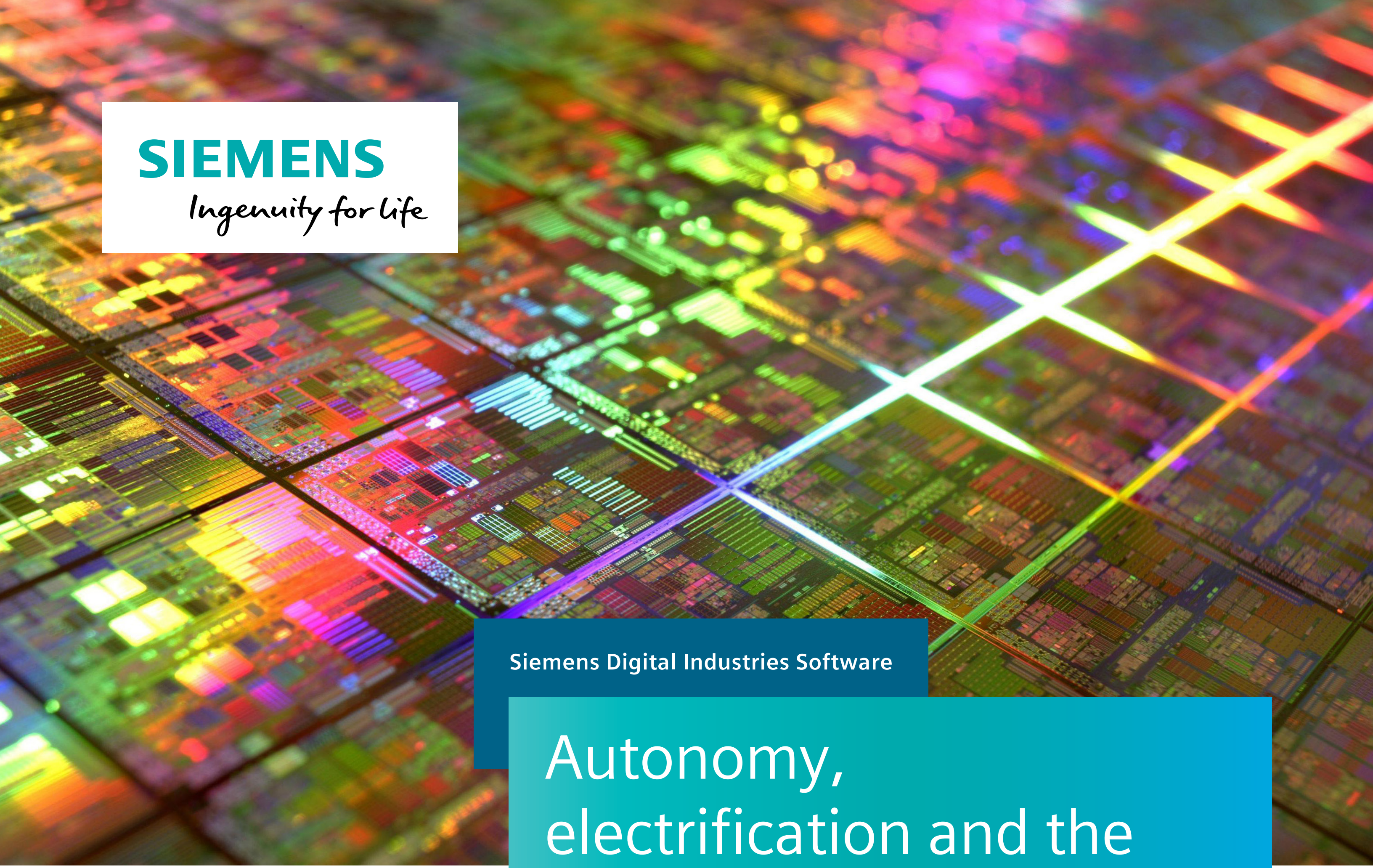

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Autonomy, electrification and the rise of model-based EE design

Automotive

siemens.com/electrical-systems

The impact of vehicle electrification

Race for self-driving cars

Leading automakers' plan to launch autonomous cars

Tesla	2017
GM	2018
Hyundai	2020
Renault-Nissan	2020
Toyota	2020
Volvo	2020
Daimler	2020-2021
BMW	2021
Ford	2021
Honda	2025

6
Countries announced ban on gasoline or diesel by 2040

2022
Automatic emergency braking coming to 99% of cars
USA Today

Brazil 95%
USA 60%
India 86%
Germany 37%
China 70%
Japan 28%

57%
of global consumers trust driverless cars
Cisco

Introduction

We are living in a time of significant change and disruption of the automotive industry. The amount of electrical and electronic content in new vehicles continues to explode as consumers demand greater personalisation of products along with regular updates and new technologies such as autonomous and electric drive become established. Meanwhile established carmakers are grappling (and sometimes partnering) with newcomer OEMs and tech companies, whilst also having to deal with changing ownership preferences, including in my home country of England. “British people have suddenly stopped buying cars,” reads a recent headline in Business Insider, representative of the broader trend. The article lists a host of possible reasons, from the rise of app-based services like Uber, Gett and Lyft to low household savings rates to reticence caused by the government's announced plan to ban sales of all petrol and diesel cars by 2040. Indeed all firms in the auto supply chain, from the old guard nameplates to Silicon Valley and Chinese start-ups, are facing an unprecedented level of competitive pressure – coupled with new opportunities to gain customers and market share. And all this churn has some very real effects when it comes to how electrical/electronic vehicle architectures, which are more complex than ever, are designed today.

EE (electrical and electronics) complexity is manifested in the changing nature of network and architecture design. Across a wide spectrum of technical requirements — bandwidth, weight, cost, CPU utilization and so on — manual design processes are giving way to an automated, metric-driven approach. Advanced design tools encourage iteration, building in configurable metrics to help engineers refine the network architecture or design rule checks as they go. Such tools also allow for visualizing the network subnets and overriding parameters such as node-IDs, priority or value tables, which in turn enables further refinement of messages and signals early on in the design process. And all of this data filters into other domains as this network information can be readily exported, as a DBC or XML file, for a platform, subnet or ECU.

Complexity of course traces directly to consumer demand, especially when it comes to delivering on the promise of 'mass-customisation,' which enables customers to choose the specific combination of vehicle options they want at unit costs in-keeping with the reality of mass production. This requires platform-level optimisation of vehicle electrical and electronic architectures early in the design process. In a typical vehicle there are hundreds of possible options which combine so that manufacturers have to manage billions of potential electrical configurations to satisfy that demand. The two main approaches to solving this challenge are exemplified by the Porsche Cayenne options booklet, which runs to 160 pages, compared to a similar Lexus vehicle option booklet, containing only 14 pages. However, whether it's cars or cappuccinos, norms in luxury markets almost invariably flow down to more mainstream markets, so customized EE architectures will loom ever larger throughout brand hierarchies everywhere.

Today German automakers appear to lead the way in adopting the KSK method, a customer-specific modular design and manufacturing approach where individual harnesses are built to cover multiple option choices. The other widely utilised alternative is to adopt the 'packaged' or composite approach, where the available options are grouped together, so the total number of possible options to be supported is reduced.

Global trends impact EE architecture

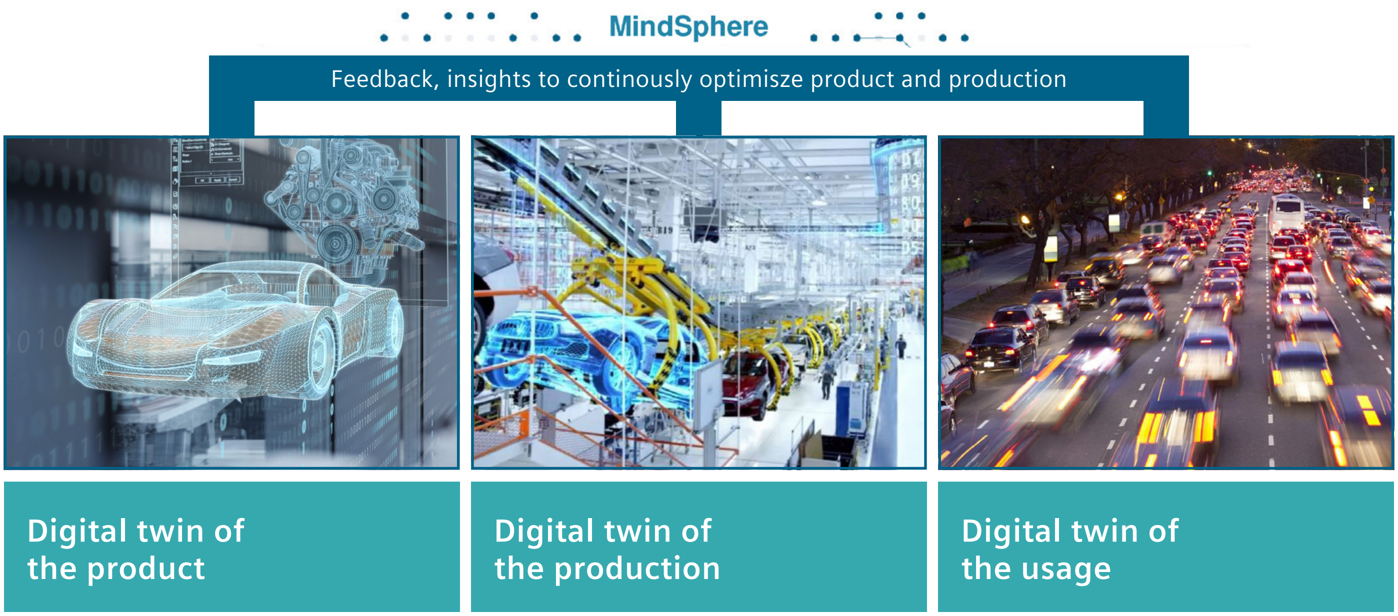
Autonomy and electrification are demanding significant changes to EE architectures. This is due in part to the introduction of high voltages, increased safety considerations and significant weight reductions needed to maximise EV range from electrification. Autonomy's impacts include the need for 'fail operational' designs, hugely increased data network loading and enhanced virtual validation requirements.

These trends are coming soon and in many ways, are already upon us, despite a fair bit of industry hype. At a recent count there are approximately 300 companies developing electric cars and light trucks, with approximately 100 companies having announced autonomous drive programs. The list of countries with announced plans to ban fossil fuel vehicles covers some of the most important markets, including China, which announced that the new policy would be implemented "in the near future" in a recent article from the official Xinhua news agency. Asked last summer about plans for a ban in Germany, Chancellor Angela Merkel said: "I cannot name an exact year yet, but the approach is right because if we quickly invest in more charging infrastructure and technology for electric cars, a general changeover will be structurally possible." Also noteworthy is Volkswagen's announcement of "Roadmap E," which may well be one of the most comprehensive electrification initiatives in the industry. The roadmap includes 80 new EVs by 2025 and plans to spend more than €50 billion in battery cells, one of the largest procurements in industry history.

Electric vehicles dominate the thinking of all automotive leaders today. Concern about electric drive technologies jumped from number 10 to number one in the last three years, according to a KPMG survey of auto execs. According to the survey, electric vehicle-related technologies occupy three of the top four slots, displacing usual business concerns like emerging market-growth or big data.

> *"In a typical vehicle there are hundreds of possible options which combine so that manufacturers have to manage billions of potential electrical configurations to satisfy that demand."*

Though the EV wave is arriving first, the race to self-driving cars is on, as well. Nearly all leading automakers have responded with plans to launch autonomous cars including GM (targeting 2018), Ford (2021), Hyundai, Renault-Nissan, Toyota, through to Honda (aiming for 2025). In January, Uber CEO Dara Khosrowshahi told Bloomberg he expected automated Uber cars in use on public roads in the United States in just 18 months. Elon Musk famously promised that a Tesla would complete a fully autonomous cross-country drive of the United States by 2018, though of late has hedged his bets, in-part due to the challenge of processing large amounts of visual sensor data within a reasonable power budget (a challenge that incidentally, Mentor engineers are working on, as well). Nearly 300 Chinese cities and regions have introduced "smart cities"



projects to spur adoption of autonomous vehicles. And in September, the Chinese search firm Baidu announced $1.5B USD (10 billion yuan) autonomous driving fund to invest in 100 autonomy projects in China over the next three years.

This explosion of new entrants into the automotive arena, driven largely by new autonomous and electrification technologies, is consistent with the change that accompanies every new industrial disruption. This was equally true in the early days of the U.S. automotive industry which, in 1909, had just under 300 auto producers. However, by 1930 only 27 of these had survived. Similar disruptive winds are now blowing through the industry; they will no doubt lead to comparable consolidation and change. The capacity for incumbents and newcomers to evolve and adapt both their business models and product development processes will determine who prospers in this new automotive world. Old interactive processes are inadequate to move quickly and survival in this new world is only possible through incorporating high levels of design automation, synthesis and validation at all stages of the product lifecycle.

The digital twin

Though software and services matter more than ever, the global auto industry remains a manufacturing juggernaut. Nearly 100 million vehicles are produced annually by an industry that, despite the rise of automation, still directly employs around nine million people and indirectly creates many times that number of jobs. The process of building cars (and indeed building almost everything else) has been transformed by digital twin tools which mirror the entire value chain, from design and testing through to manufacturing and even service. Siemens Digital Industries Software has emerged as a digital twin leader, especially for overall product lifecycle management, also simulation and testing of mechanical systems. As just one example of the power of the methodology: Siemens tools helped Maserati put its Ghibli sports car into production in just 16 months, nearly half the usual design cycle, largely by slashing the need for many physical prototypes.

The Mentor tool portfolio, with its strength in EE architecture, systems and network design, complements Siemens established expertise in industrial and mechanical domains. The combined set of offerings enables true multi-domain systems engineering, which is an absolute necessity to effectively develop today's highly integrated automotive products. In particular, Mentor's 'Capital' product portfolio, which supports the electrical-systems and network domains, is an example of how we can transform design capabilities across organisations. With its model-based design paradigm, Capital can define system architectures and then, using built-in metrics and design rule checks, compare and contrast multiple potential architectures to ensure the platform design meets the original intent. Using Siemens' advanced generative engineering approach, Capital can then automatically synthesise the wiring schematics from the logical connectivity design, taking into account the mechanical constraints. Systems devices are automatically placed, interconnected and the entire wiring system automatically generated using rules and constraints embedded by the OEM into the software. The result is design tasks that took months can now be achieved in hours or days and critically, the designs can be verified as they are created. Data can be reused across vehicle programs and in the downstream processes of manufacturing and service.

Indeed the basic rationale and biggest value of design tools of nearly all stripes is to vastly improve the upfront functional system design, ensuring it is correct by construction and set up to remain tightly linked, via robust data, to the eventual physical implementation. At least historically, many early functional models created by engineering teams did not contain all the necessary information to influence other design domains of software, electrical distribution, networks and mechanical. This was not due to deficiencies among the aptitudes of the engineers themselves (we have all seen how technologists steeped in hands-on, home-grown processes often possess an astonishing feel for the systems they design.) It's just that no matter their skills and training, the sheer amount of complexity both within and across technical domains was simply impossible to account for in any detailed way.

Now, newly powerful design tools like Capital (which is integrated with NX via an XML schema; see the white-paper "Automotive ECAD-MCAD Co-Design Leads to First-Pass Success"), paint digitized, data-rich pictures of nuanced functional designs, giving data on signal, message, part definitions and other attributes. Once this data is captured, it's that much easier to build robust network and platform topologies; apply design rule checks, also customer options and variants; and ultimately create the logical and physical topologies that are the last step before actually generating a physical harness.

Conclusion

The bottom line is this: among the many EE design trends that cut across the automotive industry today, the one that looms largest of all is that increasingly powerful software automatically transforms input models to deterministic outputs. This is true at every level of the design and manufacturing process – from IC to electrical and mechanical systems to assembly line. And it's glaringly obvious at the consumer level, as well, where the question of how to best get from point A to point B is increasingly best answered via software, smartphone and cloud services, rather than the car parked in the family driveway.

If there are billions of possible software, electrical, mechanical and manufacturing configurations when it comes to building cars today, there must be many times that number of possible outcomes of the future of the auto industry. One certainty is the likelihood that, despite the rise of automation everywhere, transportation will be more human-centered and broadly accessible than ever.

Moving from point A to point B can mean more than a trip to the corner store. Design and manufacturing have long been described as metaphorical journeys of their own, whether the task is assessing cost, weight and function tradeoffs in a wiring harness, or ergonomically modelling workers on an assembly line. So perhaps the best advice for forward-looking automotive manufacturers and suppliers is to look for tool vendors that do for them what customers demand more and more of the transportation system – that is, provide a comprehensive and efficient software-mediated experience for solving problems, new and old alike.

For more information

- siemens.com/mentor
- Martin O'Brien and Amin Kashi, "ADAS and the Systems Engineering Challenge," Mentor whitepaper
- Walden C. Rhines, "Discontinuities in Automotive EE Design," IESF conference keynote (video)

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