

## Techniques For Designing Successful Products

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Did a product of yours ever fail to perform as expected in the market? Such failures happen frequently in the fast-paced electronics field. We have reduced our market failures virtually to zero by following one doctrine: a product can be successful only if it makes the customer happy. This principle implies that the product must satisfy an actual — not imagined — customer need. The item must also be available when the customer requires it at a price he can afford. And it must provide him with dependable service over an extended period of time.

To create a product that meets these criteria, we developed a design

process and a firm belief that each step in the process is critical and can potentially cause product failure if neglected. You cannot omit any of the steps and you go through them as thoroughly as possible. Does the process sound plodding and slow?

Actually, our new product development time is quite short. We do not push engineers to work faster to meet unreasonable deadlines. Instead, we ask our engineers to take care in each step of the design process and do each task right the first time around. In the long run, this methodical care saves the costly time needed to correct the errors that haste inevitably causes;

with it, we can skip certain traditional procedures, such as wirewrap prototyping. The design process works, because in less than 36 months, we introduced 18 products, all of which are selling competitively and profitably on a worldwide basis.

Our product development procedure is divisible into the following four phases:

(1) **architecture**: basically consists of generating a solution for a need or gap in the market, (2) **project cost analysis**: since we like to ensure a profit from our products, we analyze a product's cost effectiveness before we begin design work, (3) **design**: we don't

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Fig 1 Instruction format used for the Able Uniface microword.

design the product by just creating a schematic; the procedure includes several well-defined steps, and (4) **product support**: keeping a customer happy after he has purchased a product means providing adequate user documentation and speedy repair service.

### Architecture

In the first step you take in determining product architecture, you identify a need in the marketplace. This task is typically referred to an applications engineering group within the marketing department. Traditionally, the applications group consists of technically-oriented individuals who will fill the gap between marketing and engineering functions. These people must remain current with the state-of-the-art to be able to meet with customers and advise them on applications and systems. After the applications group identifies a need in the market, it relays this information to the design group. The design group then assumes the task of creating a solution to a problem that it has received second hand. This group often gets too few inputs and can draw only upon its usually narrow experience to find a solution.

To broaden the experience of its design engineers, we insist that they participate in the applications engineering world by interfacing with customers. As a result, Able has a group of product engineers with the experience and knowledge needed to create high-quality designs. They are also more sensitive to customer needs and

design products that are genuinely helpful to users.

Placing engineers in the dual applications/design role also allows you to aim for general product solutions that meet the needs of many customers. Each customer's requirements are specific to his application. By talking to several customers with similar problems, an engineer can sometimes find a solution that is applicable to many different problems. Instead of satisfying a demand from one customer for 10 or 20 pieces which often will not justify the nonrecurring engineering costs, such a general solution for several customers can increase the volume sufficiently to amortize these costs. In the final analysis, the customer is offered a product that would not otherwise be available to him because of his limited volume.


A general solution that typifies the broad scope approach is the Uniface (TM of Able Computer Tech.). Company engineers noticed that the more difficult part of a PDP-11 interface design also involved the common thread between all interfaces — the DMA and interrupt facilities — and the ability to emulate existing DEC hardware to maintain software compatibility. This recognition led to the decision to put the Unibus (DEC TM) interface functions on one microprogrammable interface board. Each PDP-11 interface must additionally provide I/O functions to give it its "personality" or uniqueness for a particular application. But this I/O portion of the design is relatively simple, once the more complex Uniface is complete. This ge-

neral solution allows us to supply the market with solutions to many applications easily and quickly. For instance, Uniface plus a personality card or cards can perform as a multichannel DMA communications controller (such as the DV/16), a customer-specified product or other proprietary Unibus compatible devices.

Once you choose a general solution, you should specify it in writing. The specification should include a block diagram and an indication of the performance features that the new product is expected to provide.

Then you should measure new product specifications against the capabilities and limitations of the host computer. The chosen solution must not overburden the bus or demand a faster response that the computer can provide. If incompatibilities are found, improve the product architecture to correct them. For example, you might make it more intelligent or less restrictive.

Once you have measured the solution against the computer and adjusted it as needed, the next step of the architecture involves considering product requirements from software and hardware points of view. Many companies derive the architecture from the hardware or software department and the other department must live with the structure that this imposes upon them. To reach an optimum solution, hardware and software specialists must work together. One instance when this joint effort paid off occurred in the design of the microword for Uniface. Although hardware requirements dic-

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separate sheet of paper. Keep each sheet uncluttered and easy to read. Depict logic gates in the form that best represents their function.

**Timing analysis or waveform charts.** From the schematic, build timing diagrams. Use them to verify the design against the block and flow diagrams and what you want as the end result.

**Worst case analysis.** (We feel that worse case analysis is an extremely important part of the design phase and is often omitted by many companies.) Suppose that an engineer executes a design, debugs it in the laboratory, verifies that it runs and releases it as the final design, only to find out that it does not run well in production. During the design of a product, you should always do a worst case analysis on paper. For example, if a product works on paper, it stands a good chance of working well in production. However, a typical Uniface cycle time was 155 ns, low enough to appear to make the 200 ns we had specified ample. Our worst case analysis produced a possible 210-ns cycle, which was outside of our specification. So we modified the design to employ a different CPU and Schottky RAMs. Our new worst case turned out to be 193 ns, which is well within specification. This change eliminates later timing problems that are more difficult or even impossible to get rid of.

**Product test considerations.** LSI and MSI devices make contemporary printed circuit boards very complex. This condition sometimes makes it difficult to reach enough conductor lines to diagnose the board. Make every attempt to avoid this problem, by formulating designs with an eye toward product testability. If an engineer cannot test his product, production will not be able to test it either. During the design stage, build the necessary adapter board, cables and other paraphernalia that will be used in production testing. In this way, the engineer can debug his prototype by using the same tester that will later be used in production. From this procedure, he can often find ways of improving the test equipment and can sometimes improve the product so that the tester works better.

**Wirewrapping.** Able does not use wirewrapping in its prototypes. It generates the artwork for its circuit boards. In most cases, Able reduced the design cycle by a matter of months and readied its product for the market sooner. But more importantly, the company feels that the

design should be sound the first time around. Its engineers spend sufficient time with each design before the artwork stage to be confident that the product will work. Knowing that he has the wirewrap stage to debug any glitches in the design tempts an engineer to be less careful than he should be.

The company also noted that the wirewrapped board does not always succeed in its intended function of pin-pointing problems before getting to the final form of circuit board etched from artwork. A product that works with wire-wrapped interconnections may still have noise problems at the final artwork level. Although going straight to artwork may create the need to add extra wires to the initial circuit board design, you can detect noise problems early enough to correct them before your deadline date.

**Mechanical considerations.** The design of mechanical layout is also important. For example, place switches and indicator lights on PC boards where they are easy to use and see. Appearance is important; an attractive piece of equipment receives better care from users than unattractive ones.

**Artwork.** At the artwork level, aim for a good analog approach in design. Time spent with analog equations can reduce noise problems. Similarly, when designing the artwork for the logic functions, make sure that they do not fall apart in a noisy environment. Put special emphasis and stress on the use of good ground and power connections and avoid placing critical lines near noise-sensitive lines. To insure a good sound design at the artwork stage, the engineer must work closely with the artwork designer, to prevent the creation of a noisy environment.

All this endeavor should result in a workable product — one that not only works in the lab, but after large scale production begins. For an effective endeavor, the design/application engineer must interface with many people: with the customer to determine a need, with software people to create a better system solution, and with manufacturing to determine that the product is producible. No longer can you lock engineers away like mad scientists in a room to do their design work; they must be active in all phases of the design process. Your engineers should continue to participate in product refinement after they release the product for marketing.

## Product support

The engineer's work does not end after his product goes into production. He must be willing to spend time locked arm-in-arm with Marketing and to listen for customer response to the product. Look upon any response from a customer as a potential problem for the engineering group. No matter how much you have tested, how much you have evaluated a new product, its design does not become "solid", until it has operated in customer applications. As a product goes into the field, engineers should wait for any customer call that might pinpoint unique performance demands from the new product; they must be ready to go into the field to inspect the problem on-site to incorporate appropriate engineering changes into production as quickly as possible.

Make user documentation a prime concern. A well documented product is less likely to be misused and stands a better chance of providing reliable operation. Comprehensive and easy to understand installation and preventative maintenance sections in the user manual reduce the number of problems that customers will encounter and thus save support time for the seller.

## In conclusion

Make directing new product development and support toward customer requirements a major goal. For a product to be successful, it must supply customers with what they want. For a company to be successful, it must help customers when problems arise. A structured design and implementation process should allow you to build readily marketable products. You must perform each step in the process well; if you omit even one step or do it poorly, your customers suffer and your product will not be successful.

## ABOUT THE AUTHORS

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