Right

RIGHT

RAPID

ROUGH

Mission Specialist James H. Newman tests the Portable Foot Restraint used on the first Hubble Space Telescope servicing mission.

Rapid - Rough

IDEO (pronounced "eye-dee-oh") is an international design, engineering, and innovation firm that has developed thousands of products and services for clients across a wide range of industries. Its process and culture have attracted the attention of academics, businesses, and journalists around the world, and are the subject of a bestselling book, *The Art of Innovation* by Tom Kelley (reviewed on page 39). One of the keys to IDEO's success is its use of prototyping as a tool for rapid innovation.

BY DR. CRAIG LAWRENCE

RIGHT

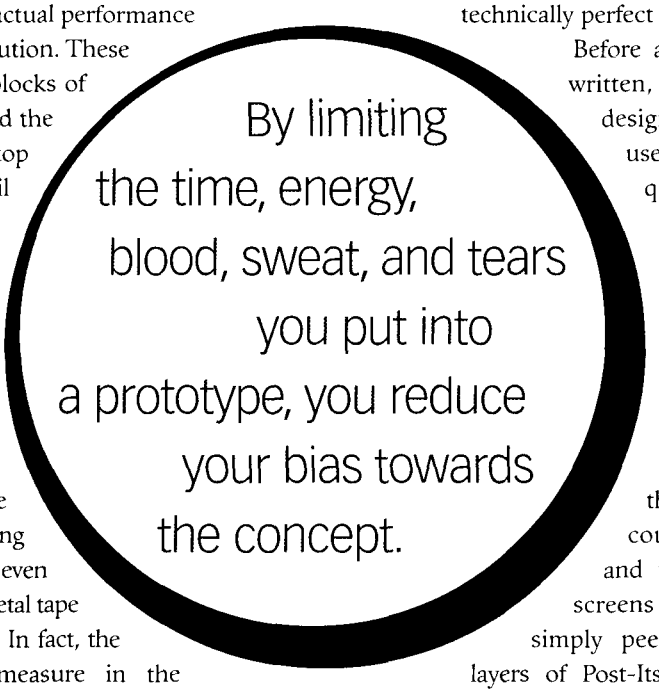
A LEADING MANUFACTURER OF PERSONAL COMPUTERS came to IDEO to design a new laptop. One of the many areas they wanted us to improve was the design of the door that covers and protects the connectors on the back of the product. Why were they so interested in this door? It turns out that one of the most common failures in a laptop is the connector door. This little feature is constantly used and abused, and inevitably breaks or falls off, causing great annoyance to the user. Our customer wanted an innovative solution that was reliable and easy to use.

The team brainstormed hundreds of alternate solutions, and quickly narrowed down the field to

several that seemed promising. How to select the best concept? Analysis was not enough; we needed to know how the doors functioned when used, and this clearly called for prototyping. At this point in the program, the overall design of the laptop had not yet been developed. Regardless, the team pressed ahead and built a series of prototypes that focused exclusively on the connector door.

Models of the door concepts were machined from plastic that would simulate the actual performance and feel of a real production solution. These models were then attached to blocks of wood that roughly approximated the size and weight of the final laptop design. Great attention to detail was placed on the areas around the door and hinge, while no effort was made to simulate any other aspect of the laptop.

Some of the concepts were complex. For example, one concept used a clever geared hinge to open a set of double doors, revealing the hidden connectors in an appealing way. Others were simple; one even "borrowed" from the common metal tape measure to create a sliding door. In fact, the team literally used a tape measure in the prototype—a quick method of testing the concept. These prototypes were taken to potential users and tested. They were pulled, pushed, squeezed, dropped, and cycled until the flaws in the concepts were revealed and a clear winner could be selected.



This example illustrates an important concept in prototyping. A prototype should be designed to answer a specific question. The key is to ask the right question (the right question is the one you really need answered), and target your prototypes to answer it.

We find that if we try to answer too many questions with a single prototype, the prototypes become more expensive, take longer to create, and often provide less value than a series of quicker, cheaper prototypes targeted at individual questions. Prototyping in this manner keeps the cost of failure low.

RAPID

Prototyping does not have to be painful. Prototypes don't have to break your project budget and devour all of your project resources. A prototype can (and should) be built in a few minutes.

IDEO developed a small digital camera that plugs into the expansion port of a PDA (Personal Digital Assistant). While this product provided serious engineering challenges, one of the toughest challenges was developing the software interface that the user encounters when operating the product. A poorly designed interface can ruin a user's experience with a technically perfect product.

Before any software code was written, IDEO's interaction designers prototyped the user interface using the quickest method they could think of: Post-It® notes. They created a series of handwritten Post-Its that represented the on-screen menus and windows the user might encounter while using the product. The team could quickly simulate and test different interface screens and menu logic by simply peeling away successive layers of Post-Its as a user navigated through the "software." If something did not make sense, they could toss the Post-It and quickly create another.

Again, this prototype was taken to users and tested, refined, and iterated. By the end of the prototyping process, the team had a solid structure they could use to develop the actual software. All without ever turning on a computer.

The main value of this sort of rapid prototyping is the ability to quickly evaluate your concept, and refine it through a series of iterative prototypes. Instead of spending your time and resources speculating solutions and analyzing the problem, spend your time solving it. Fail early in order to succeed sooner.

One of my favorite tools for rapid prototyping is Lego®. These ubiquitous children's toys are a great way to prototype fairly complex mechanisms. During the development of a medical instrument, an IDEO team used Legos to prototype several concepts for a mechanism to convert continuous rotary motion into reciprocating linear motion. These prototypes clearly

could not be used for surgery, but they are great for allowing an engineer to visualize a concept and work through some of the complex details rapidly.

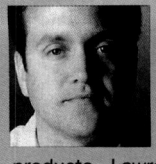
There are many great materials and tools available for rapid prototyping. Often, these are things you can find laying around: wood, plastic, tape, hot glue, coat hangers, boxes, plastic tubes, and toys. For more complex problems, tools like fused deposition modeling (FDM) and stereo lithography (SLA) are often useful. Feel free to mix high-tech and low-tech components and techniques. Use your prototype to get feedback, and then move on.

R O U G H

A prototype does not have to be pretty.

Sleep apnea is a significant problem facing millions of people. While a sufferer of this condition sleeps, the muscles at the base of the throat relax and obstruct the airway. This results in a drastic slowdown or even stoppage of breathing that can cause hypoxia or even death. One solution to this problem is to provide positive pressure to the person's airway to keep it open. The user wears a mask over the nose connected by a tube to a pump to provide the needed pressure.

IDEO worked closely with a medical device manufacturer to develop a product designed to help people with sleep apnea. Several products existed on the market, but all shared a common flaw: They were uncomfortable to wear while sleeping, and many sufferers refused to use them. IDEO set out to develop a product that exceeded the performance of existing products on the market, and that would let a user sleep comfortably.



After earning a Ph.D. at Stanford University, **CRAIG LAWRENCE** joined IDEO in 1999 as a mechanical engineer and project manager in the Smart Products studio. Focusing his efforts on developing electromechanical products, Lawrence has been a technical contributor and manager on such projects as a portable fuel cell battery for consumer electronics and a handheld medical instrument to measure human metabolism.

Lawrence is a frequent instructor at IDEO workshops, helping clients understand how to work with innovation tools. In addition, he is a regular instructor at APPL's Advanced Project Management course, and he has participated in other NASA forums for the knowledge sharing community.

One concept that quickly emerged was to mount the air tube over the user's head. This idea seemed attractive since it addressed a number of complaints from users. It could locate the tube in a predictable place, keep it from moving around as the user shifted during sleep, and it relieved the weight of the tube, preventing it from pulling at the mask.

A series of head-mounted concepts were generated and quickly prototyped at the engineers' desks using commonly found objects and a little creativity. Engineers put prototypes together using the lining of a bicycle helmet, stereo headphones, and pieces of hand-cut plastic in order to try out different ideas. They took them home and slept with them on, waking up to modify them as they encountered problems.

Fail early in order to succeed sooner.

These prototypes weren't attractive; however, they did the job and allowed the team to focus in on a winning solution. The final product incorporated a number of concepts from the various prototypes, including a unique cantilever design allowing it to accommodate various head sizes and shapes. The final product was beautiful, but it was a beauty that came from humble beginnings.

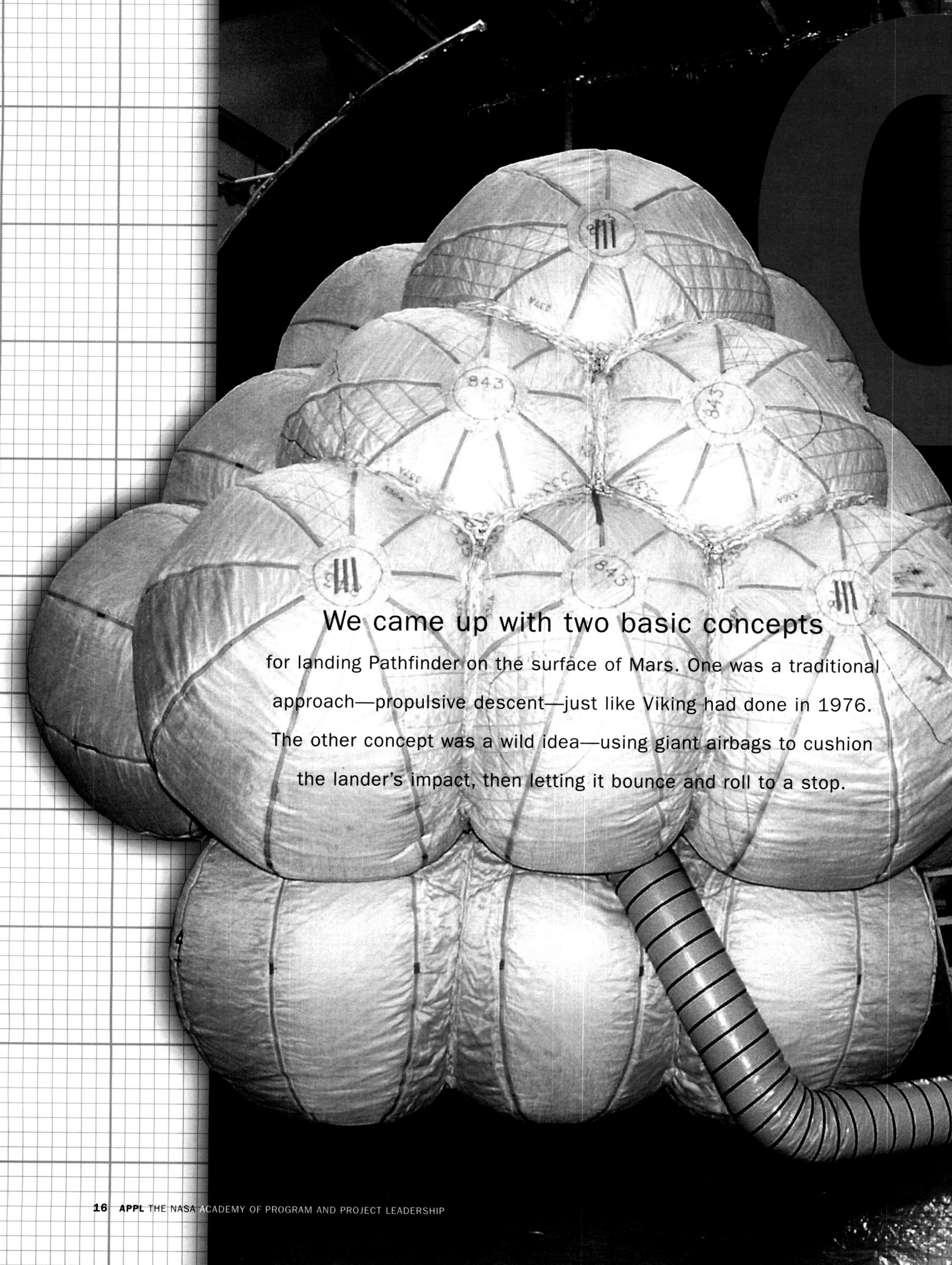
One of the benefits of creating rough prototypes is that you reduce your emotional attachment to a concept. By limiting the time, energy, blood, sweat, and tears you put into a prototype, you reduce your bias towards the concept, and are more likely to make objective conclusions and decisions about its value. •

Lessons

- Prototyping is a technique that embraces failure as a means to ultimate success.
- The Right-Rapid-Rough approach fosters innovation by forcing you to use all of your senses to attack a problem.

Question

- *How do you learn from small failures on a project?*



We came up with two basic concepts

for landing Pathfinder on the surface of Mars. One was a traditional approach—propulsive descent—just like Viking had done in 1976. The other concept was a wild idea—using giant airbags to cushion the lander's impact, then letting it bounce and roll to a stop.