

Enhancing Product Innovation with Computational Engineering

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Silicon Valley is the home of many of the most innovative high-technology industries that have ever existed, and their level of innovation gives them a competitive economic advantage that sustains a significant portion of the US economy. While there have been dozens of attempts in the US and abroad to replicate this success, few have been very successful. A relatively new approach to product development, *computational engineering*,¹ is based on the use of computing, especially high-performance computing, to design, construct, and analyze virtual prototypes of new products. Because this new approach intrinsically shares many of the operational characteristics of Silicon Valley companies—including small, highly skilled product development teams that are empowered to take risks, make decisions, and accept failure on the path to success (see Figure 1)—it isn't surprising that the application of computational engineering can achieve levels of operational success similar to Silicon Valley companies, which exhibit high levels of product innovation, short times to market, high-quality product designs, and high customer appeal.²

Many high-tech industries are achieving product innovation by employing computational engineering. For instance, the automobile industry improves the crash worthiness of its products by modeling crashes using high-performance computing simulation models for vehicle crashes.³ Goodyear uses physics-based models of tire performance to reduce its time to market and to increase the annual number of new products.⁴ Ping Golf models the interaction of its golf clubs with golf balls to maximize the effectiveness of its clubs.⁵ Integrated circuit manufacturers model their new integrated circuits to maximize performance, reduce power consumption, and minimize defects.⁶ The value of computational engineering is described in many reports by the Aberdeen Group (www.aberdeen.com) and the Council on Competitiveness (www.compete.org).

A comparison of the two cultures identifies many common features between them:

- The computational engineering culture involves small teams, indeed, sometimes only one or two subject matter experts. These people are usually highly skilled and experienced engineers trusted by their management to take risks and make the necessary decisions and product tradeoffs, and who are intimately familiar with the technical performance issues of the organization's products. They generally have access to influential decision makers. In the words of Goodyear senior management,⁴ the computational engineers run the company's "innovation engine."
- Computational engineers can generate many, many design options, explore the trade-space of these design options, and test the performance of those options very early in the design process. They can use both lower fidelity rapid analysis tools and high-fidelity (but less rapid) tools to identify design defects and performance shortfalls and fix them before designs are turned into real systems. This reduces expensive and time-consuming rework, resulting in lower risks, a faster time to market, lower costs, and a better performing product.
- The level of expertise, the time and commitment, and the long-term perspective required to be successful with computational engineering encourages leadership continuity and the development of close working relations with customers. The rapid response and flexibility that computational engineering tools provide for supporting the design and analysis process for products make it much easier and much more likely to produce a successful design option than does the conventional "design, build, test" paradigm.

1. Small, highly skilled technical teams with significant autonomy that are empowered to take risks and make decisions
2. Fanatical pursuit of promising options to a successful conclusion
3. Generally flat organizations but with a clear hierarchy and accountability
4. Early development and testing of many options and alternatives
5. Early identification of things that work and things that don't
6. Leadership continuity
7. Close working relations and connections with customer communities

Figure 1. Key features of Silicon Valley innovation culture.

The comparison is very suggestive that adopting computational engineering (virtual prototyping) naturally captures many of the success features of the Silicon Valley culture. ■

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