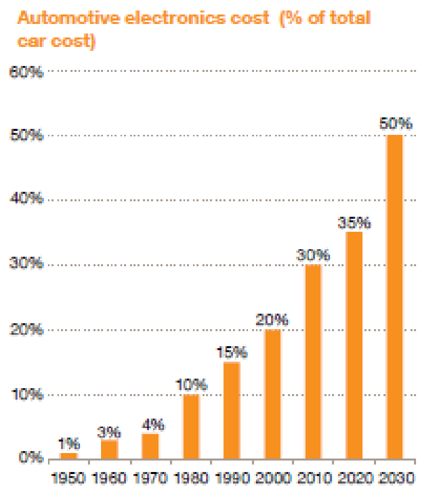
Capitalizing on change and complexity in evolving product landscapes

10 years ago, cars had around 10 to 15 Electronic Control Units (ECUs). Today that number is well over 90. In fact, in some luxury cars, it's as high as 150. Mercedes-Benz in the mid-90s' had eight models. Now they have over twenty, and on each of these, build and trim options far exceed past models.

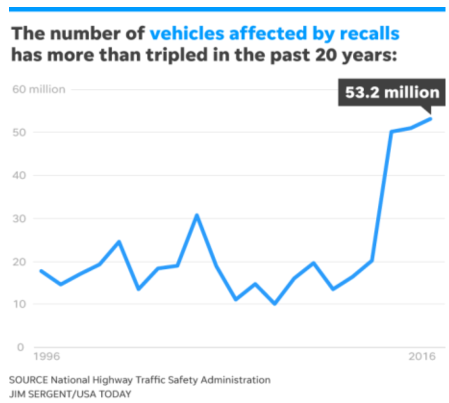
There is no doubt that today's products are changing more rapidly than ever before, and they're doing so to cater for the increasing expectations of customers. These changes aren't limited to the automotive industry, the same thing is also happening across most major product segments.



Source: [Spotlight on Automotive: PwC](#)

Today's customers expect connected products, with sophisticated software-driven features. They invariably want more choice, new types of materials and finishes. Products are expected to be safer, more compliant, and their manufacturing processes more eco-friendly. And, as is often the case, they are expected to be delivered at lower cost, with better performance, and developed in much shorter timescales than ever before.

These demands, and more, drive complexity into products and importantly their design-to-manufacturing-to-service environments. This complexity is both opportunity and threat. The opportunity to capitalize on the situation to deliver differentiated product experiences, growth and profit. Unmanaged, the negative effect on customers and business, not least through unintended, but costly and reputation threatening product recalls.



Source : [New Statesman Journal](#)

Products such as cars, planes, complex medical equipment and large industrial machines have, in truth, become ultra-sophisticated cyber-physical systems. They often have software content of millions, if not hundreds of million lines of code, across dozens, if not hundreds of interconnected circuits; in addition to a plethora of attached sensors, actuators and communications interfaces.

The corresponding development environment for these products needs to connect multiple technologies, across systems of systems, and frequently siloed mechanical, electrical/electronic and software engineering teams. It may need to do this between multiple locations and amongst many companies. The resulting ecosystem contains immensely complex design workflows, and fractures or disconnects means lost time, opportunity and increased cost.

> *Just one example of technology disconnects was that of the Airbus A380 harnessing mismatch in the mid-2000's. This situation highlighted just how costly errors between mechanical and electrical disciplines can be. Unexpected differences between the designed aircraft structure and the wire harnesses that connected the plane's complex electrical network were estimated by some to have cost Airbus multiple billions of Euros in lost profit.*
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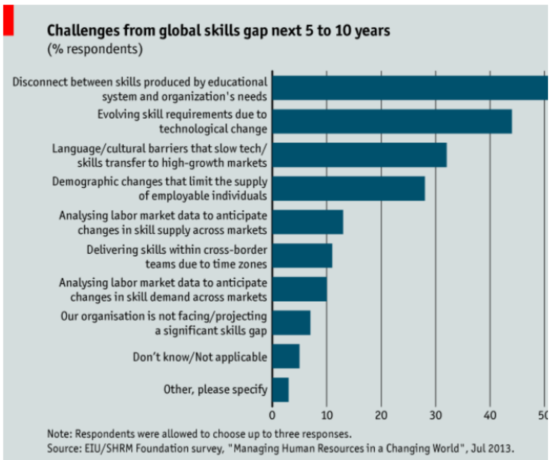
> Source : New York Times

The potential for ambiguity in product development in such situations is immense. In addition to this, increasing the variability and choice demanded by today's ever-more discerning customers; this makes for a perfect design storm, where disconnects and ensuing problems are much more likely.

Design complexity at this scale cannot simply be managed by more human intervention. Any thoughts on managing complexity by simply applying more people to the problem doesn't scale. It's not cost-effective and companies simply can't source enough skilled personnel to satisfy the new skills required for today's complex products and systems. This skills-gap is further exacerbated, certainly in western economies, by an aging and retiring workforce. In short, companies must find new ways to manage design complexity to deliver scale, efficiency, quality and ultimately profitability.



Source: Evolution of Work and the Worker, The Economist Intelligence Unit February 2014

Looking for opportunities

Of course, there are no silver-bullets, no instant solutions to the design challenges in such complex circumstances, but options do exist, and some of these include:

- Consider new methods to lower barriers between the domain silos of old, encouraging more inter-disciplinary teamwork, efficiency and time-to-market. This might be best described as a focus on process, methods and tools. Streamline processes to take advantage of synergies across domains. Update in-use methodologies to contain engineering costs and improve efficiencies. Lastly, align the tool ecosystem with these processes and methods to deliver practical results.

- Systems Engineering and more specifically Systems Driven Product Development have proven to be valuable methodologies. These top down methodologies and developmental approaches are both collaborative and domain-inclusive. Supported by technologies such as Product Lifecycle Management (PLM), they address many of the challenges faced by companies in areas such as complexity management, product variability, optimization and traceability; starting from earliest requirements through to product-in-service. The use of product design and lifecycle technologies to support system workflows also provides the digital consistency and thread that's vital to information use and reuse across the company, its platforms and its products.

> *With more sophisticated electronics in today's cars, the importance of managing electrical infrastructure in the context of the mechanical design is essential. We're seeing bigger more complex vehicle harnesses connecting more ECUs, sensors and actuators. Safety and reliability constraints, bundle topology, body strength, weight, thermal, electromagnetic, security, installation and repair considerations benefit immensely from decisions made in context of the whole, and not just the part or sub-system.*
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> *Patrick Fahy, Digital Plant Architect*
> *Mahindra Automotive North America*

- Create workflows that exploit the unique value of digital models. The ability to model products and evaluate options and designs from the earliest stages of development, through increasing levels of fidelity to final form helps companies optimize development cycles. Architectural studies and simulation, for example, are valuable from the earliest stages of systems design through virtual part and product development, to final production and test. They help to understand design situations and engineering trade-offs. Engineers can optimize and validate designs through design cycles. Prudent architectural and systems modeling, optimization and simulation strategies reduce the need for unnecessary design cycles and costly prototypes; ultimately delivering products more suited for their intended market, with improved quality and manufacturability.

- Lowering the barriers between disciplines and integrating design environments, for instance those across electrical, electronic and mechanical disciplines, leads to more productive, frictionless working environments. Working on collective views, perhaps with cross-domain technologies, common data backbones and shared libraries helps developers make faster, more informed decisions; ultimately delivering better designs. The connections among Siemens's NX (mechanical design) solution and Mentor's Capital (electrical) and Xpedition (PCB development) systems provides a good example. The user experience delivered from these integrations means that miscommunications and incorrect assumptions on common objects, form, function and fit; the most frequent sources of errors, are more likely to be caught early and hopefully not made at all. In addition, design changes and associated data sets through lifecycle iterations become instantly traceable and automatically managed. Mistakes commonly made through manual or semi-automatic transfers, perhaps though design cycles or between (often multi-disciplinary) team members can also now be avoided.

> *We used to have to model complex wiring systems accurately in-context to make sure, for example, there wasn't the possibility of abrasion in service. Obviously short circuits in a plane, especially near fuel might well be catastrophic. At that time, we had to go through numerous design iterations, copies if you will, to make sure we catered for full extents of all internal mechanisms and control surfaces, and this was very time consuming. To add to that, any change to electrical systems or (mechanical) structures meant we had to re-integrate our electrical and mechanical models, and re-validate all over again.*
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> *David Herriott: Consultant and Aerospace Systems and Technology Specialist*

- Re-use of platforms, digital models, and other product related information improves investment returns, and can dramatically shorten development cycles. It makes sound business sense to capitalize on reusable elements but consider extending the value of digital models to other areas as well. Model Based Definition (MBD) for instance adds Product Manufacturing Information (PMI) to 3D models. Using MBD helps companies bypass legacy 2D documentation processes to improve design understandings, product quality and (internal and external) manufacturing processes.

- Companies that can more effectively assimilate and share with others; on requirements, experiences, data, design intent, models and workflows for example, are at an advantage. In the heterogeneous environment that's the hallmark of todays' design and manufacturing ecosystem, time and effort spent wrestling to connect, manage, collaborate, integrate or export to both internal or foreign systems is non-value added and costly. PLM (Product Lifecycle Management) helps in areas such as collaboration and orchestration and it's often an essential component in managing the complexities of today's product development. However, the openness of PLM, and indeed all in-use design and engineering technologies can be a critical success factor. The ease and accuracy of data import and export, the ability to successfully assimilate and reuse foreign information can directly influence project profitability, and often success.

Thoughts on the future

The escalating cost of failure and reputational damage across all product types reminds us how important it is to get products right and get them right first time. To do this where product ecosystem is becoming ever more complex, perhaps moving rapidly from mechanical, to software and electronic bias, requires new design thinking; and the skilled people, workflows and tools to put this into practice.

With skills in high demand, time being short, and costs under increasing pressure, using design tools to augment and automate multidomain design workflows makes both business and technological sense. Fortunately, new features, more open and seamless technological integration between (mechanical and electrical) domain toolchains now makes this much more practical. If companies haven't already started to do so, they might want to investigate product options anew to take advantage of these advances.