# The place of "basics" in product development

Virtual prototyping is valuable, but companies should build and test functional prototypes as early as possible.

A First Cut CNC machine tool is cutting a functional part from a solid block of real plastic. Aluminum is also available.

Despite the recent stir over the quality of **Toyota** cars, an unusual number of recalls a few years ago spurred the company to return to its tradition of making lots of physical concept cars for every new model. Like many companies, it had attempted to cut costs by relying too much on digital simulation. (See "Digital Prototypes? Sometimes 'Going Back to Basics' is Better," MACHINE DESIGN, Sept. 8, 2009.)

In an ideal world, every part would be individually physically tested and the results incorporated into subsystem simulations. However, this is seldom possible given the time and cost constraints of most projects. Fortunately, services such as our rapid injection molding and rapid CNC machining have made it practical and cost effective to quickly get real plastic and aluminum parts with production-grade materials. This allows the testing of real parts earlier and more often in the development cycle.

What are limitations of virtual testing? First, it is only as accurate as the input you provide. Also, the world is a complicated place so it is often difficult to anticipate all the challenges the real world can throw at a product. Finally, there are plenty of recent, well-publicized examples of system failures that might have been avoided with adequate real-world testing. In the end, you only know for sure that you have overrelied on simulations after problems crops up and you gather physical data to prove something was missed ... but by then it's too late.

So, beware of overreliance on digital prototyping. While CAE methods can help predict critical stresses and fit-up issues, they can't guarantee there are no additional problems. Digital analysis can tell you a system probably isn't going to work — a valuable thing to know — but it can't assure you that it will work. A comment appended to the MACHINE DESIGN article drives home that point, "We are producing a product and have done extensive modeling. This has been valuable for several purposes, but turned out to be nearly useless for predicting stresses. The geometrically complex parts drive FEA programs nuts in meshing, even with simplification. Predicted stresses are nearly double actual. It turns out the most cost-effective method in this case was to build a part and then break it." Lesson learned: You can make the most out of FEA simulations by using them to prioritize the physical testing required, rather that attempting to replace it altogether.

Our company has focused since 1999 on producing fast, affordable injection-molded and CNC-machined prototypes using computerized processes. Our low-volume rapid injection-molding and CNC-

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MACHINE DESIGN, "Digital Prototypes? Sometimes "Going Back to Basics" is Better," *http://tinyurl.com/ylnkkss* machining techniques give designers real prototypes during the earliest stage of product development. Users can thus "build parts and break them" all they want and at a low cost.

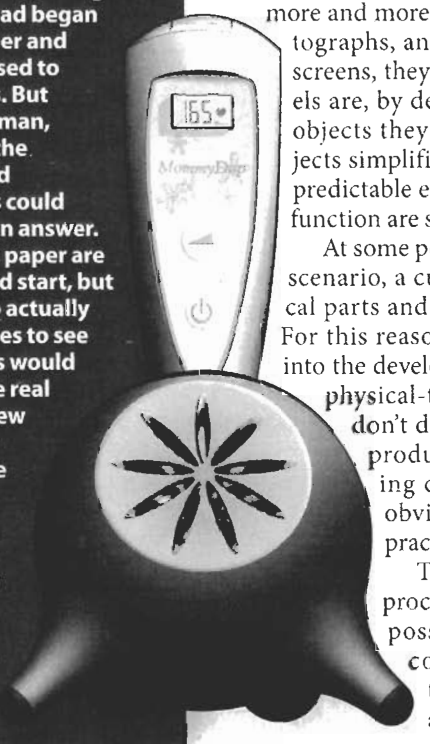
In the past, it was prohibitively expensive to manufacture injection-molded or CNC'd prototype parts in the small quantities typically needed for functional testing. Injection-molded parts used steel molds that could cost tens of thousands of dollars and take months to make, an expenditure of money and time perhaps justifiable for production runs in the hundreds of thousands, but not for prototypes. Similarly, manually setting up machine tools and programming toolpaths were costly, labor-intensive processes.

These constraints gave designers difficult choices. To control costs and keep designs moving forward, developers often put off functional testing as long as they could.This often meant bringing less-than-fully realized designs to market or having to backtrack at the last minute, significantly delaying product rollout. Alternatively, developers could bear the cost of making steel molds or programming CNC equipment to produce functional prototypes early in the process and hope they wouldn't have to repeat the process should changes arise.

True, additive plastic-prototyping processes such as stereolithography, selective laser sintering, and fused-deposition modeling let designers produce layered plastic models that simulate the shape of production parts. Unfortunately, the layered prototypes rarely match the designed finish of a part, often do not use the material specified for production, and do not share the physical properties of the production parts. The prototypes are often suitable for testing fit, but not for rough-and-tumble functional testing.

No wonder designers have jumped on the CAE bandwagon. They were already using computers to create part models so the step from virtual modeling to virtual testing was manageable. CAE systems let engineers input shapes, sizes, material properties, and the stresses to which parts would be subjected. Results are reasonably accurate, almost immediate, and costs are low.

As CAE becomes increasingly sophisticated, engineers are using it for entire assemblies as well as parts. In the case of plastic parts, CAE allowed prototyping without the cost or delay of steel tooling or the nonaesthetic layering of additive techniques. To some, virtual testing seemed a panacea, possibly a total replacement for "hard-copy" testing. But, unfettered virtual prototyping runs into unexpected obstacles as parts hit the real world.



**The BabyBeat Doppler from Newman Medical, Lake Bluff, Ill., is a fetal ultrasound system intended for home use. A redesign of the sensor head began on graph paper and then progressed to spreadsheets. But Spencer Newman, president of the company, said spreadsheets could not provide an answer. "Numbers on paper are fine for a good start, but we needed to actually test prototypes to see how the parts would hold up in the real world. We knew that additive processes like SLA or FDM wouldn't work in this case because even though they could approximate the part shape, such layering processes can leave voids in finished parts. Ultrasound is critical in the operation of the product so we needed prototypes that would be as solid as actually molded production parts."**

That said, virtual prototyping can be a powerful tool with a definite place in the development process. As computers and software continue to get faster and smarter, computer models become more and more "real." But, like maps, photographs, and virtual worlds on movie screens, they are still models, and models are, by definition, simpler than the objects they portray. Not only are objects simplified, but the sometimes-unpredictable environments in which they function are simplified too.

At some point someone — worst-case scenario, a customer — will test physical parts and systems in the real world. For this reason, designers should build into the development program their own physical-testing procedures. If they don't do this before parts go into production, it's the same as using customers as guinea pigs, obviously not a good business practice.

The goal of development processes is to produce the best possible product quickly and cost effectively. Reaching that goal demands the best available tools, and digital modeling and virtual testing can be invaluable. Digital prototypes have limitations, but they can be produced, tested, and modified easily enough to make testing of parts and entire systems an ongoing process. At the same time, it is crucial to test actual parts.

Also, consider that data from real-world testing can provide valuable input for virtual testing. If the testing of parts yields even slightly better data than the virtual testing of the same parts, then incorporating the data into virtual testing can only improve the validity of the results.

In all, digital prototyping provides valuable data that can be fed back in to identify and head off problems. It can be particularly valuable in testing complex systems and looking at the interaction of parts before they actually exist. However, because virtual testing has limitations, designers should build and test functional prototypes as early as possible. This approach becomes increasingly important as designs move toward completion and the cost of backtracking skyrockets. **MD**