Maximising Customer Value in Automotive Engineering

Technical Article

Managing Engineering Complexity to Deliver Bespoke Products

There's a delicate balancing act to be struck in contemporary automotive engineering. Customers increasingly demand a more personalised experience, and a bespoke product that reflects and respects their particular needs. For manufacturers and designers, there are certainly opportunities in being able to meet these more specialised demands. But the stronger this pressure gets, the harder it becomes to understand what your customer's priorities are, and how to best leverage your resources to address them.

When your products are becoming more complex at the same time as becoming more bespoke, automotive companies are in danger of wasting time reinventing the wheel – maybe even literally! And if customer needs aren't fully understood that duplication of effort could be doubly wasteful, as you may not even be going in the right direction.

Lean manufacturing has become a widespread staple of good practice in the automotive industry, but best practice in applying similar principles to the engineering process hasn't yet become as widespread. It's worth remembering that Lean principles aren't just about minimising cost by eliminating waste, they also add a lot of customer value by ensuring consistent quality. In taking a similar approach to the engineering process, these value-adding aspects of orderliness and standardisation are even more pronounced, and often become the primary way it delivers benefits to both the business and its customers.

The practices and tools associated with the discipline of Systems Engineering (SE) are emerging as the best way to obtain the benefits of Lean engineering in the automotive industry. Developed by the defence industry and in continuous, evolving use since the World War II, the systems engineering process has a long-proven track record of reducing risk in contexts where reliability and performance are a matter of life and death. What's more, studies show a clear and significant relationship between project performance – measured in terms of cost, schedule and satisfaction of technical requirements – and high levels of systems engineering capability.

As the systems developed by the automotive industry grow ever smarter and more complex, many automotive manufacturers have turned to SE as a way to ensure they keep enhancing the value of their products in a more technically demanding market. Systems engineering is about drawing on the science of finding patterns in organised complexity, and the analysis of the emergent properties of a whole rather than the specific behaviour of individual components. Thinking in this way has produced a robust and scientific approach to requirements management and verification, a greater focus on the full life cycle of a product, and novel modelling techniques for complex emergent behaviour.

Almost all SE activities are the sort of thing that any engineering team 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. SE adds value to those processes by: introducing techniques for analysis and information-gathering that close the gap between the scientific and engineering methods; introducing a single source of truth that persists throughout the product life cycle and beyond it to new variants; and introducing ways of managing the stakeholder relationship to give you assurance right from the start that you are building the right product for the market, in the right way.

In other words, SE helps you level up your engineering knowledge, not just in terms of knowing your customer and your product better, but also in terms of knowing your own history, and leveraging work you have already done in the service of, even specialised, customer needs. By targeting requirements more precisely, and making sure you don't retread old ground needlessly, SE can eliminate wasteful activity in your engineering process, and deliver higher quality products faster and more reliably.

Knowing Your Customer

Having the right processes, the right skills and the right tools for systems engineering can provide benefits throughout the product life cycle, across requirements, design, workflow management and test management. But often the best place to start, and the place where many, if not most, of the primary benefits are derived, is applying SE methods to requirements.

According to the Project Management Institute's global 2020 'Pulse of the Profession' study, Project Managers (PMs) in the manufacturing industry report poor upfront planning as the primary cause of project failure[1]. In the same study, manufacturing PMs reported that 40% of project budgets are lost in a case of project failure. In all, the survey reported that 13.5% of total project and programme spending in the manufacturing industry was wasted due to poor project performance - *more than any other industry*.

In an environment driven by customer value, where products are customised to meet specialised customer needs, these risks are encountered both more frequently and more acutely, because requirements are more tightly specified and have to be revisited more frequently.

1 1. PMI (2020). Research Highlights by Industry and Region 2020.

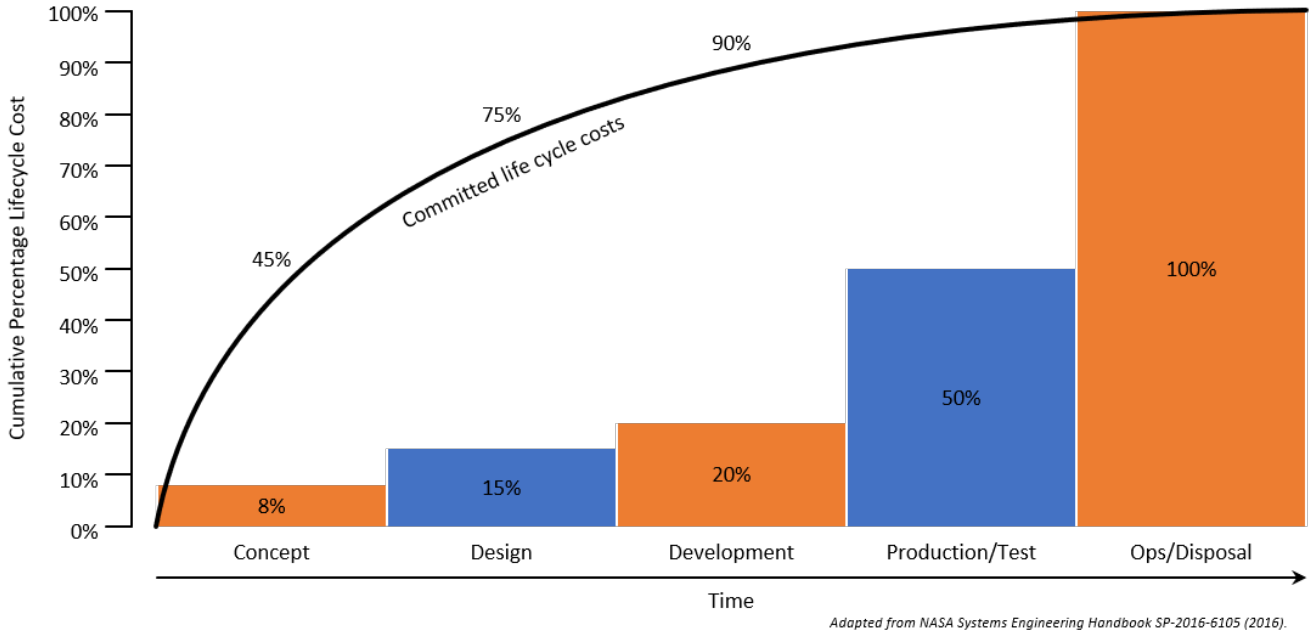
The best way to mitigate these risks is to build a strong understanding of your project requirements at an early a stage as possible. The later in the project your requirements change, the more expensive that change will be, and those costs start accumulating very quickly. As the diagram below shows, life cycle costs of an engineering project tend to get locked in early in design and development, even before expended. This can rapidly multiply the cost of changing design direction at a late stage. Naturally, this leads to budget and timetable overruns, or even cancellation.

An SE approach to requirements is designed to cleanly and specifically identify ambiguities and gaps in stakeholder needs. Getting stakeholders to articulate their needs can often be an extremely frustrating process. Half the time – even more when the stakeholders are not technical experts, as can often be the case in automotive – they don't even know what they want themselves. The best way to get a straight answer is to ask a straight question, and the SE process is very good at generating straight questions.

Systems engineering treats the requirements engineering process like formulating a scientific hypothesis. The philosopher of science Karl Popper famously said that for a statement to be considered scientific, it must be falsifiable; it has to be possible to tell the difference between a world in which the statement is true and a world in which it is false. Similarly, systems engineers work towards requirements by which it is possible to tell the difference between a system that achieves them and one that doesn't.

If an SE process for generating requirements is followed, it is immediately and specifically visible when individual requirements are not clear, verifiable, functional or minimal, as well as when they are together incomplete or inconsistent. As a result, the question that needs to be answered either by stakeholders or by engineering is specified precisely and robustly.

An SE approach to requirements can reduce waste and enhance value by helping you discover something is wrong before the associated costs have been committed. By defining stakeholder needs appropriately and translating that functional understanding of the project into scientifically rigorous specifications, engineers can be sure they are delivering maximum value to their customers with much lower project risk.



Adapted from NASA Systems Engineering Handbook SP-2016-6105 (2016).

Knowing Your History

Systems engineering isn't just about knowing what to do with a blank sheet of paper; its processes and tools enable you to maintain a single, unambiguous source of truth about a product. All teams involved in making and maintaining the product at every stage of its life cycle can participate in that shared project definition, both inside your organisation and when you have to collaborate with suppliers.

If SE processes are followed and SE-specific tools are utilised, that information is retained in a modular way, with requirements, designs and workflows for individual components easily separable from the project as a whole. Information is retained, and its value maximised, not just within a single project, but from one project to the next.

Requirements kept in Word or Excel documents, even if they are kept free of comments, annotations and modification, are often prone to errors, miscommunication and poor traceability. When the time comes to revisit those documents for a new project, such documents are often extremely unhelpful: it can be difficult to separate out components of interest from the system as a whole; modifications and annotations made over time can introduce ambiguities and gaps, and in the worst case information can be totally lost. We've all had the experience of trawling through a poorly-structured document history, feeling sure we have already solved the problem at hand somewhere before, and wasting time and effort that could be fruitfully spent on new work.

If your goal as an engineering function is to provide your customers with a more specialised and bespoke product, it becomes all the more important to manage information about work already done; many of the problems associated with meeting complex customer needs can be treated, not so much as questions of development, as of configuration management. Specialised designs can be readily assembled from modular definitions of individual components, and where genuine innovation is necessary it becomes readily visible, and engineers have a much more precise statement of the problem, as well as far more time to work with.

Furthermore, in an environment where compliance and certification drive a lot of engineering decisions, this modular approach to requirements management enables you to apply those constraints consistently across multiple engineering projects, without having to solve the same problems repeatedly in a slightly different context.

A systems engineering approach to configuration management starts by distinguishing a special category of 'baseline' configurations, which are known to work. Deviations from that baseline are carefully tracked and interpreted in terms of changes to the requirements for the system.

Variant components are defined separately, and the design and modelling of a new configuration is built from the baseline out of these atomised subsystems, allowing you to minimise duplication of effort in reusing components. As a result, when you need to reuse requirements, you don't have to just duplicate the entire set of requirements and then manage them separately: you can reuse those components that are not changing; use the correct version of those that do change; and be able to add or remove components as necessary.

In a specialised automotive context, being able to track the change in product requirements and configurations over time, and reutilise existing knowledge in new projects, prevents your engineers from having to go back to square one. Instead, they can start from where they ought to start, with the properties of the existing system known, understood and ready for change.

If you have found this article useful, and would like to hear more about how your organisation may use systems engineering to better accelerate time to market, manage risk and improve quality visit: www.synthesys-technologies.co.uk or contact us on: cet@synthesys.co.uk

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