

Ensuring Reliability and Safety of Connected Car Technology



The internet has now come to the automobile, bringing connectivity for infotainment, telematics and vehicle data analytics. The connected car is rapidly becoming a key node in the emerging Internet of Things. While connected car technology is a bonus and a pleasure for car buyers, it poses unprecedented new engineering challenges regarding reliability, safety and security for car manufacturers. These challenges are particularly daunting since, on the one hand, connectivity is introducing heightened complexity in vehicle systems, while on the other, connectivity is becoming safety-critical, with any glitches leading to potentially fatal consequences.

Vehicle makers are turning to sophisticated engineering tools such as simulation to address these myriad new challenges in developing connected car technology. Simulation cuts through complexity by enabling vehicle makers to virtually test many operating scenarios, and to uncover and fix hard-to-find, potentially disastrous reliability, safety and security lapses well before a car is manufactured.



Connectivity is an essential part of life today. Just as we have come to expect our phones, watches, tablets, TVs, and other everyday devices to be connected to the internet, we now want our cars to be continuously connected to the internet as well.

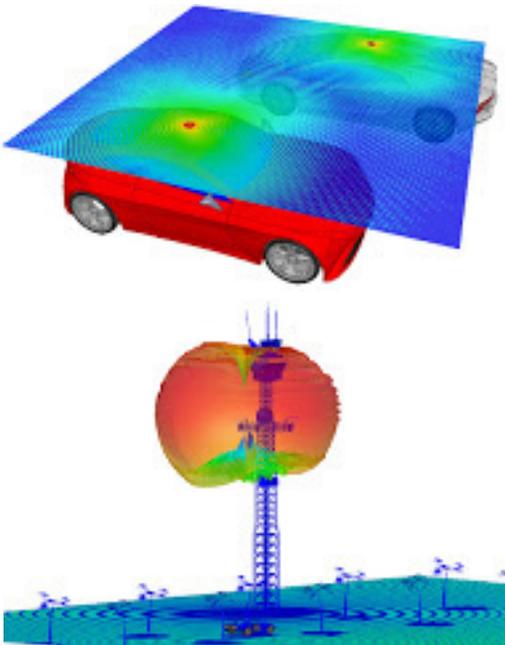
Connectivity is an essential part of life today. Just as we have come to expect our phones, watches, tablets, TVs and other everyday devices to be connected to the internet, we now want our cars to be continuously connected as well. Unlike phones, cars are hazardous devices that can potentially cause serious harm to humans and property if any of their parts fail or behave incorrectly.

As we rely more and more on connectivity of cars, many potential problems could emerge from faulty connected car technology, including simple connection interruptions, display malfunctions, signal interference, and expensive failure of sensitive electronic hardware under heat and harsh conditions within vehicles. Imagine being lost while driving in an unknown city due to GPS signal loss, or the frustration of being unable to operate the air conditioner on a hot day because the car's touch screen interface has difficulty recognizing the touch of sweaty fingers. Connected car technology also opens doors to much more serious, unprecedented problems, such as cyber security holes and software bugs that could lead to potentially fatal safety issues.

Such problems can quickly lead to consumer dissatisfaction and brand depreciation. And there can be even more serious consequences if, for instance, remote hackers use the connectivity to exploit security holes for theft or to jeopardize passenger safety.



Ensuring safety, reliability, and security of all the connected gadgets in a vehicle is a major challenge for car companies and suppliers



3-D electromagnetic wave simulation helps ensure uninterrupted V2V and V2I communication.

Addressing Core Engineering Challenges

Core connected car technologies include communication systems, displays and human-machine interfaces (HMIs), in-vehicle networks, sensors and power systems. The main engineering challenge of connected cars is to ensure the reliable and secure operation of these devices by optimizing the design, integration and durability of these systems and their components.

Sensing and Connectivity – The hundreds of sensors in a connected car gather detailed information about various aspects of the car, such as its speed, steering angle or engine oil level. This information can be used to notify the driver, to make autonomous decisions, and to send updates over the Internet of Things to the cloud for maintenance data analytics. Ensuring reliable sensor operation throughout the lifetime of a vehicle requires careful evaluation of the underlying sensor physics over the entire gamut of operating conditions the sensor is expected to encounter.

Similarly, a detailed understanding of antenna physics and radiation patterns is essential to ensure uninterrupted connectivity of connected car technology. For instance, no matter where they are located inside the tightly packed vehicle body structure, antennas need to successfully capture signals arriving from all possible directions. Whether placed in the driver's left or right pocket or somewhere else in the vehicle, a smartphone should remain connected with the Bluetooth antenna of the central console. This can only be ensured by a detailed understanding of the antenna radiation patterns, including consideration of obstructions caused by all possible objects within the confined vehicle cabin space.

Reliability and Safety – Today's connected cars have many millions more lines of embedded software code than vehicles from the past decade. The software is highly modular and developed by many different suppliers who deliver touch screen displays, voice recognition, telematics, sensors, controllers and numerous other smart gadgets. Millions of lines of code, with many different organizations developing parts of the software independently, make connected car software highly susceptible to bugs and glitches. Vehicle makers and suppliers are therefore adopting the ISO 26262 functional safety standard and the AUTOSAR standard for software architecture in developing connected car technology to minimize risk.

For safety-critical systems, it is essential to analyze risk early, establish safety requirements and fulfill requirements through thorough testing. Developing software to the ISO 26262 standard therefore requires detailed software life-cycle management, comprehensive validation and thorough verification. This makes software development laborious, expensive and time-consuming.

Using ISO 26262 *qualified* software development tools and qualified code generators drastically reduces software development effort, expense and time, while greatly increasing the confidence level in the generated code. Given the sheer size and complexity of connected car software, it is imperative for connected car engineers to use ISO 26262 qualified software development tools.

The Benefits Cannot be Overlooked

SIMULATION vs NO SIMULATION

Simulated Environments Experience:



Durability – Developing electronics systems for connected cars is much more challenging than for smartphones and other high-tech devices for two reasons. First, vehicle systems are subject to harsher environments, such as high heat from the engine, soaring in-cabin temperatures when the car is parked for hours in the sun, or jarring vibrations caused by bumpy roads. Second, vehicle systems are expected to last the entire life of the vehicle. The average age of cars on U.S. roads is 11.5 years, compared to the 2–3 year typical turnaround for a smartphone.

Ensuring durability over a long life span requires thorough design for thermal and structural integrity of chips, boards, packages, connectors, cables, antennas, displays, and all other electronic components. This can only be ensured by in-depth understanding of the thermal and structural physics at play in connected car technology.

ANSYS: The Value of a Consolidated Simulation Platform

Engineering simulation is a key enabler in solving the engineering challenges of connected car technology. Simulation enables vehicle makers and suppliers to virtually test vehicle systems and components with the precision of fundamental physics for scores of test scenarios, early in the product development phase, even before the first physical prototype is built. For example, General Motors reports doubling the productivity of their motor design engineers by using simulation and high performance computing.¹

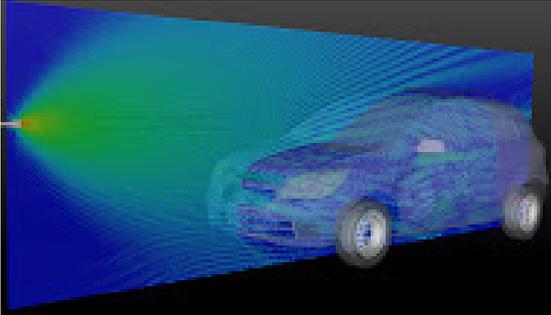
This is supported by quantitative research reported by the Aberdeen Group, which suggests that by using a simulation-driven product development strategy, companies can realize a 15 percent increase in profit margin on new products.²

Many vehicle companies use simulation today. However, the best-in-class among them have recognized that there is more to be gained by consolidating on a single cross-functional simulation platform to address the highly interdependent nature of connected car engineering challenges. Independent research has shown that successful development of these products requires an increase in communication and collaboration between functional engineering teams. Without this, product delays, reliability issues, and cost overruns are likely. A product made without collaboration can lead to integration issues, especially when subsystems are built and over-designed because each team added their own safety margins.

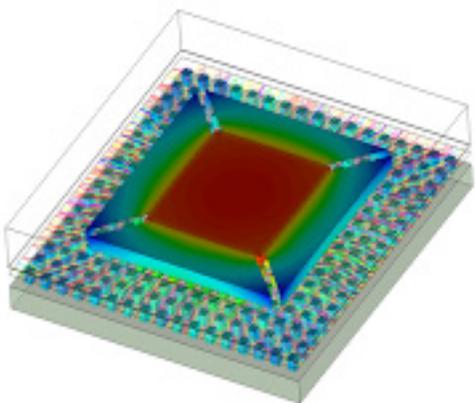
Companies with a strong culture of collaboration are leapfrogging their competition through the use of engineering simulation. Best-in-class companies use a consolidated simulation platform to analyze component and system-level behavior, as well as subsystem interactions, before physical prototyping. Designers at these companies are able to quickly explore the performance of numerous design alternatives. This allows them to optimize the design for cost, quality or performance. The metrics in the adjacent chart highlight just some of the benefits of a simulation-based design approach

¹Smith B., General Motors – 16X Speedup in ANSYS Maxwell DSO on 32-Core High-Performance Compute Farm Doubles Traction Motor Design Productivity at General Motors,” ANSYS White Paper, www.ansys.com.(2012)

²Aberdeen Group – The Impact of Strategic Simulation on Product Profitability, Research Brief, www.aberdeen.com.(2010)



3-D electromagnetic wave simulation can replace expensive full vehicle EMI-EMC testing, while providing deeper engineering insights



Chip package thermal simulation helps prevent thermal failures.

executed on a consolidated platform that enables cross-functional engineering interaction.

ANSYS' consolidated simulation platform is the only one that provides comprehensive solutions for all key aspects of the connected car engineered by vehicle manufacturers as well as Tier 1 and 2 suppliers. These solutions consist of a number of applications that are integrated within a common simulation platform.

Antenna Design & Placement

ANSYS accurately simulates the performance of antennas, both as components and when integrated into the vehicle and its surroundings. A range of solvers are available to use depending on the scale of the problem and fidelity of results desired.

For example, a detailed study³ conducted with ANSYS electromagnetic radiation simulation software evaluated the GPS signal reception by a telematics electronic control unit (ECU) in a Volvo truck. Different designs of the sheet metal body of the truck were evaluated, along with different locations for placement of the telematics unit to determine the best configuration that ensured uninterrupted GPS signal. All this was accomplished with virtual computer models, potentially saving hundreds of thousands of dollars and months of time that would have been needed to achieve the same results with physical hardware and lab testing.

Similarly, Fiat-Chrysler^{4,5} used ANSYS electromagnetic simulation software to efficiently determine electromagnetic interference and compatibility of a car's wiring harness with a full vehicle simulation. The ISO 11451-2 standard test was conducted entirely virtually in a realistic vehicle body-in-white model placed in a model test chamber. Such simulations save millions of dollars and months of time as compared to physical testing. Moreover, the deep physical insight that engineers get through simulation allows them to conduct accurate what-if analyses upfront in the design cycle. This can help to identify and eliminate potential EMI issues caused by brought-in devices such as smartphones and tablets.

Chip-Package-System Design

The ANSYS simulation platform includes special solvers and detailed noise models for ICs along with channel models of package and board to perform thorough power integrity and signal integrity simulations.

For example, NXP Semiconductors⁶ used ANSYS simulation at the chip level to ensure reliable, noise-free performance of automotive infotainment units. The simulations enabled NXP to reduce the IC chip's footprint by 75 percent while simultaneously reducing cost and improving sound quality.

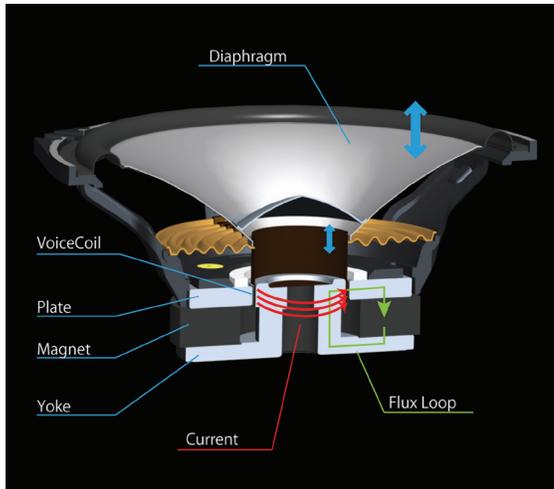
Similarly, Molex⁸ was able to develop a virtual test procedure with detailed ANSYS physics simulation for determining insertion loss, return loss and TDR of a connector. This procedure helps in uncovering issues and fixing them,

³ Mogni et al. – Full Vehicle Electromagnetic Simulation Using the Hybrid Finite Element Boundary Integral Approach, Paper 2011-36-0085, Society of Automotive Engineers (2011)

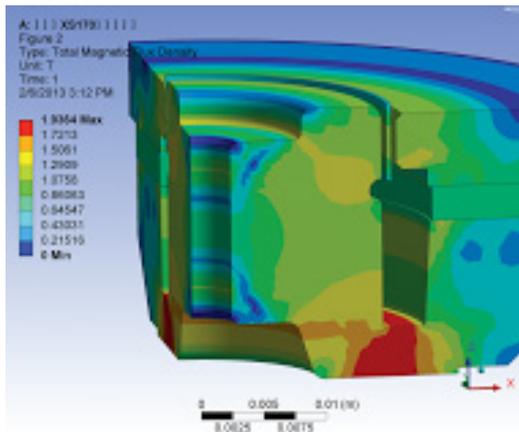
⁴ Colin et al. – Test Drive for EMI, ANSYS Advantage magazine, v 9 no 2 (2015)

⁵ Baker J. – More Music, Less Noise, ANSYS Advantage magazine, v 9 no 2 (2015)

⁶ Yoo et al. – Automotive Connector Simulation vs measurement – A Case Study, Automotive Simulation World Congress, Detroit (2015)



Car speaker



Simulation helps optimize car speakers for sound quality and cost

as well as identifying and exploiting optimization opportunities in connector design and PCB tuning well before developing production tooling.

Power Management

ANSYS' simulation platform provides tools to address a broad spectrum of power management challenges in connected car technology. These include optimizing power consumption and integrity in the system, as well as wireless charging of brought-in devices such as smartphones.

For example, in a recent article⁷, Murata manufacturing reported developing a direct-current-resonance power transfer system with the help of ANSYS simulation software and found that simulation makes it possible to consider the impact of various design alternatives and deployment strategies in the early stages of the design process. Simulation saves months of testing time and tens of thousands of dollars in resources for each design project by enabling engineers to refine options through virtual prototypes rather than physical prototypes.

Sensors

Whether sensors are of the Hall effect, variable reluctance, magneto-resistive, flux gate, eddy current or other variety, the ANSYS simulation platform provides detailed models and capabilities to simulate the underlying physics to help engineers develop robust and reliable sensors.⁸ ANSYS simulation tools enable engineers to vary geometry, material properties, environmental conditions and other aspects to understand key factors that affect sensor performance. The simulation tools further allow engineers to optimize the sensors for reliability and robustness.

Engineers at Delphi⁹ used ANSYS simulation tools in the development of an all-silicon pressure sensor. The fabrication process was simulated to determine if significant residual stresses existed in the final structure of the sensor diaphragm, which could potentially lead to premature failure.

Embedded Software

The ANSYS simulation platform not only simulates hardware but also embedded software. The ANSYS SCADE (Safety Critical Application Development Environment) – a model-based embedded software development tool including a built-in automatic code generator – is ISO 26262 qualified up to ASIL-D and AUTOSAR compliant, and it drastically reduces software development and testing effort.

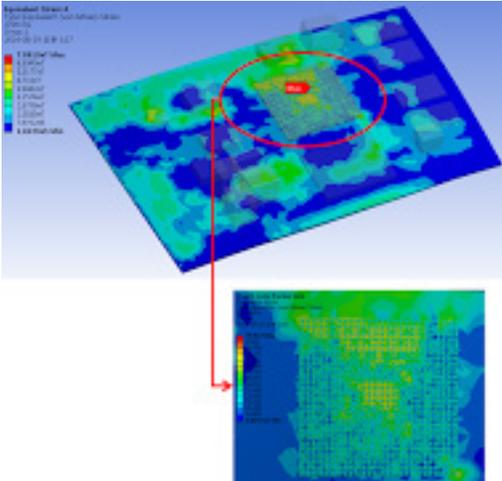
For example, Subaru¹⁰ used SCADE software to develop safe and reliable electronically controlled circuits and systems for their line of hybrid-electric vehicles. Using SCADE software, Subaru was able to describe consistent readable models ranging from safe architecture design to detailed designs. Thanks to SCADE Suite's KCG IEC 61508 certified code generator, the verification time at code level was significantly reduced, as most of the verifica-

⁷ Hosotani T. – Electric Power Through The Air, ANSYS Advantage magazine, v 9 no 2 (2015)

⁸ Christini et al – Sensors for Automotive Applications, ANSYS Resource Library, www.ansys.com (2014)

⁹ Dadkhah F. - Simulating fabrication of an all-Silicon pressure sensor, Automotive Simulation World Congress, Detroit (2012)

¹⁰ Kurihara M. – Safe automobile controls, ANSYS Advantage magazine v 7 no 3 (2013)



Chip package structural simulation helps ensure trace continuity under thermal and mechanical stresses

¹¹ Vaideeswarasubramanian et al – It's a Snap, ANSYS Advantage magazine, v 9 no 2 (2015)

¹² Refaeli J. – Under the hood, ANSYS Advantage magazine v 10 no 1 (2016)

tion was completed upfront at the SCADE model level. As a result, Subaru engineers completed a large and very complex application while significantly reducing software development and testing time.

Designing for Harsh Environments

ANSYS' simulation platform includes best-in-class fluid, thermal, and structural solvers to virtually test products in simulated harsh environments such as jarring vibrations and high heat loads inside cars. Such simulations ensure the product's correct operation under all circumstances, and ensures that it is durable enough to last throughout the life of the vehicle.

For example, Valeo¹¹ used ANSYS software to ensure durability of snap-fits used in display and electronic control unit (ECU) enclosures. By using best practices and ANSYS software, Valeo engineers have confidence that their snap-fits will work reliably. Performing structural simulation very early in the design process helps to avoid costs associated with multiple prototypes, rework and changes to tooling. ANSYS high-performance computing has reduced simulation time by 50 percent, making it possible to complete the structural simulation for clipping and declipping processes in one week.

Likewise, NXP Semiconductors¹² used ANSYS software to ensure reliability and life of electronics components mounted in the harsh environment under the hood of a car, where temperatures can easily reach 135 C. NXP's design team faced the challenge of ensuring that junction temperatures of devices would remain at safe levels while also guarding against failure due to electro-migration. NXP addressed this challenge using the ANSYS semiconductor thermal toolset to model the detail of the chip and determine the power density and thermal gradients at any point. The ability to make design decisions based on thermal gradients enables NXP to ensure reliability and reduce time to market.

ANSYS: Your Trusted Partner

As can be seen from the above examples, companies large and small across the connected car technology supply chain rely on ANSYS to realize their product promise of safety, reliability and security. ANSYS is a trusted partner to these companies, delivering the proven simulation capabilities that they rely on to thrive in the connected car business.

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