Automotive Engineering's Integrated Future

Constant pressure from vehicle manufacturers for price reductions has caused many automotive suppliers to investigate more efficient production processes. Streamlining product design and workflows can be a daunting, time-consuming endeavour, especially in an environment of growing product complexity. Quality standards have never been higher or more challenging to meet and must increasingly be validated across the supply chain to meet the demands of more integrated and intelligent automotive systems.

Growing complexities matched with rising pressure means automotive companies will have to collaborate much more closely with their supply chain to keep up with the fast-moving market. Innovation, not just in products, but also in process, is the only way to meet the challenge of growing complexity in a still very cost-driven environment.

Lean manufacturing was invented by the automotive industry to streamline workflows and reduce waste, but similar principles are only just starting to be applied to the engineering process. Automotive suppliers can ensure they are developing the right product in the right way, getting it right the first time.

The ability to test and validate against clear, integrated specifications held in common along the supply chain, as well as to define requirements and produce specifications with this test and integration orientation in mind, are the best way to achieve this Lean approach to engineering. And what's more, like Lean manufacturing, Lean engineering can also boost customer value by ensuring consistent quality.

The processes and tools associated with 'systems engineering' are emerging as the best way to obtain the benefits of Lean engineering in the automotive industry. Systems Engineering (SE) helps design, integrate, and manage complex systems over their life cycles. Instead of focusing on the individual behaviours of a component, SE focuses on understanding and validating the component as part of the whole.

By having a suite of processes and tools designed to model and anticipate the structure of a system, projects can have assurance from the start that the right thing is being built in the right way, and that the project will interact appropriately with its context. This drives down cost by reducing the risk of mistakes and unanticipated defects, while simultaneously driving up quality by tying engineering activity more closely to precisely defined stakeholder needs.

Thinking in this way has produced a robust and scientific approach to requirements management and verification, a greater focus on the entire life cycle of a product, and novel modelling techniques for complex emergent behaviour.

Most SE activities are what engineering teams will be doing as a matter of course: collecting and managing customer requirements, designing a product and modelling its behaviour, managing implementation workflows, and providing the basis for verification and validation tests.

But SE adds value to those processes by introducing techniques for analysis and information gathering. It bridges the gap between scientific and engineering methods by ensuring every aspect of a product's definition reflects its role in the whole system in a manner which is measurable and verifiable.

TECHNICAL ARTICLE

In other words, SE brings rigour and consistency to the engineering process, increasing value while reducing waste. As a result, you understand your products and customers better, understand your history and leverage work you have already done in the service even of specialised customer needs. SE targets requirements more precisely and makes sure you don't retread old ground needlessly.

According to research by Carnegie University in 2012[1], adopting SE techniques can increase the likelihood of success by a factor of eight for large-scale complex projects. With automotive suppliers facing pressure to reduce costs, closer collaboration with customers can ensure quality while maximising value.

Futureproofing your Engineering

Pressure to reduce costs at a time of growing product complexity naturally leads to concerns about the long term sustainability of a business line. Continuous improvement isn't just about looking to a sunlit vision of the future, it is about retaining and building on the best lessons of the present and the past.

Systems engineering helps organisations standardise and retain their existing knowledge, to prevent duplication of effort and to enhance best practice by making sure that knowledge is utilised and propagated widely. If the best processes for retaining knowledge are in place, engineering teams can devote their time and resources to what they do best and what is most needed from them at this time - innovation. Quality goes up while costs go down because less time is spent reinventing the wheel.

Better requirements management can be a major driver of this sort of improvement, not just by retaining existing knowledge, but also making it easier to adapt to change. Using good SE practice generates a solid and adaptable bank of information about a project's objectives, design, workflow, implementation and testing. If the requirements change when work is already underway, the structure of this information makes it far easier to interpret the effect of this change on the project as a whole.

Many unexpected interactions with other requirements, as well as pressures on schedule and budget, will be immediately visible through requirements management practices and the project model. The change will be immediately promulgated to all relevant teams, who would be working from the same single source of truth, even between customer and supplier. Plus, any new verification and validation standards implied by the change will not be ignored, as these are tied directly into the specific and measurable project requirements.

Furthermore, with sound knowledge management supporting SE activity, this project information can be retained throughout the life cycle of the product, and if any midlife upgrades are necessary, it becomes much easier to make those changes without reinventing the wheel.

By using SE techniques to generate standardised and transparent project information, suppliers and customers can ensure they are working from a consistent definition of quality while embracing change and the innovation-driven future of the automotive industry. Suppliers and customers can work together efficiently on decarbonisation, autonomous vehicles, changing regulatory demands, and the smart products revolution.

Quality in the Customer's Context

As automotive products start to rely on ever more sophisticated technologies, the risks associated with project change become more difficult to manage. Different systems in a vehicle interact in increasingly complicated ways. Not understanding how your work fits into this big picture can be a huge risk: never more so than now. It can be hard for automotive suppliers to guarantee their product can retain its quality with end products changing so rapidly, while avoiding the excess costs of *overdelivering* on what is actually needed.

These risks don't just arise as projects change while underway, but also in terms of how what you're building will be adaptable to changing customer needs as technologies improve. Delivering value in this environment isn't just about understanding your stakeholder needs as fully as possible, it's about having an approach to quality that puts the outputs of your work in terms of user satisfaction, the operating

environment and how it integrates into the broader products both of now and the future – in short, the value derived throughout the full life cycle of your product – at the front and centre.

Taking a whole-system view of quality allows you to better calibrate your project objectives to stakeholder needs, not just in terms of raising the bar, but also in terms of preventing waste and improving project control. By thinking about quality and measurability as early as possible, and tying how you think about it explicitly into stakeholder needs, you can better guard your project against doing too much as well as doing too little.

The saying that quality cannot be 'inspected into' products has become a cliché at this point, but the more complicated your products and the system around them get, more and more quality activities need to be shifted to the earliest possible stage, not just to minimise the cost incurred when something doesn't come up to standard, but also to maximise value when quality is as much about what's going on around what you've built as it is what's going on inside it.

Thinking about quality like a systems engineer is about thinking in terms of a hierarchy of complexity. When designing the system, we start with the broad needs of the client, turn that into specific requirements for the system as a whole, create an architecture at the system and then the subsystem level, and only then produce a detailed design for the individual elements.

Ensuring quality of a whole system is about going through that hierarchy in reverse: testing the reliability of individual components or modules against specifications; verifying the performance of subsystems against requirements; then validating the outputs of the system in terms of customer need. This is coupled with a clear recursive process for when standards are not met, to ensure definitions are revisited at the most specific level possible.

From the point of view of a supplier, this means firmly integrating your quality standards with those of your customer and understanding the unexpected ways your product might interface with the vehicle as a whole. Managing quality in this way rests on project requirements being as specific and measurable as the hypothesis of a scientific experiment, with a clear and unambiguous difference between compliance and failure.

When the definitions of individual components are derived from the context of a definition of the whole system, far more of the potential emergent defects in the whole can be detected in testing the individual parts. This means rework can be anticipated earlier and performed more easily and cheaply.

In other words, you start with a design and modelling process that is engineered to assure that stakeholder needs are being precisely met before your costs are sunk.

Thinking about quality as a question of adherence to robustly defined stakeholder needs minimises waste and improves project control, by guarding against scope creep and overengineering. It's not about getting above the line, it's about hitting the bullseye, and systems engineering tools and skills can help you ensure quality without overdelivering and generating excess costs.

The automotive industry is reaching a threshold of product complexity, past which engineering must think more about the properties of the integrated whole product. The only way to address this is to collaborate more effectively through a more fully integrated supply chain. The processes, skills and tools associated with systems engineering are the best way to bridge this complexity gap.

[1] Carnegie Mellon University, 2012. The Business Case for Systems Engineering Study: Results of the Systems Engineering Effectiveness Survey (cmu.edu)

About SyntheSys

SyntheSys provides defence systems, training, systems and software engineering and technical management services over a spectrum of different industry sectors. Along with distinct support and consultancy services, our innovative product range makes us first choice provider for both large and small organisations. Established in 1988, the company focus is on fusing technical expertise with intuitive software applications to solve common industry challenges.