SIMULIA

3DEXPERIENCE®

TAKE THE LEAD IN ELECTRIC VEHICLES

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Electric vehicle sales are increasing year on year, and several significant jurisdiction have already committed to phase out fossil fuel cars in the coming decades. The electric mobility transition will be one of the biggest transformations in the history of the automotive industry. Companies that seize the initiative on electric vehicles have the potential to grow rapidly and gain an advantage in a competitive market.

Vehicle electrification completely upends many fundamental assumptions of car design, and taking the lead in the field will require revolutionary insights. Simulation enables engineers to analyze and optimize electric vehicle concepts from the very beginning of the design process and discover ideas that improve vehicle performance, efficiency, drive experience and aesthetics.

The Dassault Systèmes **3D**EXPERIENCE® platform offers an integrated solution for electric vehicle design. It brings together systems engineering, modeling, simulation and project management tools, and enables collaborative working as well as making the development process more streamlined. This whitepaper focuses on the simulation tools from SIMULIA, a brand of Dassault Systèmes, for numerous electric vehicle applications, including electric drive and battery engineering. Integration of multiple simulation tools and products from other Dassault Systèmes brands, such as CATIA, on the **3D**EXPERIENCE platform allow the creation of a **3D**EXPERIENCE twin—a virtual replication of the complex vehicle system for fast and flexible performance assessment and optimization. This approach makes it easy to utilize simulation in the design and verification process to cut development time and costs without compromising on quality.

INTRODUCTION

Electric vehicles that were developed and sold in the past decade catered primarily to luxury vehicle clients. That will change as it is estimated that by 2027[1] the cost of ownership will be on par with the cost of ownership of Internal Combustion Engine (ICE) vehicles, in parallel with the expansion of EV models. In addition, improvement in electric vehicle range has already supported the sales of EVs today.

Most electric cars on the market currently are targeted at the high-end of the market—sports and luxury—but as battery and motor costs come down, these technologies can be adopted by other market segments as well. This will be a crucial turning point for the automotive industry, and companies that can establish themselves in the EV market will hold a dominant position in the years to come.

The transition from IC to battery electric vehicles brings both new challenges and new opportunities. Removing the engine block opens up considerable space within the vehicle and allows body concepts that would not otherwise be possible. Sealing up the front grille makes the car more aerodynamic, and the electric motor is much quieter than an engine and demands different cooling strategies to be adopted.

Challenges meanwhile include placing the large, heavy batteries in the vehicle and keeping them cool, achieving the range that customers expect, and delivering a satisfying experience for drivers and passengers used to petrol and diesel cars. Durability and battery degradation simulation models the behavior of EV components across their entire lifespan, allowing years of use to be modeled analyzed within hours.

Converting core competency of the traditional vehicle manufacturers' development work from ICE to EV technology will require a significant amount of training and new expertise. Thus, a democratized vehicle development process, connecting design and engineering, will be key to speeding up time to market.

The driver and passenger experience itself is increasingly important in the automotive industry. Many buyers of electric cars are expecting the experience and performance of a luxury sedan or a sports car, and even as other market segments electrify, the car that has the most comfortable and enjoyable driving experience will have a big competitive advantage. Dassault Systèmes has long focused on the importance of consumer experience, and its simulation tools can be used to optimize the look, feel, comfort, noise and handling of electric vehicles and to ensure that they can fully compete on performance characteristics such as speed, acceleration and range.

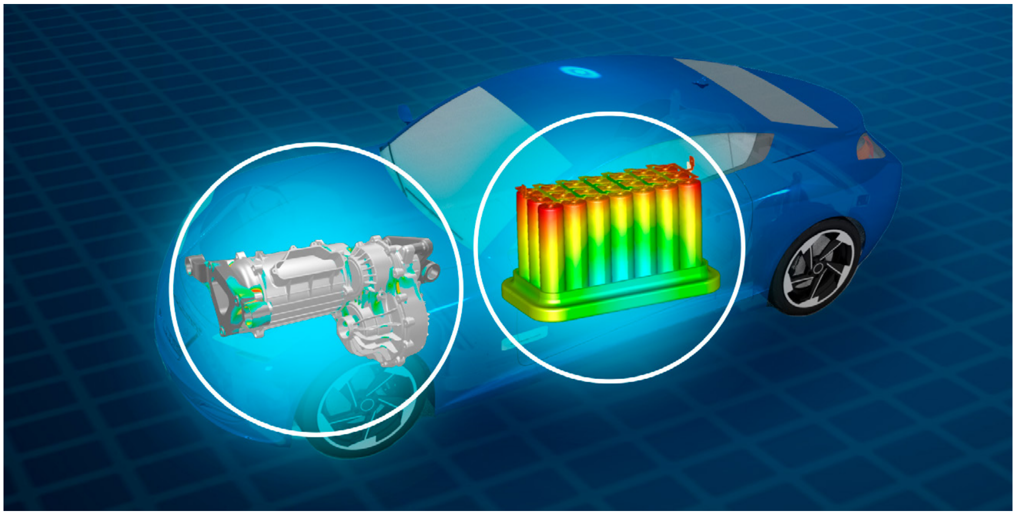
BENEFITS OF SIMULATIONS

Simulations can be used to build virtual prototypes quickly and cost effectively. Instead of having to physically construct and test prototypes and concept vehicles, designs can be built, analyzed and tested using computers. CAD data can be converted directly into simulation models with minimal effort, and test realistic operating scenarios can be replicated in the virtual environment. This reduces the number of physical prototypes needed, reduce cost associated with physical testing in testing facilities, cutting costs and development time, and it also allows innovative and radical design concepts to be tested earlier in the design process. Simulations will also play a critical role in optimizing the design of electric machines to minimize the use of rare earth and scarce materials and to evaluate design alternatives. For battery systems, simulations can ensure favorable thermal conditions are met at all operating conditions and that the vehicle range is not adversely impacted.

Simulations can also replicate real world environments that cannot be modeled in the laboratory. For example, the aerodynamics of a vehicle on the road may be very different to a wind tunnel, as the road surface and surroundings influence the air flow. It also reveals effects that are otherwise invisible, such as the distribution of temperatures inside a battery to find a hotspot, or the propagation of electromagnetic waves around a motor to identify the cause of interference issues. Simulation offers engineers insights that would simply not be available through measurement alone.

To gain widespread acceptance, battery electric vehicles need to rival internal combustion vehicles on metrics like range and performance. Automatic optimization powered by simulation finds designs that achieve the best tradeoff between these often competing factors.

Simulations also help ensure quality and avoid costly and embarrassing recalls or warranty claims. Motors need to last for many years, and batteries need to withstand thousands of charging cycles.



Simulation of an electric powertrain.

BATTERY ENGINEERING

Rapid technological advances are increasing capacity, charging speed and life span of EV batteries, but the battery is still the largest and most expensive electrical component in the electric car. Large currents are delivered to the battery during charging, and drawn out from the battery during driving. This generates massive amounts of heat that need to be safely dissipated.

Batteries are also subject to various structural stresses and vibrations that they need to withstand. They also need to be crashworthy to avoid the risk of leaks and fires, and the battery's total life span needs to be known to avoid safety issues or warranty claims.

SIMULIA software offers the simulation tools needed to solve the challenges of battery engineering and placement. Fluid dynamic simulation can be used to analyze both liquid-cooling and air-cooling systems. Temperature changes can be simulated over time, in a range of different weather and driving conditions. The flow of air through the battery module and pack can be visualized in order to identify potential hotspots, evaluate different cooling strategies and the cooling fan design optimized to minimize noise while meeting cooling requirements.

Structural considerations, such as the effect of road vibrations or how much deformation the battery can be tolerated without rupturing, can also be taken into account. Impact simulations virtually test the crashworthiness of the battery module and pack without the cost of manufacturing numerous crash testing prototypes. The battery unit can be optimized to ensure structural integrity while minimizing weight.

The electronic battery control system is an important part of the EV system. Electromagnetic simulation models the currents and fields in the electrical and electronic components in and around the battery. The risk of interference from power electronics can be identified and mitigated, and the exposure of passengers to high-power electric fields can also be characterized. The link between electromagnetic and thermal simulation also allows the heating of electronics and cables to be accurately predicted.

The battery doesn't exist in isolation, but is deeply embedded in the vehicle as a sub-system. System-level simulation connects the battery model to the other components in order to analyze how they interact. Engineers can ensure the battery will function harmoniously with the other elements of the vehicle, and examine how the battery behaves under different usage scenarios.

For more complete analysis, products from other Dassault Systèmes brands such as BIOVIA for chemical modeling and CATIA for cell and system level analysis can be added into the workflow. The **3D**EXPERIENCE platform brings together Dassault Systèmes software across brands, making it easy for users to share their data and to combine different design and simulation tools on one project.

Electromagnetic simulation of an electric drive.

ELECTRIC DRIVE ENGINEERING

For electric vehicles to become mainstream, high-torque and high-efficiency motors need to become affordable, reliable and lightweight. Electric motors are extremely multiphysical, with interactions across disciplines: electromagnetic, thermal, strength, durability, noise & vibration, fluid and multibody simulation all have roles to play.

Electromagnetic simulation is vital to understanding and maximizing the motor performance. Not only can fields and currents inside the motor be visualized, but the size, placement and geometry of magnets, coils and other components can be automatically optimized. The rotational behavior of the motor can be simulated in motion to analyze transient effects such as cogging torque. The simulation can also generate an efficiency map, showing motor efficiency at different speeds and torque, which can be used to improve motor efficiency and vehicle range.

Both electric currents and friction lead to significant heating in the electric motor. The electric drive is typically liquid cooled, and the cooling systems needs to be able to operate even at high speeds in challenging climatic conditions. Simulation calculates heating within the motor, allowing engineers to find the optimal cooling system given the trade-offs of weight and size.

Lubrication is another issue. In order for the electric drive to operate at maximum efficiency, surfaces inside the motor must be properly lubricated, but at the same time, mechanical power losses from the lubricating oil must be minimized. Advanced fluid dynamic simulation models the flow of oil inside the motor, including effects like splashing. Engineers can use this data to optimize the oil volume needed, which not only minimizes power losses, but also reduces the size and weight of the drive housing.

Electric vehicles generate far less noise than equivalent internal combustion vehicles, but the noise they do produce has very different characteristics. The motor noise tends to be tonal instead of spanning a wide frequency spectrum. Noise and vibration simulation characterizes motor noise and identifies the sources of specific kinds of noise. The ride experience can then be improved either by engineering the motor by insulating the cabin for those frequencies.

Finally, the different areas of simulation were brought together for strength and durability simulation. The electromagnetic and thermal data is combined with a structural simulation of the motor's components in order to calculate the strain on the motor components. Multibody simulations are needed to model all of the different shafts, gears and bearings together. Durability analysis calculates the fatigue life of the motor under these strains, allowing manufacturers to reduce the risk of warranty claims.

OTHER AUTOMOTIVE SIMULATION APPLICATIONS

The role of simulation in electric vehicle design goes far beyond just the electric components. For many aspects of design, electric vehicles can be simulated using the same workflows created for conventional vehicles. These include aerodynamics, crashworthiness, suspension, cabin comfort and tire engineering. Further information and whitepapers about these topics are available on the vehicle electrification trend page on the 3ds.com website.

REFERENCE

1 https://insideevs.com/news/506465/evs-price-parity-europe-2027/

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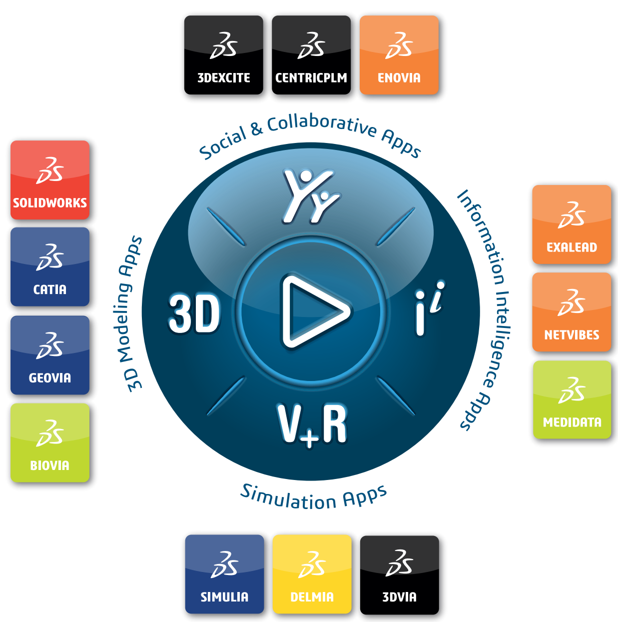

Our 3DEXPERIENCE® Platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3D**EXPERIENCE Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating 'virtual experience twins' of the real world with our **3D**EXPERIENCE platform and applications, our customers push the boundaries of innovation, learning and production.

Dassault Systèmes' 20,000 employees are bringing value to more than 270,000 customers of all sizes, in all industries, in more than 140 countries. For more information, visit **3ds.com**.

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