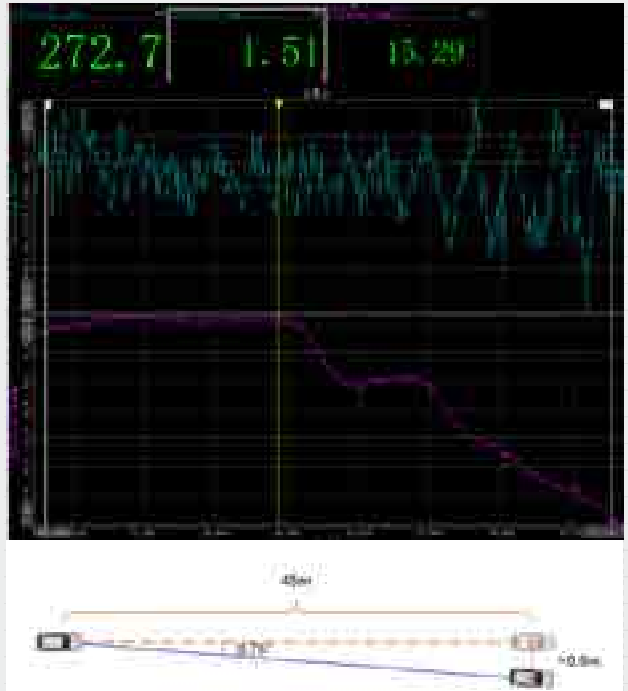
In DewesoftX data acquisition software, you can use the Brake Test plugin to perform a brake performance test, and the Polygon plugin to measure the centerline offset of a braking vehicle.

Brake testing and brake noise testing with Dewesoft YouTube video -> watch here

However, the Polygon plugin can only measure the distance between the end position of the vehicle and the vehicle's heading extension line at the moment of braking.

Polygon screen recording YouTube video -> watch here

Because the vehicle's heading angle will fluctuate slightly during straight driving before braking, measurements are inaccurate. For example, during a straight measurement, the heading angle can fluctuate up to 1.51°. Assuming a braking distance of 45m, the error of the measurement of the brake centerline offset is sin (1.51°/ 2) * 45 = 0.6m, which is too imprecise - see Figures 1 and 2.



Figures 1. and 2. Heading angle fluctuation and braking centerline offset

The measurement solution

Combining the actual needs of customers, we proposed a test solution based on GPS RTK technology to the customer.

The system is composed of:

- DS-IMU2 with RTK
- RTK-RF-Modem
- DS-WIFI3
- DS-RTK-BASE
- DewesoftX data acquisition software
- DewesoftX Braketest plugin
- DewesoftX Polygon plugin

Figure 4. Heading angle one second before the test trigger was used for the calculation of straight-line driving trajectory.

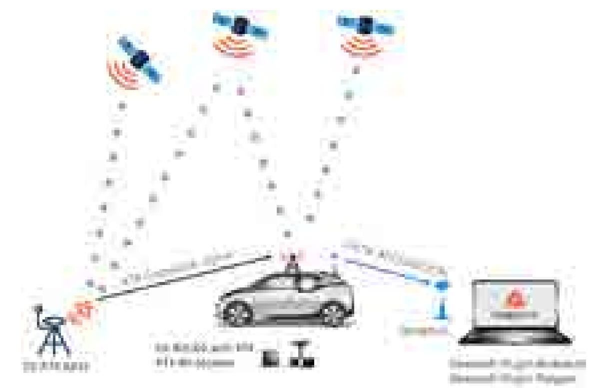


Figure 3. Overall measurement setup.

In terms of calculation of test data, we proposed for our customers to use the average of the heading angle one second before the test trigger as the predicted heading angle to calculate the straight-line driving trajectory - see Figure 4. Hence, errors can be reduced caused by heading angle fluctuations or driving direction deviations.

Software settings

1) Using the statistical function in the mathematical formula to increase the average heading angle calculation channel - see Figure 5.

2) Setting a virtual vehicle in the Polygon plug-in. The vehicle uses the average heading angle as its heading angle - see Figure 6.

3) Adding prediction heading and using a trigger lock function - see Figure 7.

4) Adding the channel for calculating the distance from the vehicle center to the predicted heading line - see Figure 8.

This value is the brake centerline offset calculated using the average heading angle 1s before the trigger as the predicted heading angle.

Conclusion

This Dewesoft brake test solution can also be recommended to customers engaged in automotive braking research. Help them engage in automotive braking research and improve automotive braking stability.

This solution has been demonstrated for the customer, and the customers are satisfied and preparing for procurement.

Compared with competitors' solutions, the Dewesoft solution can well meet customer testing needs, with flexible parameter settings and high accuracy data acquisition equipment for testing.

Figure 5. Basic statistics software setup.

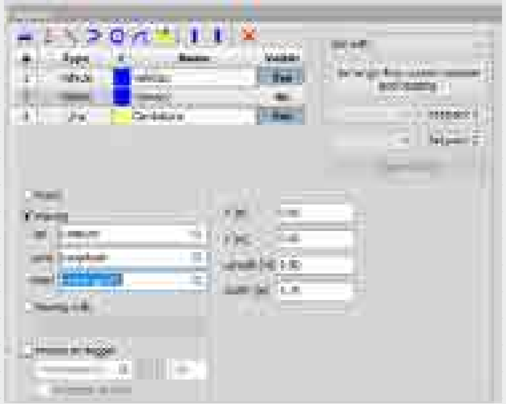


Figure 6. Heading angle in Polygon plug-in.

Figure 8. Software outputs.

Figure 7. Trigger lock function.

Performance tuning in tractor pulling sport

By Marlies Lacroix and Andries de Bué, Dewetron Benelux BV

CASE STUDY

An explosion of force. Overwhelming horsepower values like 1000 to 8000 bhp, diesel fuel formulas like $C_{10}H_2$, $C_{15}H_{28}$, or CH_3OH, and deafening sound levels above 100 dB - all on a short track of just 100 meters (330 ft). This in short is tractor pulling. Events where standard and modified tractors (running on diesel fuel or methanol) compete with each other in strength and over distance. In the Netherlands, a Dewesoft measurement setup was used to measure a range of parameters, valuable for tuning performance and optimizing the tractor engines.

Whenever you visit a tractor pulling event you can hear the engines roar from afar. The smell of exhaust gases mixed with the smell of fried hamburgers and fries fills the air. The spectators walk onto the terrain in large crowds and watch the different, powerful machines standing quietly and well-polished at the stand of the various teams, in anticipation of their moment of fame.

The sport originates from the 1950s in the United States, where farmers battled with each other by pulling a weight over a certain distance. In 1977 the sport was introduced in Europe – also in the Netherlands – and it is still growing in popularity all over Europe. The rules are simple: pull a 28000 kg sled over a 100 m track. The goal is to determine the strongest machine and the best driver - it is not about the speed, but the distance pulled. 100 meters is a 'Full Pull'.

Tractor pulling uses a sort of weight that does not rest on wheels but on a sled - see Figure 1. However, the tricky part is, that the sled will dig itself, due to its weight, more and more into the soil, as the distance progresses. When a pull starts, the weight is at the back of the sled. The weight is connected to the wheels with a cable or chain through transmission and moves to the front when the sled is pulled. This creates a gain in weight causing higher and higher friction: thus, more resistance to the tractor, until it is no longer able to overcome the force of friction and comes to a halt - see Figure 2. Today's sleds use a complex system of gears to move weights up to 65,000 pounds/29,000 kilograms.

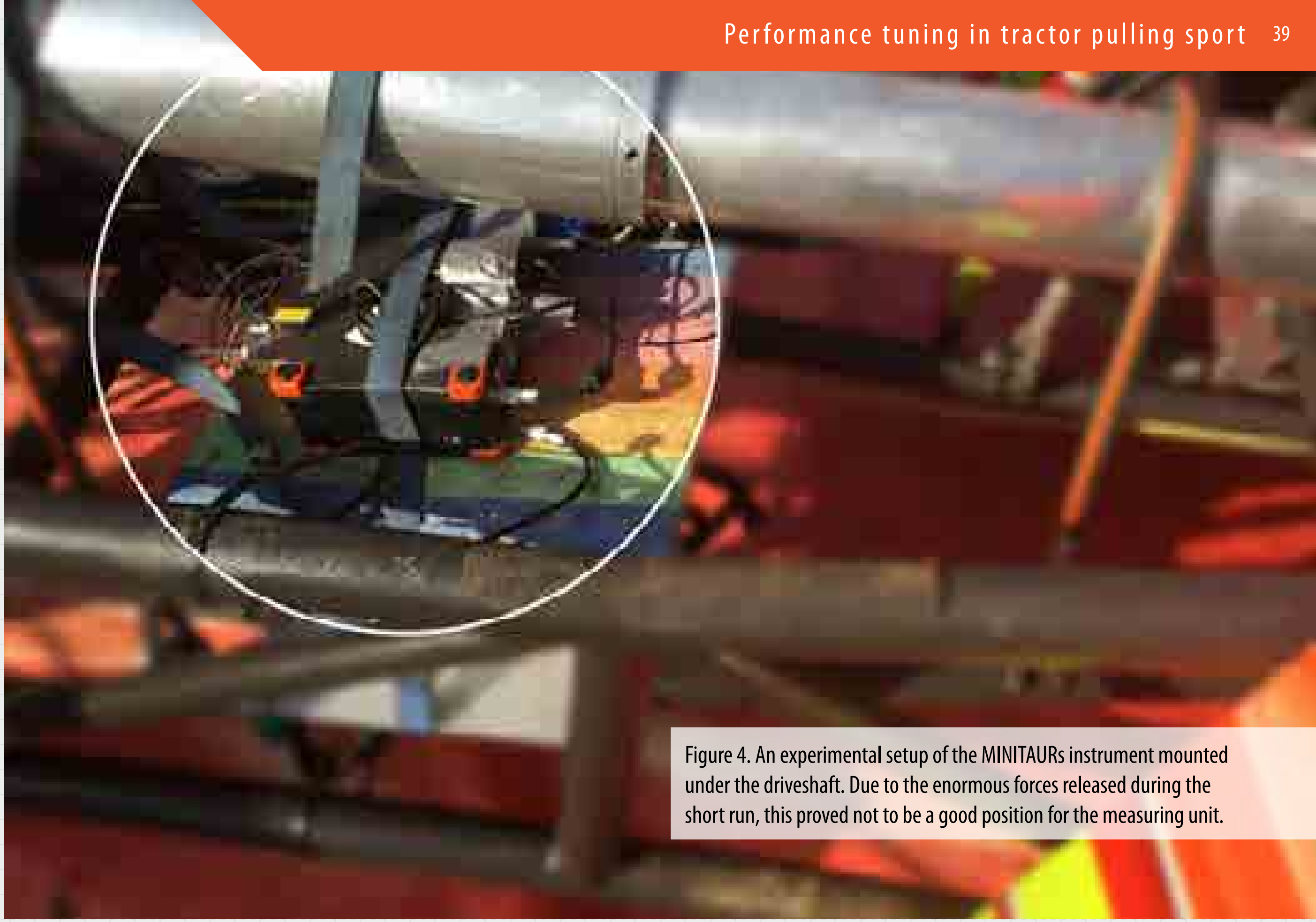


Figure 4. An experimental setup of the MINITAURs instrument mounted under the driveshaft. Due to the enormous forces released during the short run, this proved not to be a good position for the measuring unit.

Measurement history

There are several pull classes in the Tractor Pulling Sport from Lightweight to Heavy Modified. To perform the pulling, the machines must have enormous power. That means that the techniques are pushed to the limit. No ready-made machines from the factory join the track; only self-built machines. Diesel engines that deliver more than ten times their standard power, or gasoline engines, delivering over 1,500 hp blowers and use methanol injection All these Specials are unique and have an individual design based on an engine that could, for instance, be a tank engine or even a combination of multiple helicopter turbines. These tractors can theoretically achieve speeds over 200 km/h (125 mph).

In the early years, nothing was measured and in recent years data loggers (5 to 10 pt/sec) have been used for measurement, but this is not enough anymore.

At pulling tests of tractors, it is crucial to determine the magnitude of power losses. Losses resulting from the transformation of the effective engine power to pulling force/power can be determined from the power balance of the tractor.

A primary parameter is engine torque or power. Mathematical models of forces and moments representing the balance can only be used if it is possible to measure or calculate the actual engine power.

The tractors usually use the CAN-bus to transfer data between control units. Most tractors are equipped with several electronic control units that communicate with each other directly or using various network bridges. These control units provide regulation for the engine and the gearbox among others. They work on information obtained from many sensors, installed inside the tractor. The processed signals of these sensors are transmitted over digital networks such as the CAN-bus. The data from the network can be used, without the installation of expensive measuring equipment.

Signals and sensors

Typical "standard" configuration needed

- 6 to 10 Pressure sensors (turbo(s), inlet, oil, water, gasoline)
- 6 to 16 Temperature sensors (one sensor per cylinder exhaust, oil)
- 2 to 6 Counters (wheel speeds, engine rpm, turbo rpm)
- Video (now post sync GoPro video)
- Math channels

Expected future requests

- GPS (at least 5 pt/sec as the run is only 10 seconds!)
- Combustion pressure (only for expert users)
- Vibration measurement
- Order tracking
- Alarms (indicator and output)
- A video camera that can withstand the huge shocks and vibrations

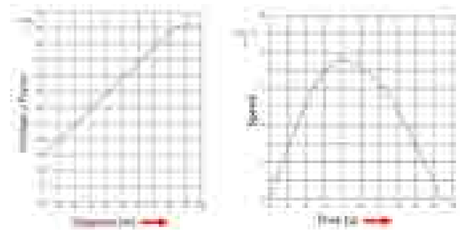


Figure 2. Friction and Speed vs. Distance. Over distance, the sled gains weight and increases friction.

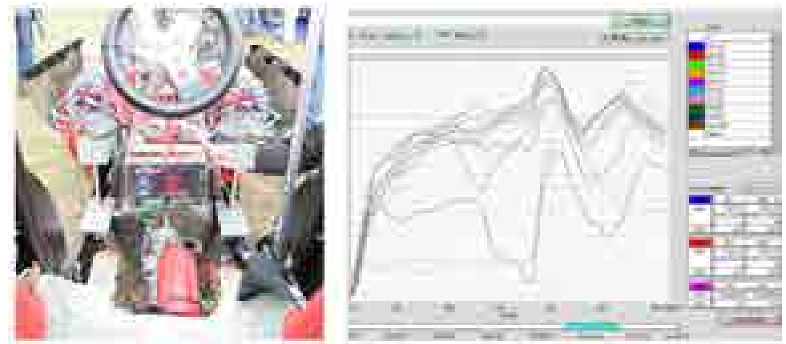


Figure 3. Old style – data loggers.

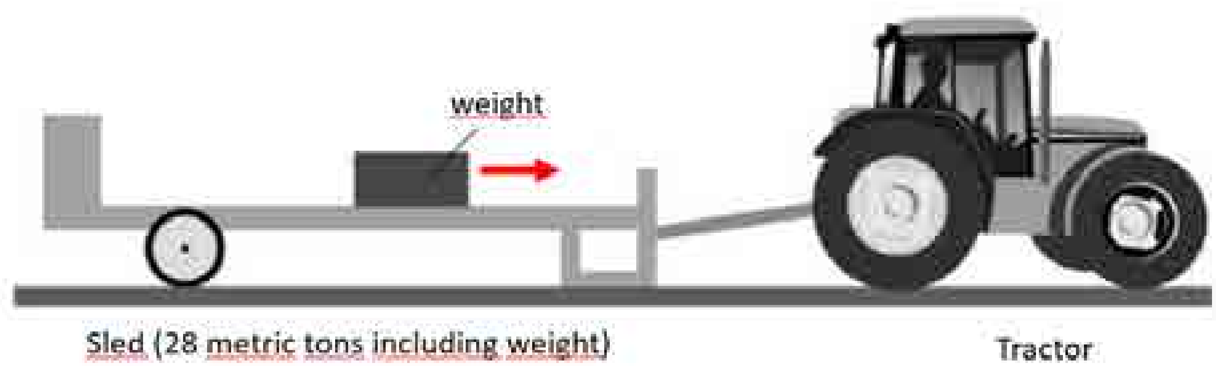


Figure 1. The vehicle setup in tractor pulling sport - a combination sled and tractor.

Measurement and analysis

The first tests were done with the Dewesoft MINITAURs data acquisition system and a CAN-bus measuring device for temperatures - see Figures 4 and 5.

The Dewesoft MINITAURs packs a powerful data logger and data acquisition device in one compact chassis. Inside this small instrument lives a powerful Intel Core i3 CPU computer, solid-state drive, Wi-Fi, two LAN ports, four USB 3.0 and two USB 2.0 ports, EtherCAT master port, and optional 10 Hz or 100 Hz GPS receiver.

The MINITAURs have isolated CAN input: High speed CAN 2.0b channels with 1 Mbit/sec data throughput with additional support for CCP, OBDII, J1939, and CAN output. Each channel, analog, digital, or CAN, is synchronized with microsecond accuracy.

Figure 5. Location of the DEWESoft MINITAUR.

Figure 6. Test of housing using SIRIUSi slice under the driveshaft.

Figure 7. The driver's view with the Dewesoft display in the center.

Figure 8. The driver's measurement dashboard.

Figure 9. Data presentation with video and various types of displays.

Figure 10. Data presentation with video and various types of displays.

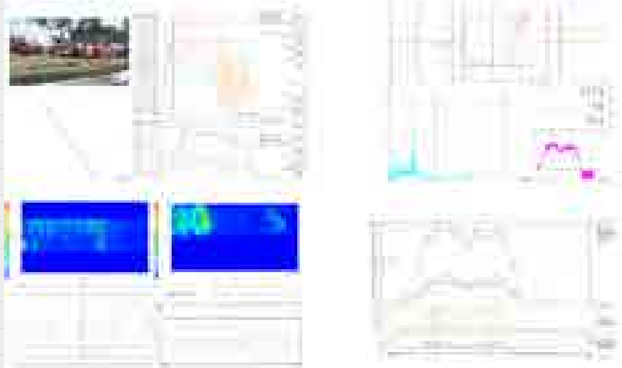


Figure 11. Post analysis of the run.

Conclusion

By collecting data over a time span of just 1 minute (the actual race takes only about 10 seconds!), the high-speed data provide useful information to optimize the tractor engine. Next to that, engine failures can already be detected at an early stage, which saves money and downtime of the machine. The Dewesoft solution can be used to measure, analyze and provide solutions to optimize the engine, ensuring the best balance between power and grip on the track.

The Dewesoft equipment is compact, fast, and has an easy-to-use configurable user interface. For the driver, a simple view screen can be configured to display just a selection of key information. And after the run, or when the show is over, well away from the roaring noise, the dust, and the smell of exhaust and fast food, the experts can perform extensive offline post analysis and generate statistics from the data collected during the run.

Analysis of transfer path of noise from in-wheel motor to cabin

Operational transfer path measurements and analysis
Elaphe Propulsion Technologies Ltd., Slovenia

CASE STUDY

As a developer of in-wheel powertrain, Elaphe Propulsion Technologies Ltd. has to make sure that its powertrain does not emit excessive vibrations, which will result in structure-borne noise. Since vehicle suspension is typically not considered to also perform as a motor insulation system, there is a lack of knowledge on specific vibration insulation properties, especially in higher frequencies that are excited by the electrical powertrain.

Elaphe, based in the Slovenian capital, Ljubljana, is a company focusing on innovation, research, and development of in-wheel motors for electric vehicles. Elaphe has produced several generations of in-wheel motor prototypes that are being tested on more vehicles. These vehicles and motors have served as showcases for customers and shown the way to meet the standards and regulations of the automotive industry. Elaphe is on the way to meet serial production demands by Tier 1 suppliers and OEMs.

The issue - vibration control

Control of motor vibration is very important since it results in structure-borne motor noise, which can compromise passenger comfort. When developing motors to emit low vibration levels, some degree of vibration insulation is needed. To understand what can be solved by the vehicle design and what needs to be solved on the motor level, transfer path analysis on mule vehicles during the operation was performed.

Elaphe used its mule cars to study the role of vehicle suspension systems and to determine how vibrations from the in-wheel motors are transferred to the vehicle. The results are used in further product development as well as in communication with customers since in several cases the overall experience did not meet the customer expectations.

Testing equipment

The equipment used was Dewesoft Sirius slices connected to various sensors - accelerometers, microphones, human-controlled inputs - and vehicle CAN. One Sirius was used for regular NVH measurements, which were performed on more than a dozen of vehicles in-house and at clients to evaluate NVH performance. For extended testing three synchronized Sirius slices powered by battery were used on a single mule vehicle, as modifications of the powertrain and suspension tuning had been performed.

Figure 1. The mounting of sensors around motor and suspension components.

Typically, one Sirius was used for regular NVH measurements, which were performed on more than a dozen of vehicles in-house and at clients to evaluate NVH performance. For extended testing three synchronized Sirius slices powered by battery were used on a single mule vehicle, as modifications of the powertrain and suspension tuning had been performed.

Measurements

All the measurement equipment had to be mounted and connected to the vehicle in a secure and reliable way since the vehicle was operational. Several sensors had to be mounted below the chassis and also on the unstrung mass and suspension components. The acquisition system had to be powered offshore. While Dewesoft enables direct power supply from the vehicle low voltage system, for the most sensitive measurements a Dewesoft battery source was used, not to introduce any line noise from low-quality vehicle power supply or portable power converters.

Measurements of the noise and vibration levels on the in-wheel motors, on the chassis, and in the cabin, during on-track operation, were recorded. The data collected were post-processed to reveal the amount and spectra of intrinsic vibration that penetrated the vehicle resulting in-cabin noise.

Elaphe now has a much better understanding of the most problematic frequencies and working points that need to be addressed on the motor level. They also discovered issues on vehicles, that need to be addressed to improve customer experience. The measurements enabled Elaphe to set the guidelines on how to address the NVH issues, they have already resolved many of them and are working on the remaining.

Conclusion

Elaphe made significant changes to motor control algorithms and started collaborations with companies specialized in suspension system development. The measurements were used to evaluate the progress and Elaphe managed to eliminate practically all powertrain contributions to the cabin noise.

This overall test gave the company confidence in product quality and an advantage in communication with customers since they can present the viability of their solutions, and all the improvements that were identified and already performed. It also places Elaphe in a better position in the in-wheel market as a development partner due to obtained know-how on the system level.

"Fast learning curve, ability to use the equipment, we are familiar with from other measurements and support from Dewesoft, mostly by lending additional equipment for the most demanding measurements, enabled us to identify and characterize the critical operating conditions,"says Martin Strojnik, Head of Development at Elaphe. "Based on this Elaphe could set an efficient strategy for NVH reduction and monitoring of the progress."

Figure 2. Three Sirius units powered by a battery pack.

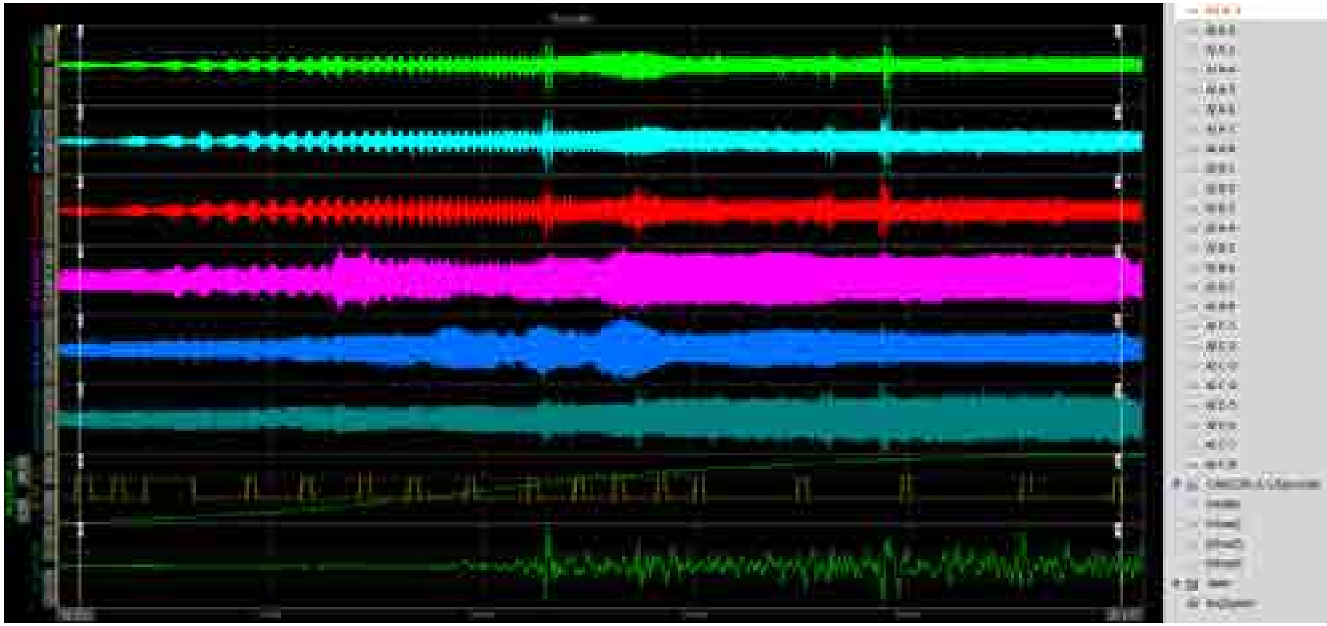


Figure 3. Synchronized acquisition with several Sirius units; accelerometers, microphones, triggers, CAN, and real-time math channels.

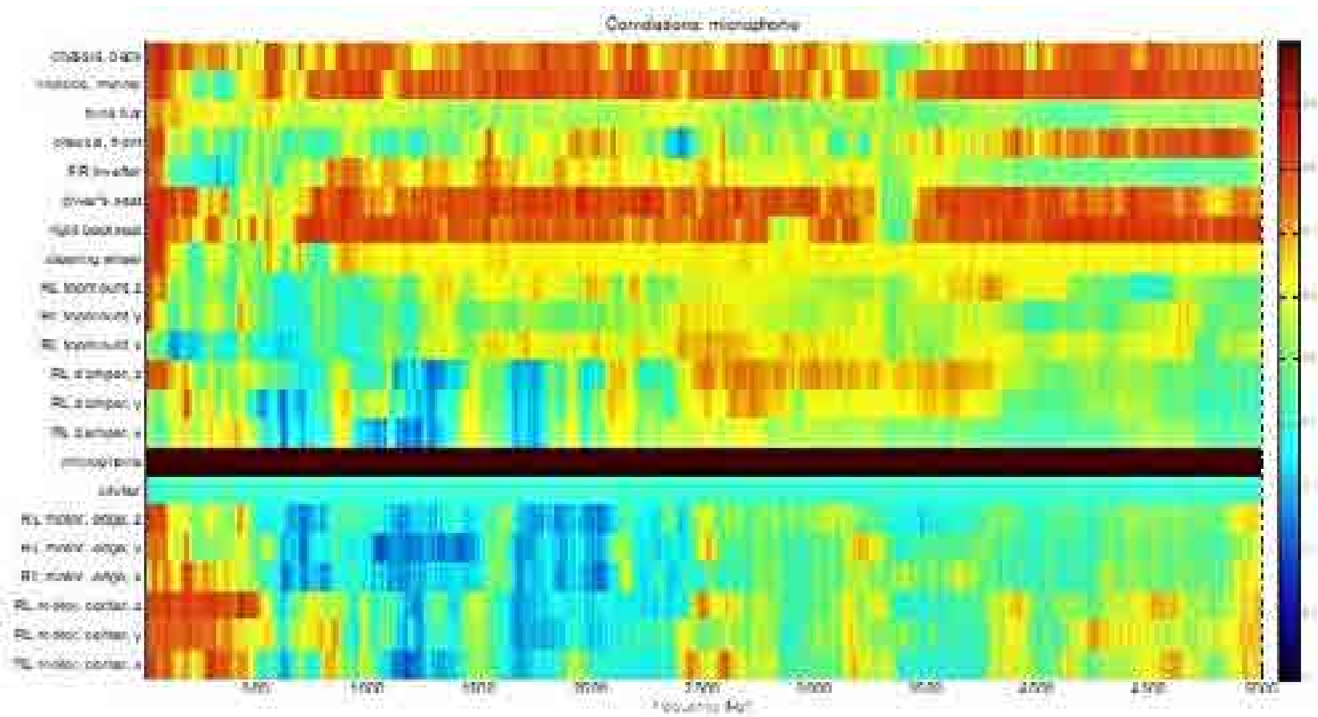


Figure 4. Correlation matrix between vibrations on different vehicle locations/components and cabin noise with respect to noise frequency.

Coast-by method for measurement of tire noise according to ECE R117

Automotive tire manufacturer

By Marco Pesce, Automotive & Vehicle Dynamics Expert, LEANE International Srl, Italy

When you are a tire manufacturer, one of the parameters fundamentals that you are called to measure in phase homologation is that of noise, understood as a sound level that creates an unpleasant hearing experience for the driver, passengers, and the environment itself. LEANE International supplied a Dewesoft solution that simplifies testing to a tire manufacturer.

CASE STUDY

Since 1978 the automotive division of Italian LEANE International, a Dewesoft partner, has provided comprehensive solutions in automotive data acquisition. Starting from sensors, the company has extended its professional staff of mechanical and electronic engineers, data acquisition experts, application developers, professional drivers, and data analysis experts to support automotive testing activities from car setup to final testing reports.

"The sound", explains Davide Del Fatto, the LEANE noise and vibration expert, "is nothing more than a propagated vibration in the air in the form of sound waves. The source of this can be a solid - like a tire - stimulating the air to vibrate and creating pressure waves around it. The more the source vibrates, the more noise it generates".

Davide Del Fatto knows that in the speed range from 50 to 100 km/h tires are the main source of the noise emitted by the vehicle in motion. "All manufacturers must perform homologation tests before being able to market their products", he says.

Not just coast-by-measurement

In this context, one of our customers, an important tire manufacturer that wants to produce increasingly quieter tires, asked us for a new system. It should not only be able to perform coast-by-noise measurements for homologation but at the same time calculate other parameters to be compared with the tests in an anechoic chamber.

This was a request for a very complex system - but simple and immediate to use, which directly generated the test report

Figure 1. Working on the system expanding DewesoftX functionalities.

and the data necessary for the research and development. We immediately decided to design the system around the pilot based on R117.

In 2012, ECE regulation 117 came into force. The United Nations Economic Commission for Europe (UNECE) took this initiative to increase the safety and environmental and economic efficiency of road transport. ECE R117 defines the measurement of fuel efficiency, wet grip, and tire noise on passenger cars, commercial light trucks, and trucks.

Other regulations from UNECE specify the provisions for the type approval of sound emissions from tyres:

- UNECE 51 on motor vehicles having at least four wheels,
- UNECE 41 or motorcycles,

The international standard, ISO 13325: 2019 (Tyres — Coast-by methods for measurement of tyre-to-road sound emission) specifies methods for measuring tire-to-road sound emissions from tires fitted on a motor vehicle under coast-by conditions, i.e. when the vehicle is in free-rolling, non-powered operation. It describes how to test, where to place the microphones, how the track for external vehicle noise is made, etc.

Data acquisition system setup

The DAQ system has two distinct hardware parts, a base station, and an in-vehicle station.

The base station is composed of a 8-channel Dewesoft DEWE-43A data acquisition system. Two microphones were positioned on both sides of the roadway as per ISO 10844-2014, and a weather station for environmental parameters.

The in-vehicle station uses the Dewesoft DS-VGPS GNSS receiver with the GPS antenna connected. This instrument measures precise speed and uses the photocell to determine the vehicle position. A tablet PC computer is used for controlling the acquisition, and for storing and visualising the data in real-time.

The communication between the two measuring stations is enabled via DS-WiFi3 wireless antenna solution. DS-WiFi3 is now replaced by the DS-WiFi4 system. DS-WiFi4 uses increased power and extends the range to two kilometer range.

The Figure 2 illustrates the whole system used in the measurement.

The entire test was automated using DewesoftX Sequencer. The user interface was customized to hide all the unnecessary parameters and functions and automated to guide the test operator and. This way the driver can focus on what is the core of his job: driving safely at the right speed.

The large and easily visible click-buttons on the Initial test selection screen allows the driver to select:

- Init: Insertion or modification of test parameters: tire data, vehicle length, track orientation.
- Valori live: Display of live values - microphones and weather station.
- PassBy: Registration of pass-by tests
- Analisi: Test analysis and reporting

Thanks to the basic data acquisition and analysis software from Dewesoft and the high WLAN transmission performance, the driver can see in real-time if the test was successful or not.

At the same time, the Dewesoft DAQ software and hardware saves everything for later analysis. Even many other datw that can be used for research and development. For example thirds/twelfths of an octave in function space to understand the sound emissivity and parameters environmental influences that affect noise and temperature asphalt along the entire test track.

Results are provided in tabular form for quick display. It displays the overall noise value and generates the final test report.

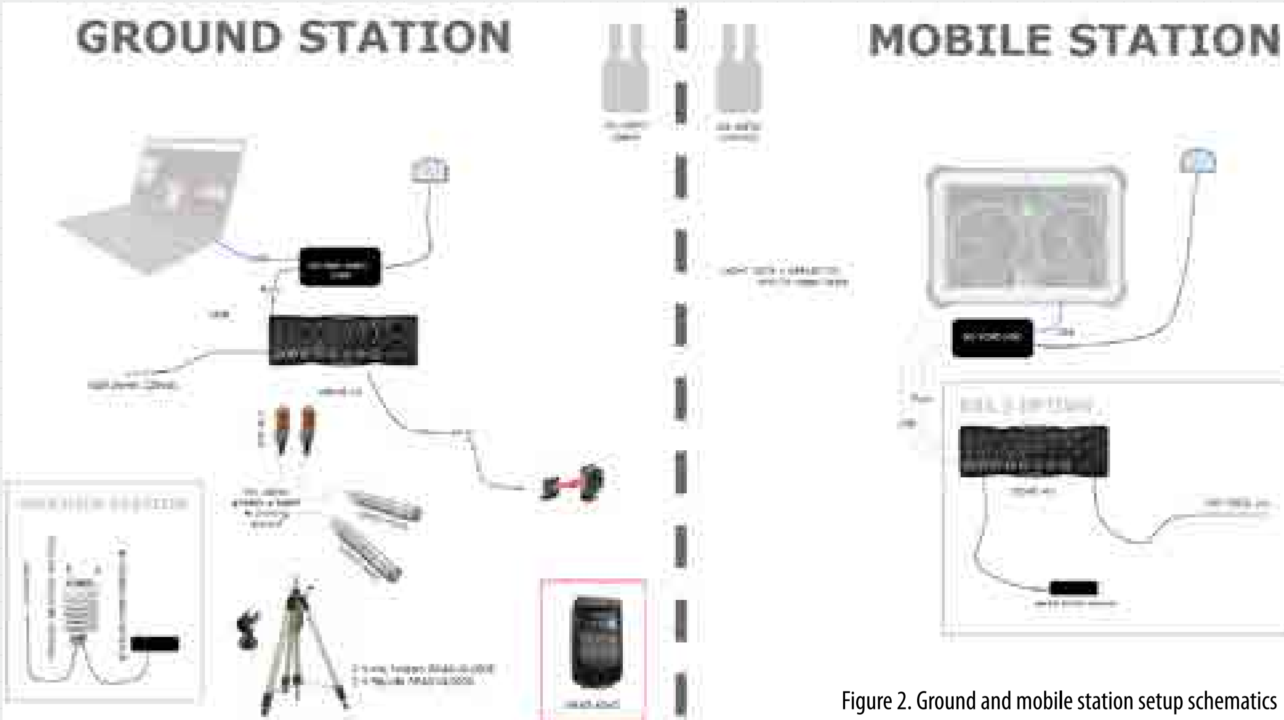


Figure 2. Ground and mobile station setup schematics

Figure 3. The initial test selection screen - designed for in-vehicle use.

Figure 4. The database with the final results.

Measurement control is provided by a simple graphical interface with very large buttons to facilitate data entry operations.

At the end a handy summary table allows you to have the reports according to the regulations selected and the system is automatically saving all data necessary for research and development - see Figure 4.

Conclusion

The Dewesoft testing system is designed to comply with ECE R117 and automated processes allow the driver to focus on driving safely at the right speed. The system can perform a noise test according to the regulations and is easy to operate.

Thanks to its simplicity of design and use, the system allows the tire manufacturer to obtain the measurement report in just twenty minutes. This increases tje productivity and the security of saving all data correctly.

Figure 5. DS-WIFI3 - a Dewesoft Mobile outdoor Wi-Fi communication set mounted on the roof of the test vehicle.

Formula student race car exhaust noise testing

Rimac FS Alpe Adria, Croatia

By Matjaž Strniša, Automotive Customer Support Engineer, Dewesoft

CASE STUDY

At any Formula Student racing event, the cars go through thorough checks to ensure overall safety - mechanical condition, tilting and braking capacity, and noise tests. In Novi Marof, Croatia at the last race of this season the team from Dewesoft performed the exhaust noise testing and calculated the vehicle RPMs based on the sound measurements.

Rimac FS Alpe Adria is an annual Formula Student racing event held in Northern Croatia. Formula Student competitions are held every year in more countries and on some of the most iconic race tracks in the world like Silverstone, Hockenheimring, Red Bull Ring, and Circuit de Barcelona - Catalunya. From 26th till 29th of August it all took place on the karting race track St. Rauš in Novi Marof near the city of Varaždin - see figure 2.

It was early Thursday morning when we - the Dewesoft team - packed up our show car, a Ford Ranger, with technical equipment and some promo material. After the around 140 km drive from Trbovlje in Slovenia, we arrived at the event of FS Alpe Adria. And immediately, we were blown away by the atmosphere - the students there were all loaded with pure engineering and racing energy.

This year at Novi Marof 37 teams from 14 countries took part in the competition. Hundreds of young people, and a lot of tents. Every team had a tent - a place to get their cars ready for the racing disciplines. At these pits, the teams presented themselves with signs and banners. Other tents were reserved for officials and spectators; inspections, mechanical or electrical services, food stalls, etc.

The main sponsor of the event is the Croatian company RIMAC Automobili which makes electric hypercars and associated technologies such as batteries or powertrains. Also, Dewesoft is a sponsor of the event - and at Novi Marof we not only did the exhaust noise checks on all racing cars but were even selected to do the final check-ups and testing of all the cars before the race.

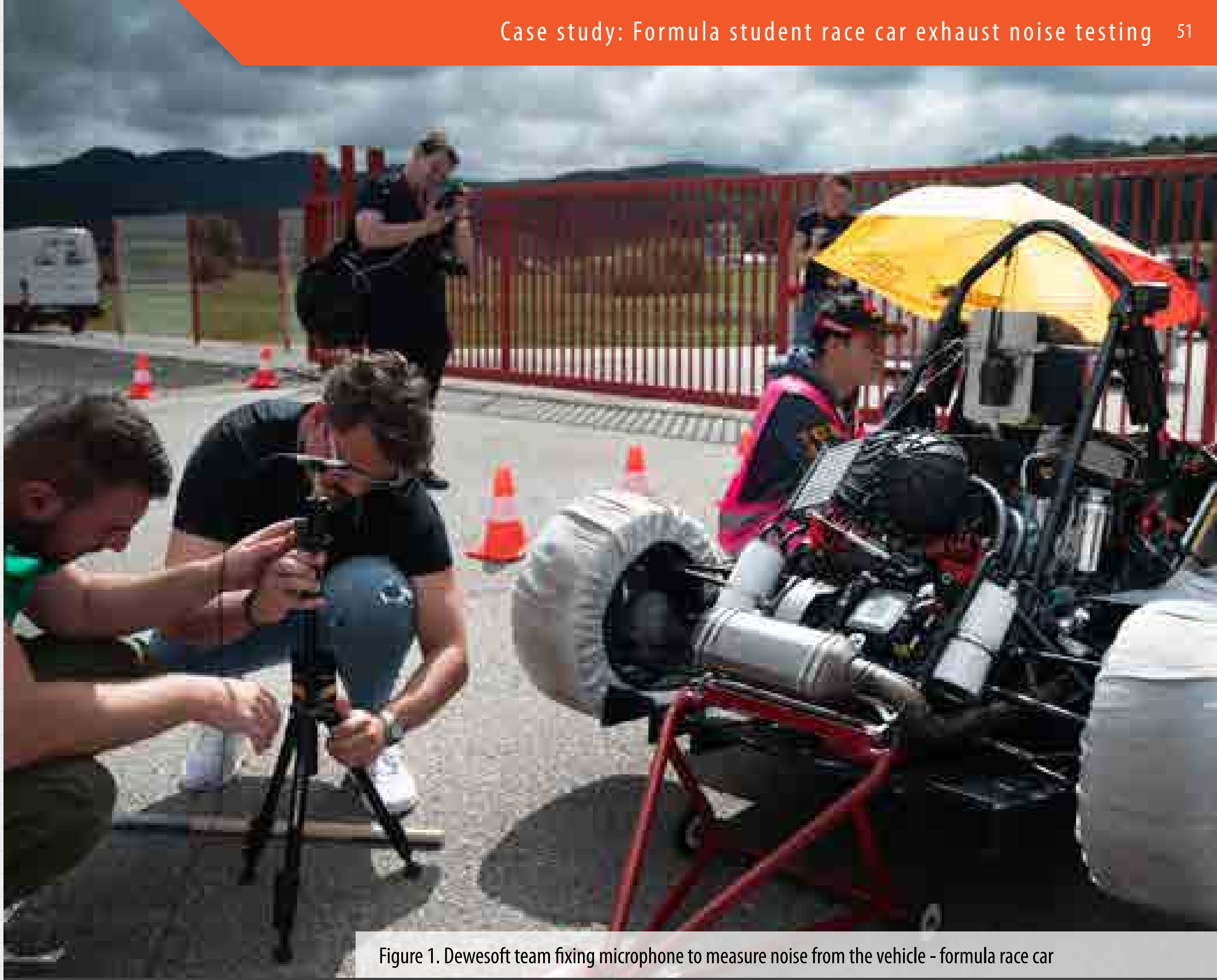


Figure 1. Dewesoft team fixing microphone to measure noise from the vehicle - formula race car

The Formula Student competition

Formula Student (FS) is the biggest engineering competition in the world. There are over 500 teams and more than 40 competitions worldwide. The organizer of the competitions is usually a national engineering association with the help of some of the biggest names in the automotive industry such as Porsche, Daimler, Audi, Škoda, and so on.

FS is an engineering design competition promoting clever problem-solving. Student teams all over the world design, build and test a prototype racing car based on a series of rules made to ensure on-track safety. At the events, the motor vehicles are then driven by the students themselves.

Taking part in the competition, the students gain valuable knowledge about practical work, turning theory into practice, develop their engineering and problem-solving skills and learn to work together as a team. However, the competition is also about networking. Every event is an opportunity to share experiences, meet like-minded people, and potential future employers.

Entering the competition

Every team that wants to compete in the desired formula student events has to qualify for participation. First, there is a quiz. All events are taking place during the summer while the quiz is done in February. The quiz questions derive from the formula student rule book; some are on problems from the engineering field and some are of a business nature. The best-scoring teams are eligible for the next step.

Because that's not all. The next hurdle to enter the competition is the vehicle status video (VSV). Every team has to produce a video of their vehicle traveling 30 m with 180° cornering while driving at least 10 km/h. The VSV video must be submitted at least 6-8 weeks before any FS competition.

Then, when the event starts, every team has to go through a variety of mechanical inspections and tests before going on the training grounds - and before joining the dynamic events. Every part of the technical inspection is 'awarded' with a pass sticker put on the nose of the vehicle. In the end, when your race car goes to the track, all stickers must be there.

There are 3 main categories of FS cars: combustion vehicles (CV), electric vehicles (EV), and driverless vehicles (DV). The competition consists of various static and dynamic disciplines and it is governed by several judges who are often renowned experts in their respective areas of the automotive industry.

The teams will compete in more disciplines. Each of these carries a certain amount of points, totaling 1000 points available in each category of cars. Naturally, the team gathering the most points is the winner!

The series of disciplines are falling into two different parts: static events and dynamic events.

Figure 2. Overview of the race track St. Rauš in Novi Marof

"We invited Dewesoft to help us with the measuring since they are known worldwide for their expertise in sound engineering. As expected they did their job perfectly and professionally, ensuring everything was according to the official Formula Student Rulebook. They even helped some of the teams and gave them some useful tips, after all this is a student competition, it's all about learning and growing."

Luka Pavlovič, Organizer

Figure 4. Car no.111 of the Transilvania UNI Brasov team on the skidpad run.

Static events

Designing an FS car requires an interdisciplinary approach and teamwork. Besides technical understanding, the students must also possess economic and social skills:

Business plan presentation (BPP)
In BPP the task is to evaluate the team's ability to develop a comprehensive business model which demonstrates their product – a prototype race car.

Cost and manufacturing
The objective of this event is to evaluate the manufacturing process and the cost associated with building a race car for every team.

Engineering design
In this event judges - usually, judges are engineers from the automotive industry - evaluate the engineering process, efforts, and solutions that are implemented in the design of Formula Student race cars.

Dynamic events

In this part of the competition, the teams put their „beasts" on the track to show what they are made of. The cars are put to their limits across several disciplines to evaluate different features:

Skidpad
An event where cars drive in two circles which form a figure 8.

Figure 5. The Delta Racing Mannheim electric team getting their car ready for technical Inspection.

Acceleration
The team has to go as fast as possible in a straight line for 75 m.

Autocross
Autocross is some kind of qualification for the endurance event, but here you drive only one lap and the time of one lap is measured. It is driven on the same track as the endurance event.

Endurance
The goal is to travel the distance of 22 km - in this case, 22 laps - as fast as possible. At half the distance, the drivers must be switched and the car has to be turned off.

Efficiency
This is measured during the endurance event - everybody starts the endurance event with a full fuel tank.
From the spectator's point of view, the endurance drive is the main event. Here all the vehicle's strengths and flaws will show - and up to 4 cars may be on the track at the same time. Acceleration, speed, handling, dynamics, fuel economy, efficiency, reliability, and driver skills are tested to the limits. The winner of this event is awarded the maximum of 300 points - the highest score achievable in a single discipline.

Technical inspection

The inspection is done in an order of differents steps - if you don't pass one, you can't move on:

Pre-Inspection
Here every team is checked if it has the correct helmets, safety gear, fire extinguishers, wet and dry tires. Here the teams are checked for the direct safety of the drivers.

Figure 3. Teams getting prepared for technical inspections

Mechanical Inspection
Scrutineers check ready-to-race vehicles if they are built according to the rules.

Tilt test
The vehicle is placed on the table to an angle of 60°. Scrutineers check the vehicle for fluid leaks and they check if all wheels are still in contact with the table.

Vehicle weighing
Vehicles are measured in ready-to-race condition.

Noise test
Here the teams turn on the vehicles for the first time in the competition. It is the first step for every team if they want to compete in the dynamics event. Scrutineers measure the noise that comes from the exhaust system.

Brake test
A team passes the brake test if its race car stops with locking all 4 wheels at the end of the acceleration run.

Dewesoft was invited to the event as a sponsor but also to do the official noise testing of all cars. Furthermore, as our team members have experience from past years of Formula Student, we were also given the task to check the safety features of all cars - all in strict accordance with the FS rulebook.

At the event, all cars are started up for the first time to do the noise test - participants are not allowed to turn on the engines before this. When the noise test has been successfully completed all other checks are done - and must be passed that the scrutineers are satisfied with the structural and safety features of the car.

The exhaust noise test

Race cars are loud, very loud - even the FS ones. Noise from the student-made formula cars can exceed 120dB(C). Noise is part of the fun, but noise control is a concern for all parties involved in motorsports. Loud noise is damaging and may impair hearing. Scientists recommend no more than 15 minutes of unprotected exposure to sounds that are 100 decibels or higher.

Luka Pavlović, the Rimac FS Alpe Adria 2021 organizer, says: "One of the key components during the scrutineering phase of the event is the noise test. Combustion vehicles are noise-limited, the same as your conventional road car or bike is. Teams usually design their exhaust to be as close to the limit as possible in order to extract maximum performance from their engines."

The karting track at Novi Marof Croatia is a great place for such noisy racing events. Due to its isolation, the noise is not really an issue for local residents. The areas around the track are not populated, and not even covered by unspoiled forests or pastures - wildlife is not so fond of noise either.

However, the issue here is the concern for the people on and around the track, participants, officials, and spectators. To pass the technical inspection for the formula student competition, all internal combustion engine cars need to undertake an exhaust noise measurement procedure. That's why the unified Formula Student rules state that the noise levels generated by combustion cars must be within certain limits:

- **CV 3.2** Maximum Sound Level
- **CV 3.2.1** The maximum sound level test speed for a given engine will be the engine speed that corresponds to an average piston speed of 15.25 m/s. The calculated speed will be rounded to the nearest 500 rpm. The maximum permitted sound level up to this calculated speed is 110 dB(C), fast weighing.
- **CV 3.2.2** The idle test speed for a given engine will be up to the team and determined by their calibrated idle speed. If the idle speed varies then the vehicle will be tested across the range of idle speeds determined by the team. At idle the maximum permitted sound level is 103 dB(C), fast weighing.

RPM calculation

The test was performed using a sound level meter. Usually, each team needs to have a dash display or a computer connected to show the engine RPM during the test, but the DewesoftX software offers us a variety of features and gadgets.

One useful feature, in this case, was the FFT analyzer plugin which exposed to us the first - the most dominant - harmonic of the frequency produced in sound made by the combustion process within the engine. With a little "magic" in the math module, we could calculate the RPM of the engine on the base of sound pressure coming from the exhaust.

To verify the RPMs presented by the engine management software of each team, we created a formula to detect engine RPM directly from the microphone signal - without the need for any additional sensors.

We defined a simple formula within the standard DewesoftX software feature, Dewesoft Math, which allows users to set up analysis for their measurement tasks. First, we used a function called MAXPOS - which returns the x-axis position of the maximum amplitude detected within the measured frequency range. As the input to the function, we used the FFT analysis spectra from the measurement microphone.

The output of the function is then the frequency at which maximum amplitude occurs. As we wanted output in the form of RPMs instead of Hz, we multiplied by 60 to achieve the desired units.

As the number of cylinders proportionally multiplies the location of the first harmonic, it was necessary to correct for the varying number of cylinders - the engines used in the race cars are different in design, some use a single cylinder, and others even 4.

The number of cylinders was defined as user input, allowing us to input the right value for each of the tested cars before the measurement. Since the Formula Student requires all of the cars to use 4-stroke engines it was also necessary to correct for the occurrence of exhaust cycle, which happens once every two revolutions - meaning the overall formula had to be multiplied by the value of 2.

In short, the Array function MAXPOS returns the last position of MAX value which was used to get the exact frequency of the rotating engine - the position on FFT is frequency - see figure 7. This was divided by the number of cylinders, multiplied by two, and converted from Hz to RPM - see figures 8 and 9.

As the test requires testing at idle speed and upper RPM limit, we defined a formula to automatize the determination of upper RPM limit. This was calculated and rounded to 500 RPMs with the help of the engine's stroke - defined in mm. This was defined as user input and entered into the software for every team based on the stroke length that was supplied to us by the racing teams.
Such a detection method has its limitations. It is based on the hypothesis that the 1st harmonic will always be the most prominent on the measured spectrum. In some cases, the exhaust design features resonators, blind exhaust pipe sections added to the main pipe to drive the vibration down. In such

Figure 7. The explanation of the MaxPos function in Math module

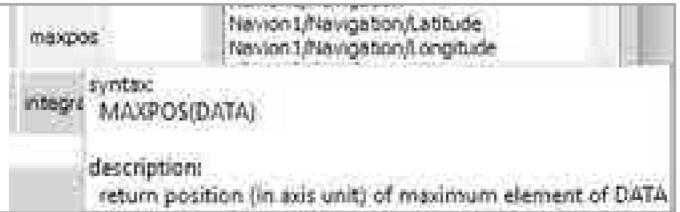


Figure 8. Math function for tracking the RPM from sound pressure waves

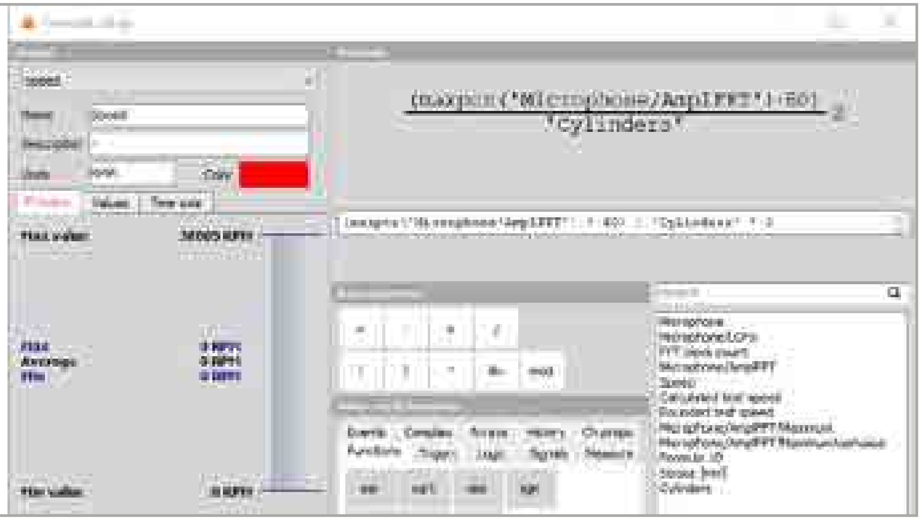


Figure 9. Math function for calculating the higher RPM limit

cases, there might be higher harmonics having higher amplitudes which results in an inaccurate reading of the engine speed.

However, the RPM detection is not required to be performed as part of the noise scrutineering procedure - it was an optional part of the measurement. Because of this and also due to the rare occurrence of incorrect reading, we deemed this method suitable. Based on the feedback from the race team members, showing results during the measurement itself was a useful feature.

Noise test setup

The noise test is performed as a static test - all cars were brought to us. We had put up our tent to have a roof that kept the equipment safe from bad weather. For the measurements, we didn't need a tent. Results from such noise tests can be misleading if you don't take care to avoid reflections from the surroundings. During our testing, the exhaust outlets were facing away from the tent to reduce sound reflection to a minimum.

As the exhaust outlet of any car is in a unique position the microphone must be set specifically to adhere to the FS rules:

- IN 10.1.2 The vehicle must be compliant at all engine speeds up to the maximum test speed, see CV 3.2.1.
- IN 10.1.4 Measurements will be made with a free-field microphone placed free from obstructions at the exhaust outlet level, 0.5 m from the end of the exhaust outlet, at an angle of 45° with the outlet in the horizontal plane.

For the measurements we used:

Hardware:
- A Dewesoft SIRIUSi with ACC amplifier,
- A G.R.A.S. IEPE microphone G.R.A.S. 146AE - half-inch free field rugged microphone IP67 rated with TEDS mounted on a tripod stand,
- A G.R.A.S. 42AG multi-functional calibrator - calibrated by an internationally accredited acoustic calibration laboratory), and
- A laptop computer.

Software:
- DewesoftX RC2021.5 DAQ software
- DewesoftX plugins:
  - Sound Level Meter
  - FFT Analyzer
  - Math module

The complete setup was not only following FS rules but also international standards. The measurement chain - the DAQ system, the microphone, and the SLM software used for analysis - complied with IEC 61672 Class 1 requirements. The microphone was compliant with the 61094 standard for measurement microphones and the level calibrator with IEC 60942 - and it had a valid internationally accredited calibration certificate. Before each measurement, the calibrator was used to ensure that the microphone sensitivity was accurately set for the current environmental conditions.

Figure 10. The noise test setup at the Dewesoft tent

The noise measurements

We set up the measurement system and put the microphone on an adjustable tripod - the decibel meter was ready - see figure 10. The teams then brought their cars to our inspection station and performed an engine warmup. All vehicles must be compliant at all engine speeds up to the maximum test speed.

As the cars are different in design it's sometimes tricky to place the microphone in the right position. It has to be 0.5 meters from the exhaust outlet and at a horizontal angle of 45°. However, the angle and direction of the outlets vary, and in some cases, there are more than one outlet - these all need to be tested separately and the highest noise reading counts. Any active tuning or throttling device on the exhaust must be compliant in all positions.

The teams are aiming to get the maximum power out of the engine - that means that they don't want to "choke" the engines too much. Our measurements showed that quite a few teams were exceeding or on the limit of the allowed noise level.

For reducing the noise level, we noticed a few techniques used by the teams. One was the so-called "dB killer" - a fitting mounted into the exhaust outlet and reducing its diameter making the gas pressure waves bounce and return to the pipe. Others are an extension of the exhaust pipe or turning the direction of the exhaust outlet into free air.

In our case, the FS Rimac Alpe Adria was the last competition of the 2021 season and almost every team had been competing in at least one of the previous competitions. That's why the noise levels were pretty much within the requirements.

Figure 11. Example of noise test recordings in DewesoftX - testing the car from UAS Hannover

When it comes to the measured noise values, the intuitive thought might be that to some extent a small difference in the dB levels is neglectable and that it is sensible to allow some tolerance on top of the prescribed limits.

But in reality, it is important to follow the limits rather strictly - even a difference as little as 1dB in value means a big increase of the measured sound pressure levels. The dB scale is logarithmic and not linear - if the noise level exceeds the required max of 110dB(C) to 111dB(C) it's not just 0.91% too loud but roughly 10%.

Figure 6. The Aixtreme Racing team from FH Aachen at the noise test

Conclusion

We were happy to spend the weekend at the race track in Novi Marof. We had great fun - and the noise tests at the Rimac FS Alpe Adria 2021 were performed in strict accordance with the specified FS procedure and the equipment used was well-suited.

The organizer Luka Pavlović, said: "We invited Dewesoft to help us with the measuring since they are known worldwide for their expertise in sound engineering. As expected they did their job perfectly and professionally, ensuring everything was according to the official Formula Student Rulebook. They even helped some of the teams and gave them some useful tips, after all this is a student competition, it's all about learning and growing."

A key to our success was to follow the procedure. However, our tests were somewhat different from those conducted at events in the past. We introduced a new level of objectiveness by displaying all measurement outputs directly on a large screen - giving the team members immediate insight into their measured noise levels as well as the test procedure - see figure 11.

One of the drivers of the UNI Maribor GPE team, the technical leader Adam Grah said: "I have been in this competition for over three years and I have been to more than six competitions now and I have to say this year's noise test was the most objective and the most impressive I've ever seen, especially as we could see the values directly from the scrutineers themselves".

In conclusion, we gave each team the measured data along with the installer of our latest software version on a USB stick. The teams can now do further analysis of the acquired data and get vital information for further improvements or modifications of their exhaust and engine design.

Dewesoft has for some years been supporting the Slovenian FS racing teams from the universities of Ljubljana and Maribor. The leader of Aerodynamics at the UNI Maribor GPE team Jakob Razdevšek concluded on our collaboration: "Our development process was made much easier by using Dewesoft measurement equipment".

This year's event in Croatia was a blast! All our sensors and the equipment complied with international standards for measuring sound. Our measurements were accurate, repeatable, and most useful. A job well done!

The teams at Rimac FS Alpe Adria

Combustion

# car no.	Team name	University	Country
235	UNI Maribor Grand Prix Engineering	University of Maribor	Slovenia
111	BlueStreamline	Transilvania University of Brasov	Romania
103	Silesia Automotive	Silesian University of Technology	Poland
50	Aixtreme Racing	University of Aachen	Germany
71	Aixtreme Racing	University of Aachen	Germany
12	Infinity Racing	Rennteam der Hochschule Kempten	Germany
84	Campus Motorsport Hannover	Hochschule Hannover	Germany
58	Fsracing Team	University of Mostar	Bosnia
3	FESB Racing	University of Split	Croatia
229	Rennteam Uni Stuttgart	University of Stuttgart	Germany
33	PRz Racing Team	Rzeszow University of Technology	Poland
158	UPBracing Team	University of Paderborn	Germany
30	CTU CarTech	University of Prague	Czechia
360	Weingarten	University of Ravensburg	Germany
35	Road Arrow	University of Belgrade	Serbia
29	KEFO Motorsport	John von Neumann University	Hungary

Electric

# car no.	Team name	University	Country
E68	Delta Racing Mannheim electric e.V.	University of Mannheim	Germany
E53	TU Graz Racing Team	Graz University of Technology	Austria
E91	STUBA Green Team	Slovak University of Technology in Bratislava	Slovakia
E54	FSB Racing Team	University of Zagreb	Croatia
E61	E-Motion Rennteam Aalen	University of Aalen	Germany
E44	Einstein Motorsport	University of Ulm	Germany
E67	eForce FEE Prague Formula	Czech Technical University in Prague	Czechia
E45	BRS Motorsport	University of Bonn-Rhein-Sieg	Germany
E113	E-Agle Trento Racing Team	University of Trento	Italy
E179	Rennschmiede Pforzheim	University of Pforzheim	Germany
E69	Superior engineering	University of Ljubljana	Slovenia
E23	PUT Motorsport	Poznan University of Technology	Poland
E107	Bern Formula Student	University of Bern	Czechia
E49	High-Voltage Motorsports	Friedrich-Alexander-Universität Erlangen-Nürnberg	Germany
E129	Lund Formula Student	Lund University	Sweden
E46	Chalmers Formula Student	Chalmers University of Technology	Sweden
E258	UPBracing Team	University of Paderborn	Germany
E41	TU Wien Racing	TU Vienna	Austria
E16	Formula Student ZHAW	ZHAW	Czechia
E26	Greenteam Uni Stuttgart	University of Stuttgart	Germany
E94	E. Stall Esslingen	UAS Esslingen	Germany

Electrical testing of automotive components

MELECS EWS GmbH

By Konrad Schweiger, Regional Sales, Dewesoft GmbH, Austria

CASE STUDY

Melecs EWS manufactures electronic and electric components for vehicles. The company complies with strict automotive requirements for verification and validation of its products' electrical safety and endurance. A Dewesoft DAQ system has helped them save time through automated testing and at the same time provided a flexible and adaptive solution for future test scenarios.

With a turnover of around 285 million euros and about 1500 employees, Melecs EWS GmbH is the largest electronics engineering and manufacturing service provider with Austrian roots. The company has more than 25 years of experience and offers everything from a single source. From development, engineering, and project management through industrialization and production to validation and logistics. Today, Melecs has more than 90 percent of its sales outside of Austria.

In Austria, Melecs operates an electronics factory in Siegendorf, an electronics R&D facility in Vienna, and a sales and development office in Lenzing. Outside Austria, Melecs runs an electronics factory in Györ, Hungary, and others in Wuxi, China, and Querétaro, Mexico. A sales and development office is located in Auburn Hill / Michigan (USA) and the centralized functions of finance and accounting are combined in a slim holding.

Electronic components from Melecs can be found in:

- ECUs and LED applications in cars of international premium manufacturers
- Household appliances (washing machines, etc.) of the European market leader
- In addition to tailor-made products and solutions for the automotive, lighting, and white goods sectors, Melecs also develops and manufactures electronic assemblies and integrated solutions. This includes equipment assembly for the industrial sector, such as escalator controls or energy-efficient heating systems.

Photo: copyright David Payr

Automotive electrical testing

When testing automotive components, test specifications are first worked out together with the OEM customer. The challenge is, on one hand, to get the components under test first running in an artificial environment. On the other hand, repeatable test conditions have to be specified. This often requires the use of more different software tools, as well as deep knowledge of the final application.
One of the most important norms in the automotive industry is the LV 124. It was drawn up by the representatives of the German automobile manufacturers like Audi AG, BMW AG, Volkswagen AG, Porsche AG, and others in 2013. LV 124 specifies various electrical tests, their requirements, and conditions.

The LV 124 is a series of tests that simulate electrical disturbances in an automobile's electrical system during driving. It includes 22 quality and reliability tests for electrical, electronic, and mechatronic components for 12 V electrical systems used in motor vehicles weighing up to 3.5 t.

All e-tests belonging to standard LV 124 can be individually selected and added to the desired test procedure - a customer-configurable and customizable test procedure is possible:

- E-01 Long-term overvoltage
- E-02 Transient overvoltage
- E-03 Transient undervoltage
- E-04 Jumpstart
- E-05 Load dump
- E-06 Superimposed alternating voltage
- E-07 Slow decrease/increase of the supply voltage
- E-08 Slow decrease / quick increase of the supply voltage
- E-09 Reset behavior
- E-10 Short interruptions
- E-11 Start pulses
- E-12 Voltage curve with electric system control
- E-13 Pin interruption
- E-14 Connector interruption
- E-15 Reverse polarity
- E-16 Ground offset
- E-17 Short circuit in signal circuit and load circuits
- E-18 Insulation resistance
- E-19 Closed-circuit current
- E-20 Dielectric strength
- E-21 Backfeeds
- E-22 Overcurrents

Several, only slightly differing, variations of the LV 124 test series are used by car manufacturers around the world. The testing has even been standardized as ISO 16750. This international standard describes the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on/in the road vehicle.

Test setup

Mr. Suat Dostal, Group Leader of Electrical Validation, gives some insights about the device under test (DUT) in this case. The MELECS GEN VI is an oil pump control unit operating in an all-wheel transmission gearbox. The recent design is even more compact, while still meeting all requirements of today's modern automotive components.

“As the automotive business is known to be most demanding, customers often require testing done far sharper than the legal requirements. Furthermore, OEM's specify additional testing routines”, explains Mr. Suat Dostal.

Figure 2. The DUT, a MELECS GEN VI gearbox oil pump for all-wheel-drive.

DAQ hardware and DAQ products

- SIRIUSi-8xSTG data acquisition unit
- 1 current clamp for DC input current
- 3 current clamps for 3phase AC output current, driving the pump
- 2 test voltages of the DUT
- 1 input voltage from the battery simulator
- DSI-TH-K for temperature measurement (thermocouple type K)
- 1x CAN bus, communication with the DUT

DAQ software

- DewesoftX

The Melecs engineers considered two instrument options. The Dewesoft IOLITE system offers a good price to performance ratio at a high channel count, for medium sampling rates. However, since for this test, a high sampling rate of 200 kHz was needed, and not many channels. The testing department decided to go with the SIRIUS system this time.

Melecs is using power amplifiers to generate the needed test signals for in-vehicle battery supply simulation, following standard LV 124. Relevant for this test is the voltage curve E-11, which specifies the starting impulse in a vehicle.

The voltage breaks down for a short time, then starts ringing, before it rises back to the normal level of e.g. 11 V, which simulates a really bad borderline case. (See figure 3) The DUT has to withstand all these supply breakdowns and afterward still stay operational.

Testing

All tests specified by the standard LV 124 - and more - were performed. Some of these tests even contain several sub-routines specified by the automotive OEM. Here are some examples:

- The E-06 "Superimposed alternating voltage" stresses the DUT by superimposing an AC voltage on the battery DC voltage, to simulate interferences on the board net. As per standard this sweep usually goes up to 30 kHz, but some OEMs require testing up to 200 kHz.

Figure 1. The Melecs team for testing and validation.

- The DUT was tested for powering up correctly for 100 cycles with the E-11 signal.
- In addition, the OEM specified to test multiple on/off-switching cycles at different environmental temperatures

In the end, all tests went successfully.

Raw data storing and live test validation

"At Melecs we are using many different instruments. We have both the fast oscilloscopes and the classical data loggers", Mr. Dostal explains. "These tests can be done with an oscilloscope. However, Dewesoft closes the gap in between the two types of instruments - it perfectly fits our application."

Data loggers work standalone but with limited functionality because of the onboard operating system, and sometimes have poor visualization. Oscilloscopes achieve very high sampling rates up to some GHz, but getting several instruments synchronized for a higher channel count is quite expensive. Based on the Windows operating system they can be extended by scripts, but memory price is quite high.

For both instruments acquiring additional bus system data (like CAN, CAN FD, Flexray,...) is often not possible. You need to post-synchronize data from several instruments after the measurement. Sometimes it is a long way from the measurement task to get the first impression of your data.

The testing group leader, Mr. Dostal says: "With Dewesoft software, we store the full raw data, not just screenshots. Later, in conference calls, we simply pull out the corresponding data file, zoom to the position. It's much easier to comprehensively demonstrate and argue the testing results to our customer. Down to the single sampling point, we can show each of the 100 test cycles individually.

Figure 4. Test setup with Power Amplifier, DUT, and Dewesoft SIRIUS data acquisition system

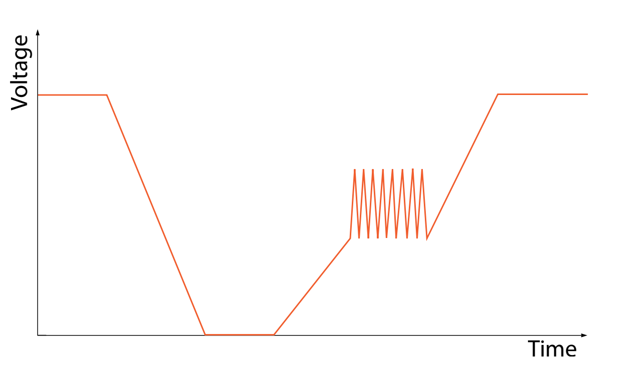


Figure 3. The E-11 starting pulse simulation signal from the LV124 standard.

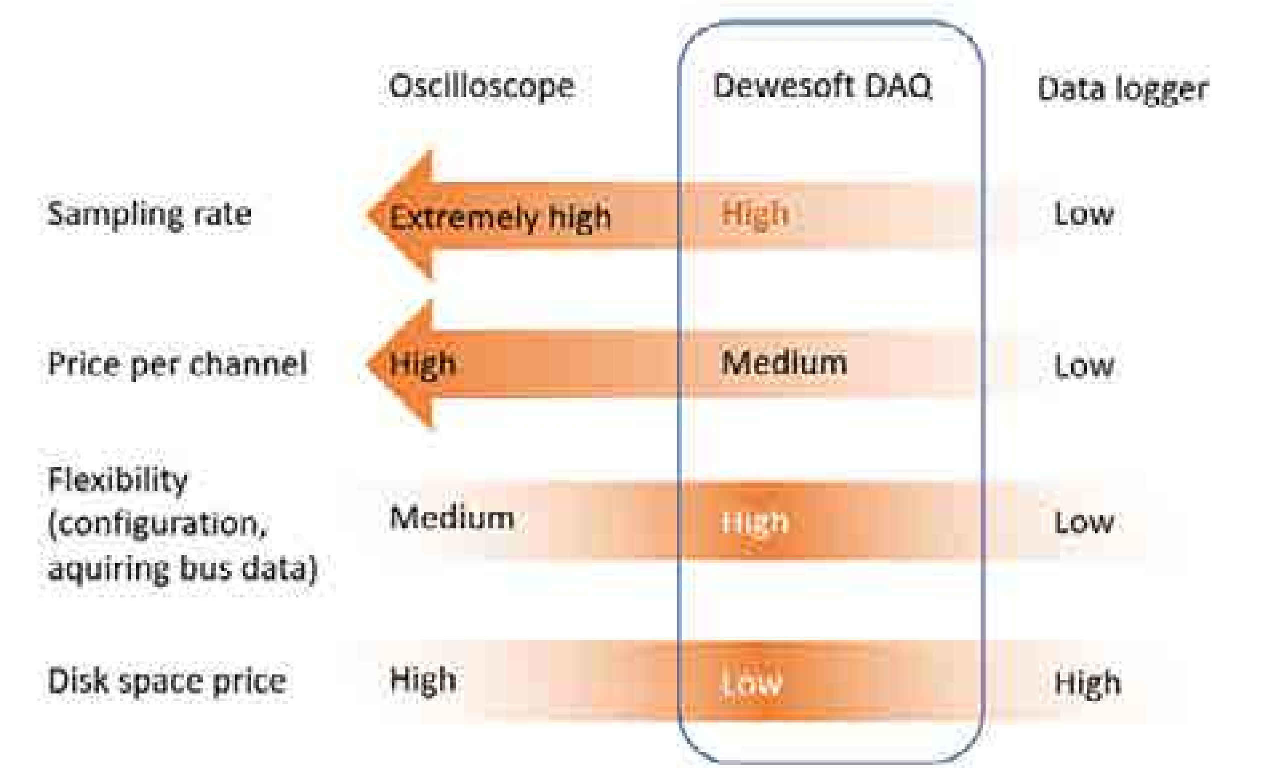


Figure 5. Dewesoft DAQ is the ideal equipment for electrical testing applications.

Conclusion

With the new system, testing is done autonomously. Melecs engineers can now even line up a series of tests, or as customers sometimes require a 72 hours continuous test, have these running during the night. Setting up the tests is usually what is most time-consuming. During the first 9 months of using the Dewesoft equipment, the Melecs engineers were able to save around 1 month of working hours.

The adaptability and flexibility of the system are an additional bonus. The SIRIUSi-8xSTG data acquisition unit has 8 isolated analog inputs for universal usages. Those are strain gauge, voltage, resistance, potentiometer, RTD (PT100, ...), extendable, and even more flexible with optional Dewesoft DSI-adapters. More measurement modules can easily be stacked for an almost unlimited number of channels, math functions, filtering, C++ scripting, etc. for live calculation and validation of the system under test.

The DewesoftX software is Windows-based - the available memory only depends on the PC's integrated SSD and RAM. The software fully accesses the available CPU power, features such as hyperthreading, SIMD and 64bit architecture ensure maximum performance. The DewesoftX software provides one software for data acquisition and analysis.

"Additional features like the Sequencer, like getting other instruments data into Dewesoft, and the divers trigger conditions are very interesting for our kind of application," Mr. Dostal concludes.

All in all, the solution is time-saving and opens opportunities to fit future needs.

Brake pressure test on buses

Brake component manufacturer
By Leslie Wang, Support Engineer, Shanghai, Dewesoft China

CASE STUDY

The brake system is rather complex in the vehicle. It consists of many components and parts, and any minor failure of one component could cause the failure of the whole system.

A Dewesoft customer, a vehicle brake manufacturer in China, needed to check whether a specific brake problem was caused by brake line pressure imbalance. Previously the customer did not perform this kind of troubleshooting. Now a Dewesoft measurement solution, including a DEWE-43 data acquisition system with a pressure sensor and Dewesoft X3 software, does the job.

Of all the systems that make up a car, the brake system might just be the most important and vulnerable one – it ensures basic safety in driving. Such systems contain a variety of parts:

- brake pads,
- brake drums,
- brake discs,
- brake calipers,
- brake shoes,
- wheel cylinders,
- backing plates,
- brake cables,

which are all consumable accessories.

The issue – deviation when braking

Most motor vehicles feature hydraulic brake systems, and the brake lines are flexible hoses transferring the pressure from the driver's foot on the brake pedal into stopping power. The brake fluid is stored in the master cylinder and is transferred from the master cylinder to the brake calipers via the brake lines when the brake pedal is pushed. This pressure forces the calipers to clamp down on the brakes and, in turn, slow and stop the vehicle.

The brake lines are essential to keep the vehicle safe on the road, if they fail or aren't reliable, it means serious trouble. So, this kind of testing is general in the vehicle industry.

Our customer, a vehicle's brake component manufacturer is supplying their products to commercial vehicles and buses.

Figure 1. Measuring and test connection diagram.

Their customers notified them that a bus that used their brake components always deviated when braking. They wanted to check whether an imbalance of the brake line pressure caused the brake problem or if the brake calipers and brake discs were responsible for the failure.

The solution – DEWE-43A data acquisition system

To do this troubleshooting, the customer used a Dewesoft solution to test the brake line pressure. The measuring system consists of the data acquisition unit DEWE-43A, data acquisition software Dewesoft X3, third-party pressure sensors type WIKA S-10 - see Figure 1.

DEWE-43A is a portable and robust data acquisition system. It weighs under two pounds and is small enough to fit in a hand.

The unit is cut out of a solid block of aluminum by CNC - see Figure 2.

DEWE-43 has 8 universal analog inputs, 8 digital/counter/encoder inputs, and two high-speed CAN bus inputs. Each channel provides power for sensor excitation, and each channel, either analog, digital, or CAN is synchronized with microsecond accuracy. DewesoftX, the award-winning advanced data acquisition, data recording, and data analysis software, is included with the hardware.

With plug and play functionality the DEWE-43A is suited for various dynamic data acquisition applications. It has universal analog inputs and can accept voltage and full-bridge signals natively as well as IEPE, charge, thermocouples, half-bridge, quarter bridge, RTD, current, resistance, and LVDT signals with the use of DSI adapters. The sampling rate is up to 200 kS/s per channel, with 24-bit sigma-delta ADC. Each channel provides power for sensor excitation.

Dewesoft X software for data acquisition (DAQ), data recording, and data analysis are included in Dewesoft data acquisition systems.

Compact and rugged, WIKA S-10 pressure transmitters are designed for industrial pressure measurement applications, including hydraulics and pneumatics, vacuum, liquid level measurement, press control, compressor control, pump protection, and other processing and control operations - see Figure 3.

The pressure sensor used is a 3-wire type, WIKA S-10 sensor. Its measuring range is 0~150 bar, the output is 0~10 v, the media temperature is -30 ~ +100 degrees Celsius, and the operation temperature is -20 ~ +80 degrees Celsius.

Figure 3. WIKA S-10 pressure transmitter.

Figure 4. The testing site is the customer's repair yard and a DEWE-43 A with a laptop is placed under the bus.

Figure 2. DEWE-43 data acquisition system.

Figure 5. Pressure sensor installed in the brake chamber with tee coupling.

Figure 6. Pressure sensor installed in the upper cavity main valve with tee coupling.

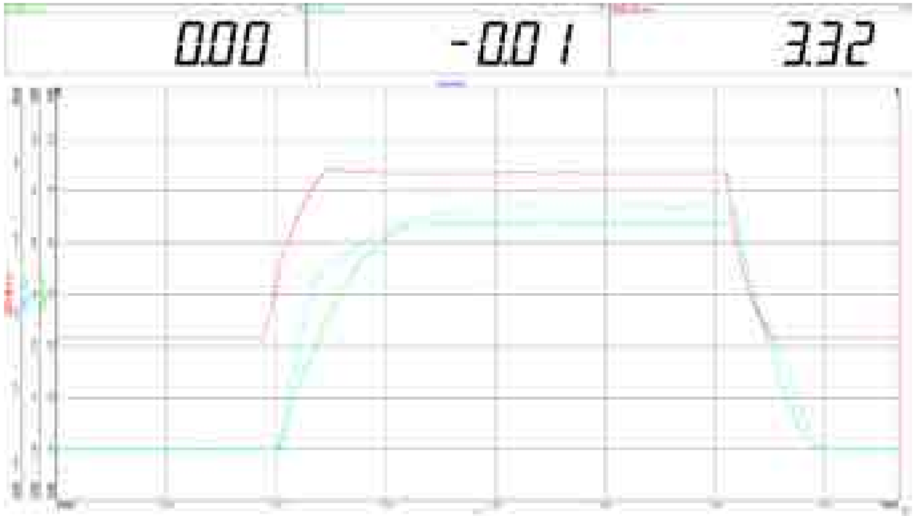


Figure 7. The pressure curve of the upper cavity main valve and two brake chambers.

Brake line pressure measurements

Using DEWE-43 with pressure sensors to measure the brake line pressure, obtains the pressure value and pressure curve of the main valve and brake chamber of the carriage wheel. - see Figures 4 and 5

In this case, the customer is limited by the number of pressure sensors. Only four pressure sensors are available, meaning that both the front axle system and back axle system cannot be measured at the same time. The front axle system was chosen to be measured.

One pressure sensor is installed in the line of the upper cavity main valve. Two other sensors are installed with tee couplings in the pressure line of the front-right brake chamber and front-left brake chamber. Measuring cables connect the pressure sensors and analog input of DEWE-43A.

Because of the test conditions, the testing is static, the pressure of the brake master pump inflate is about 10 bar.

The brake is hit, activating the brake system, and the curve of pressure is recorded. The curve is then analyzed among others to establish whether the top brake pressure of the right and left brake chamber is equal and if the timing of the right and left brake chamber is simultaneous. Dewesoft X3 is in this case only used to record the pressure values and curves.

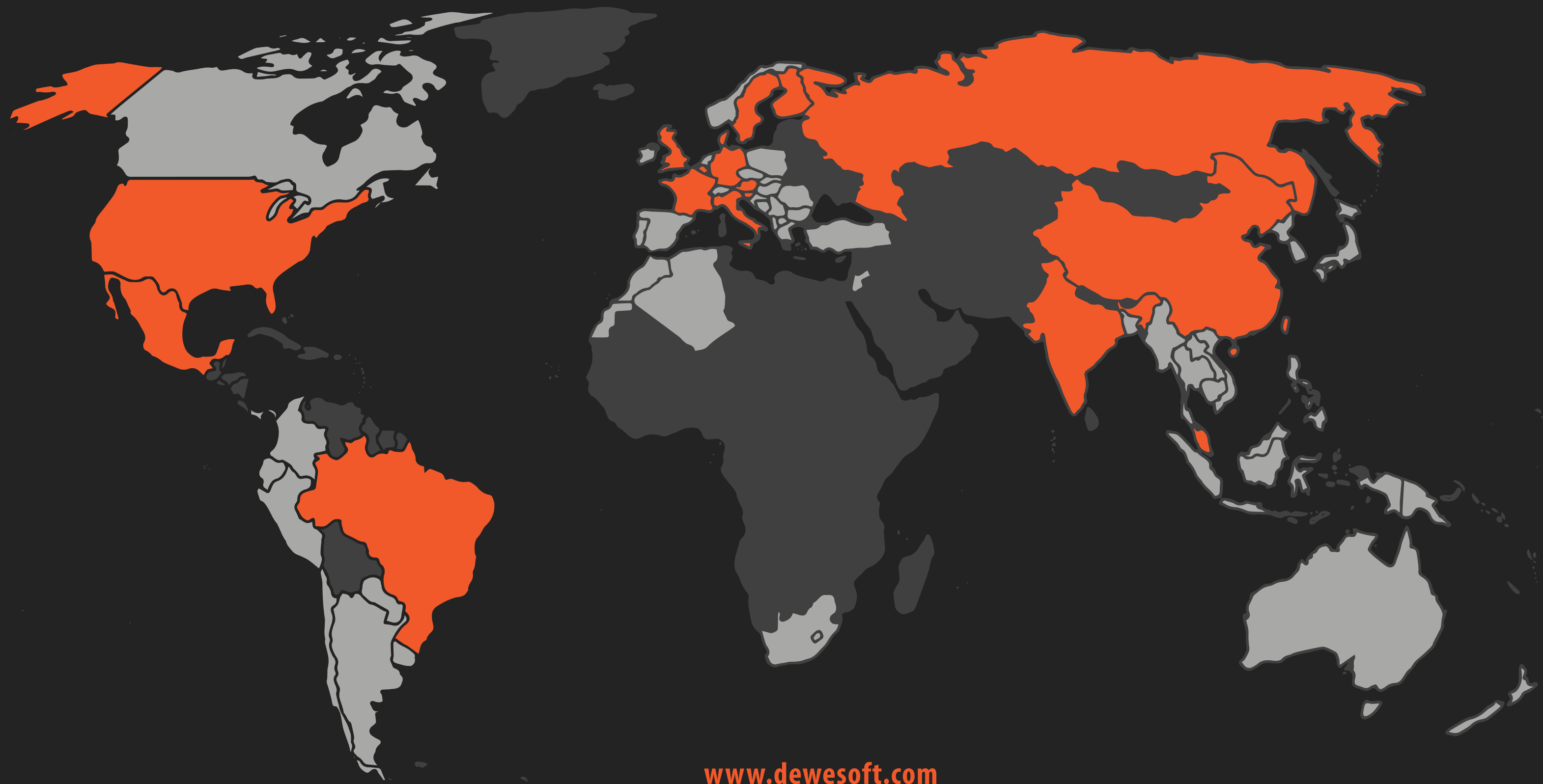
In the software, two statistical channels are added to calculate the Max pressure value of two brake chambers. The front-right brake chambers are 4.38 bar, and Front-left was 4.73 bar. Then we zoomed in on the pressure rise part, and used the double cursor, to see the time difference in timing between the upper cavity main valve and that of the brake chamber working. It was about 55ms.

This way the recorded curve of the data helps the customer to find the braking deviation caused by brake line pressure imbalance - see Figures 5, 6, and 7.

Conclusion

Previously, the customer did not perform this kind of testing, but the DEWE-43A, as a small, flexible, easy to use product, helped the customer to gain valuable new insights.

More Dewesoft data acquisition systems were already used by the manufacturer. They are connected or expanded if more channels are needed in the future when the customer intends to add the GPS module and pedal force sensors.



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