CASE STUDY

Ohio State University Sets Electric Vehicle World Land Speed Record

Heavy-Duty, Dual Channel AV-900 Test System Takes Buckeye Bullet from Lab to Speedway

BACKGROUND

Power. A lot of it.

Setting a world land speed record for electric vehicles can't be accomplished without it. A lot of it.

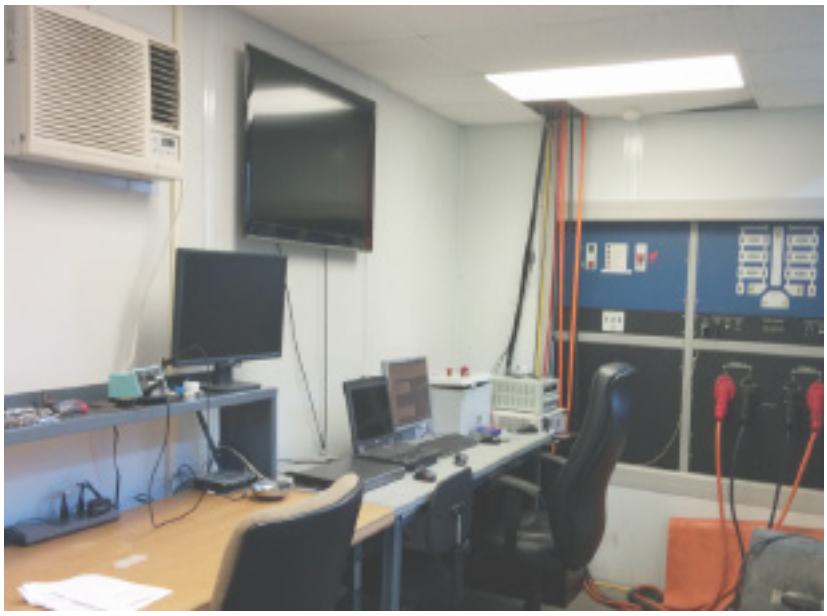
No one knows this better than the team at The Ohio State University's (OSU) Center for Automotive Research (CAR), who, in conjunction with French automaker Venturi Automobiles, were able to set this record in 2010 – and then again in 2016. The third generation of the student-built Venturi Buckeye Bullet (VBB3) holds the record of being the world's fastest electric car, with an average speed of 341.4 mph and a top speed of 358 mph. A 38-foot long, 8,000 pound vehicle with 1.5 megawatts of power divided into two traction axles and a primary braking system consisting of a parachute, the VBB3 represents a truly unique electric automotive project.

With a 24-year history of electric racing, OSU's Center for Automotive Research has made pushing the envelope of EV technology a huge focus. OSU students use an experiential learning process as they work to design and build EVs that rival internal combustion engine powered vehicles – and shape the future of the automotive industry.

For the past 3 years, the OSU team has headed to Utah's Bonneville Salt Flats to compete with the latest generation vehicles in a series of races known as Speedweek. Because the VBB3 is only in use once per year at this race for a 3-week period of time, OSU students must rely on extensive laboratory and bench testing the rest of the year. Among other things, this testing is conducted on one of its most critical components – a 2-MW 900-V battery pack – to ensure peak performance once the rubber actually hits the road. The VBB3 only needs 90 seconds to reach 400mph on a 6 mile track. Using a combination of off-the-shelf components to perform these tests had proven problematic in earlier versions of the vehicle. These makeshift test setups did not offer the flexibility, accuracy or controls needed to properly model, design and test EV battery packs and drivetrains. The OSU team needed a reliable, high-voltage, high-power DC power supply with advanced capabilities for battery pack cycling and electrical drive testing.

TESTING FOR PEAK PERFORMANCE

Knowing that real-world simulation and optimization in a lab environment would ensure better results at the Salt Flats, OSU turned to Webasto and its 900 (CE) test system.

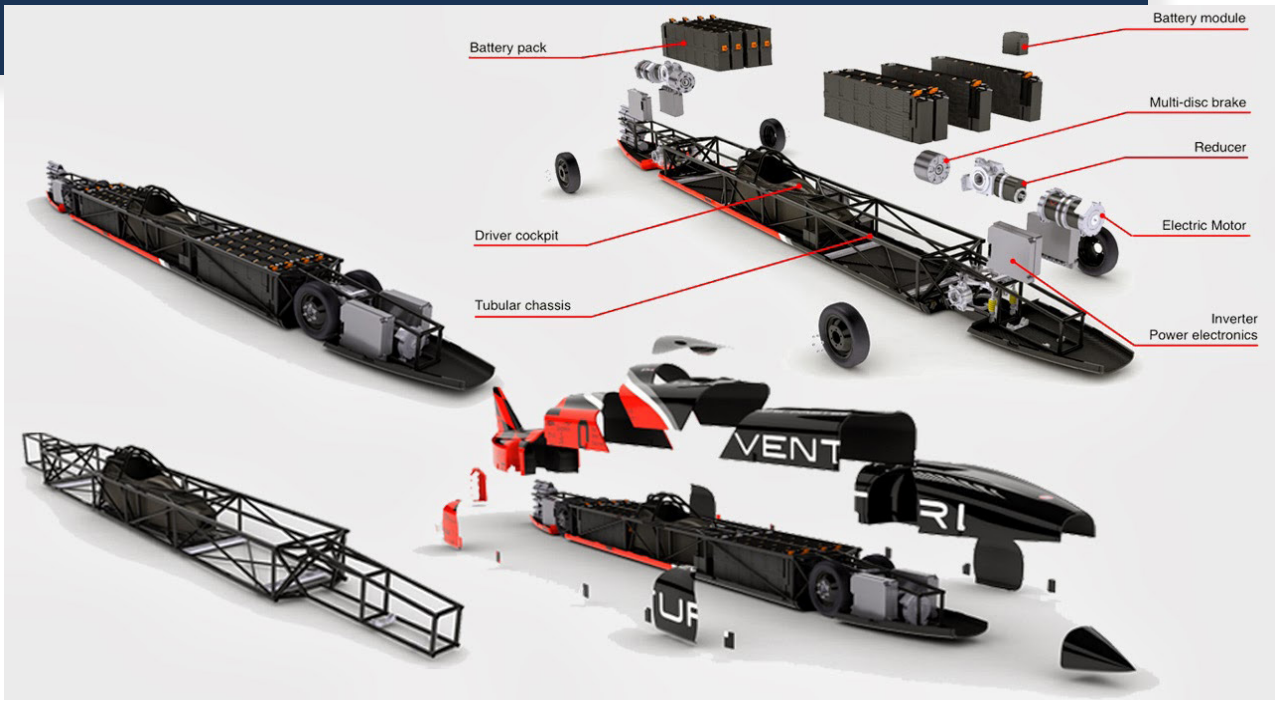


Widely regarded as the global benchmark for high-power testing, the 900 (CE) is ideal for testing and emulating energy storage and drivetrain components of electric and hybrid electric vehicles –precisely what the OSU team needed.

The OSU team had very ambitious goals for the VBB3's test bench. In collaboration with OSU research staff and Venturi Automobiles, the student engineers developed a completely custom motor dynamometer to evaluate the vehicle's powertrain performance at high speed and high power, using a hardware-in-the-loop approach. The VBB3 powertrain architecture is very complex, it is divided into two powertrains (front and rear) each with its own transmission, two permanent magnet electrical machines, two inverters, and four battery packs. The layout is the result of a complex optimization algorithm to ensure the stability and efficiency of the world's fastest electric vehicle. The testing of the powertrain is not a trivial challenge considering the power range, voltage level, and the complex control structure. The OSU team developed a 1-MW 900-V test bench to test the drivetrain performance, efficiency, and control algorithm across the entire operating range before the implementation in the actual VBB3 vehicle. The test bench is able to emulate the real-world road load while racing. With the 900 (CE), OSU is able to test the drivetrain components (individually or together) accurately emulating the battery pack's behavior thanks to HIL technology. Additionally the VBB3 battery pack was cycled using the 900 (CE) to evaluate the parameters of the temperature-dependent mathematical model of the battery technology selected for the project. This set-up greatly reduced the development time and cost – and increased the chances for success on the racetrack.

“The 900 (CE) enables us to push EV technology to its limit – and beyond – without risking the Venturi Buckeye Bullet’s systems. With help from Webasto’s training and support services team, we are able to accomplish things that we never even dreamed possible, and are empowering the movement for EV adoption.”

Matilde D’Arpino
Research Associate, Center for Automotive Research, Ohio State University



The 900 (CE) contribution to OSU setup is remarkable. With 900-V and 250-kW, the 900 (CE) is a perfect fit to regulate the test bench DC-bus and to supply the power necessary for the back-to-back configuration. The bidirectional control of the power flow of the DC-bus from Webasto allows the OSU team to easily perform tests, including replication of fault conditions without the necessity of additional components, such as a braking chopper. Additionally, the team has been able to further optimize testing time by utilizing the device in its dual channel mode which allows the power to be split and two independent tests to be performed at the same time.

The 900 (CE)’s high connectivity with automotive communication busses allows for the remote control of the cycling process of battery packs and the emulation of the VBB3’s lithium-ion-testing of the vehicle’s drivetrain with a hardware-in-the-loop testing process (HIL). The use of CAN communication allows for easy integration of industrial components in the OSU test setup, and the bidirectional nature of the 900 (CE) allows for both the charging and discharging of batteries during the cycling process.

During the vehicle design process, OSU student engineers also utilized the 900 (CE) to perform qualification testing of different battery pack designs to determine the best technology for the system. Everything from electronics and control systems testing, to motor qualification testing can also be optimally performed in the lab.

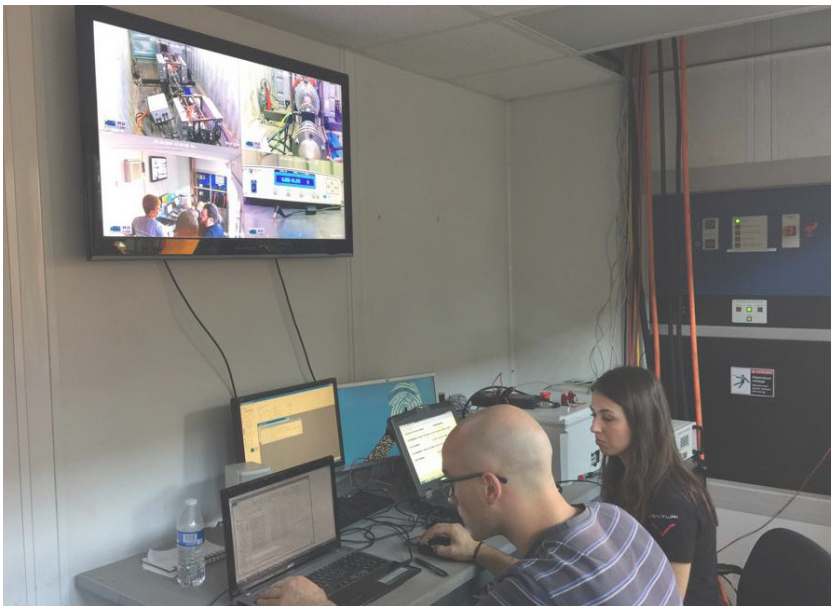
900 (CE)’s galvanic isolation and low harmonic distortion help the OSU team to perform quality high-power testing in a very safe manner, all while avoiding disturbances to the electrical network.

Rugged And Reliable – In Less Than Ideal Conditions

When the OSU team heads out to the Bonneville Speedway every year with the VBB3 – the 900 (CE) comes along as well. Built to be rugged and resilient, the 900 (CE) is able to handle the long trip, rough terrain and salty environment it encounters at the Bonneville Salt Flats. The 900 (CE) does not need an external cooling system, so the installation at the Bonneville Salt Flats is very easy and just related to the electrical connection.

The OSU team relies on the 900 (CE) to charge the VBB's batteries before races – they have around 30 minutes to precisely charge the 92 kWh battery pack. The two channels of the 900 (CE) are used in parallel to charge the front and rear battery packs of the vehicle. The precise current tracking by the 900 (CE) is a very important feature to optimize the charging time while maintaining a high level of safety and confidence in the charge.

The charging protocol has been implemented with MATLAB software and, using CAN bus communication, it allows the team to charge the vehicle between runs – guaranteeing efficiency and ruggedness. The best part is that the process is entirely automated, allowing the team to focus on the race ahead.



A 'PIT CREW' That Goes Above and Beyond

The OSU team was having some issues with 900 (CE) before last year's racing event, but a weekend call to Webasto's tech support team gave them all of the answers needed fix the issue. After hours and hours of high power testing, the 900 (CE)'s internal safety sensors tripped for over-temperature. The internal cooling fluid level was not optimal and an automated safety switch disabled the 900 (CE) operation. Webasto's tech support worked with the student engineers to resolve this problem in only a few hours. The world land speed record for electric vehicles was set just two days later.

The 900 (CE) has been a very welcome addition to our lab. It's so easy to use that we didn't even open the instruction manual that accompanies it. By allowing us to accomplish most of the 'heavy lifting' needed before we even get to the Salt Flats, the 900 (CE) has become an invaluable member of our engineering team."

Matilde D'Arpino
Research Associate, Center for Automotive Research, Ohio State University

FULL SPEED AHEAD

The VBB3 and the cutting-edge technology inside it are paving the way for the EVs of the future

By enabling engineering students to extensively and accurately test batteries and electrical drives, Webasto is furthering the reputation it has gained over the last four decades as pioneers of the EV movement.

What's next for OSU's student engineers? Further optimizing and testing of the VBB3 to hopefully shatter its own land speed record. 400 mph or bust!

Webasto

PRODUCT DESCRIPTION

The 900 (CE)/900 CE is Webasto's heavy duty test solution. With greater voltage, current, and power capability, this system is ideal for testing and emulating energy storage and drivetrain components of large electric and hybrid electric vehicles (HEV), such as buses, trucks and military vehicles. The 900 (CE) is deployed worldwide to support the development of fuel cell buses, hybrid locomotives and other HEVs. All AV power cycling systems are equipped with a real-time clock on the system's control board that enables measurement of Ah and kWh during cycling. Learn more by visiting our website: webasto-electrified.com/en-us