

PRODUCTION LINES outside a product designers' company now fabricate more than half the assembled, non-IC products that designers now develop.

One company today assembles and tests products that another company designs, and these same fabrication facilities may tomorrow make yet another company's—even a competitor's—products. Just as with IC technology, mass markets bring extreme specialization of tasks (references 1 and 2).

In some ways, this separation is a return to the past. In the 1960s and 1970s' days of volume electronic manufacturing, designers would, legend has it, "throw" their prototype designs "over a wall" to manufacturing and then go on to the next product. The manufacturing team would struggle, using a barely working prototype, mostly correct BOM (bill of materials), and rough assembly draw-



Making it under contract

ing to bring the product to reality. As a result, the same legend claims, delays and cost overruns were common, whereas product reliability and quality were poor in early production runs.

Then, high-quality products from Japan emerged in the 1980s. The quality of these products proved that electronic products could be reliable from the first day of shipping to faraway end users. Consultants proclaimed that the success of these products was due to the fact that their designers worked closely with manufacturing in the early stages of design and carried the design into manufacturing and test. Soon, almost every design team included more than just project engineers and engineering management. Representatives from purchasing, production, and test joined the "cross-functional team," and your design plans and intended changes had to get their approval, as well.

Now, our industry has given the jobs of parts procurement, board and box assembly, and final test to someone else entirely. This situation makes sense from an economic perspective, because the necessary equipment, such as pick-and-place robotics and testing setups, is expensive and needs high usage to be worthwhile but is flexible enough that users can easily reprogram it to handle different products on different days.

Even though design and manufacturing are separate from each other in the corporate and geographical senses, contractual and

**USE CONTRACT
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VERSA.**

Illustration by Dan Guidera

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marketing links bind them together. You have to know how to work within this system so that the contract manufacturer doesn't shout, "reject" when appraising your product. How do you work within this structure? What do you have to do to ensure your product a smooth trip from the development world to the production world, so your product arrives in the market as you plan?

TAKING THAT FIRST STEP

If you are considering using a contract manufacturer, you have to begin with some basic questions, such as when to start looking for one, how to find the right one, when to commit, and how to make the relationship last. If this situation sounds like finding a date that will lead to a successful marriage or partnership, it should: Breakups can be expensive in direct costs and product success. Just as with personal ads, players need to get familiar with a set of terms; I use the term "contract manufacturer" unless a reason exists to differentiate.

If you don't have a contract manufacturer in mind, you can use industry directories, such as from the IPC (www.ipc.org), the industry's pc-board and connecting association (see **sidebar** "More abbreviations, please"). It's also common to use old-fashioned word-of-mouth recommendations as a starting point, because you are choosing based on factors that don't fit neatly on a data sheet.

But selecting a contract manufacturer is more than comfort and good vibrations. Your selection checklist should include both tangible and intangible fac-

AT A GLANCE

- ▶ Working with a contract manufacturer takes careful planning and teamwork before you OK manufacturing.

- ▶ Good product documentation and many kinds of communication between manufacturers and designers are keys to success in contracting.

- ▶ Contract manufacturers are expanding into design services, and design-only vendors are moving into manufacturing.

tors, including the contractor's stability and resources. You don't want the company to run into financial trouble in pre-production or production.

Also check whether the contractor has the expertise to handle any special requirements of your product, such as UL, FCC, TUV, or other industry certifications. If your product must meet electrical standards for medical instruments, for example, make sure that the contract manufacturer has experience with the regulations, the approval, and the certification process. Even better, it should have formally trained specialists who know the details of the procedure.

It's easy to use phrases such as "check whether" and "make sure," but how do they translate into action, beyond the contractor's assurances? The best recommendation is to ask the company for references of customers that have had products with similar requirements and find out from the references how the company met these requirements. Even better,

see if the contractor can offer the names of some customers for whom things did not work out and then find out why. You may want to continue discussions with the contractor if the failure of the partnership was the OEM's fault, rather than the contractor's. For example, a partnership might fall apart because the OEM canceled the product, rather than that the contractor failed to deliver the promised expertise.

Decide how much production work you want the contract manufacturer to do on the project. Some OEMs want the contractor to produce and test just a pc board, which the OEM then installs in the final enclosure and perhaps customizes; others want the contract manufacturer to do more of the mechanical work in addition to the board work. The amount of work depends on your unit volume, the product complexity, product standardization versus customization, and even the relationship you have with your customers. After all, some of them do like to visit your factory and check out your expertise and calibration process.

Another factor in selecting a contract manufacturer is anticipated volume, because volume affects much of the contractor's production setup-and-assembly costs. Larger volumes allow the manufacturer to get better component pricing and amortize the considerable costs of setting up to make and produce your product. Some contractors can handle only large volumes of approximately 1000 units per month, whereas others specialize in smaller runs. In general, contractors that handle large, more complex products, such as medical, lab, or

MORE ABBREVIATIONS, PLEASE

Our industry has plenty of special terms and acronyms and frequently generates new ones. The tricky part is when the words or acronyms take on meanings that differ from their original meanings. Some of the terms you see in the contract-manufacturing area include:

CM (contract manufacturer): a company that builds your product based on the design you provide; the term "EMS" is replacing "CM" in most discussions and literature.

EMS (electronic manufacturing services): a contract manufacturer that also can provide other services, including design. EMS and CM companies together earned approximately \$100 billion in revenue in 2002 (**Reference A**).

IDT (independent design team): a vendor that provides for-hire design services.

ODM (original device manufacturer): a company that designs and builds a product for marketing under another com-

pany's brand and usually owns the intellectual-property rights. A typical ODM product is a generic PC. ODMs earned approximately \$36 billion in revenue in 2002 (**Reference A**).

ODM+ (original device manufacturer "plus"): an IDT that also provides manufacturing for an OEM and usually expects to make most of its profit from that effort rather than from the design phase.

OEM (original equipment manufacturer): originally, a com-

pany that both designed and manufactured a system or product. It now often means a company that designs but contracts out the manufacturing or contracts out both tasks and is thus primarily a product definer and marketer.

REFERENCE

A. "Quarterly Forum for Electronics Manufacturing Outsourcing and Supply Chain," Technology Forecasters Inc, Dec 6, 2002.

test-and-measurement systems, work better at lower volumes, and those that produce mass-market products, such as PDAs, work better for high-volume products. Make sure the contract manufacturer you are considering understands the “cost times volume” of your product and is a good match for it.

Next, you have to determine when to bring the contractor into the project. As with so much of engineering, no single right or best answer exists. The answer depends on many specifics of your project, such as its architecture, complexity, key parts, and target date for release. In general, sooner is better, because the contractor can suggest changes that may make your design less expensive to manufacture or test or that make it more compatible with the contractor’s expertise and equipment. Further, the contractor can offer suggestions on many small but crucial mechanical details, such as whether a right-angle-mount LED is better than an SMT LED with a light pipe.

Location is another consideration. Contract manufacturers have facilities all over the world, and you may not have a

problem, in theory, with a contractor’s manufacturing your product thousands of miles from your design team. But, even in this day of global connectivity, distance can be an impediment if you are new to using a contractor or if the contractor is new to your kind of product. You may want to specify that the company use a facility that is relatively close to yours or even seek out a company in your area.

The reviews of your evolving design plan before final actual design is a continuous process. As you firm up design details, you need to keep the contractor up to date on your design’s specifics. Sometimes, a change you make in layout or parts that is simple at the design stage has complex implications in test or fixturing or goes beyond some factor that the contractor is comfortable in handling. Also, the contractor may suggest nominally minor changes, such as substituting one vendor’s bypass capacitor for another’s, because the company has a relationship with that vendor. This change may be no problem, or it may be a big problem if your design is counting

on some critical, second-tier performance parameter of the part.

It is important to establish design ground rules early. Make sure you are comfortable with the contract manufacturer’s approved vendor list as a source for your components. Our industry has various component and production standards, many of which the IPC established, but not every contractor can handle the latest in component size, pc-board line width and spacing, overall physical size, and similar parameters. You may want to use the latest in 0201 (0.02×0.01-in./0.5×0.25-mm) passive components, but the contractor’s pick-and-place machines may be unable to install or inspect them. Fortunately, software and EDA tools can make it relatively easy to set and follow design rules and flag violations so that you can either avoid or discuss them.

All your ongoing interactions with the contractor, encompassing your design work, debugging, and product verification, come together with the final product documents, including BOMs, assembly drawings, functional and system-

GOING ALL THE WAY

In today’s fast-moving design and manufacturing world, many so-called OEMs (original equipment manufacturers) want another company to do some of their work, whereas the IDTs (independent design teams) and contract manufacturers hope to expand their businesses for more revenue. The result is two converging trajectories.

The IDTs are morphing into ODM+s (original device manufacturer “pluses”)—teams that provide manufacturing for OEMs and usually expect to make most of their profit from that effort rather than from the design phase. These teams reach this goal by taking on more of the contract manufacturer’s role, either by directly supplying manufacturing resources or by linking up with these contractors. In so doing, they further extend themselves into the sequence that begins with design creation and ends with product delivery. You

can give your design requirements to the independents and have them follow through into manufacturing with minimal intervention on your part.

Some IDTs specialize in delivering new designs based on a preferred architecture with which they are familiar, such as the x86 family and derivatives, and adapt their previous work to your high-level requirements. This approach can save design time and manufacturing-preparation effort. Other independents specialize in tackling a class of product, such as medical or communications instrumentation, and choose components and architecture based on the requirements of the product, such as a handheld blood meter versus a large, desktop or rack-mounted blood-analysis instrument. Independent design teams can even write a user manual for you if that’s part of the contract.

Converging with that “extend-

your-reach” trend but from the opposite point, contract manufacturers are broadening their capabilities in areas that occur before manufacturing begins. They have expanded their engineering expertise into providing design services, instead of just getting your design into their manufacturing system; this expansion forms the basis of the electronic-manufacturing-services role they play. They provide their experience at ensuring that leading-edge designs are also manufacturable. Problems in the manufacturability sometimes arise when design-focused engineers use too many of the latest components in their systems.

Which is the better choice for you? No simple answer exists, because so much depends on your design’s planned architecture, product complexity, anticipated production volume, existing relationships, and any application-specific expertise you need.

In the end, whether an OEM does the design itself or you have an independent design team or a contract manufacturer do it, the OEM generally owns the intellectual property of the design. However, exceptions exist, especially when the OEM is working with ODMs (original device manufacturers). This ownership allows the OEM to take the final design to another manufacturer, although financial and practical penalties may crop up if they do so. For example, an OEM may have to transfer a design and BOM (bill of materials) to a different manufacturer from the one it originally intended it for. The contract also has cancellation clauses that describe penalties if an OEM cancels the project at different points in the process; true OEMs that internally perform both design and manufacturing rarely need to consider this problem.



level test procedures, and approved vendors.

You must allow for a detailed design, production, and test-plan review. This review is your go/no-go point, at which you and the contractor agree that the product meets both your needs or that some action needs to occur before manufacturing accepts the design. You should encounter few surprises at this stage, because you should have been working with the contractor's project team in ongoing design reviews and discussions.

Also agree on the size of the test run you need. Good arguments exist for a longer run to build up manufacturing expertise and uncover component variations and tolerances that only a larger sample size can provide; on the other hand, a small run enables you to more quickly react and get your product to market. Depending on the size, complexity, and originality of the design, test runs usually involve 10 to 100 units.

Few products live by pc boards alone. They need cables, harnesses, panels, enclosures, peripheral subassemblies, and more. You have to decide whether you

want the contractor to provide these parts or you want to add them yourself at a final assembly stage. It may be more practical to do it yourself if your final product is customized.

If you expect the contract manufacturer to provide cables and enclosures, be prepared to spend extra time in review and planning. Unlike pc boards, which all look roughly alike and generally have no human-factor and appearance issues, completed products must look and feel correct to end users. It may take several iterations of enclosure design to find one that meets design demands, marketing needs, cost constraints, and manufacturing requirements. Be sure that the contractor you choose has the experience and even established links with metal and plastic design, fabrication, and tooling sources for your situation.

Interaction with your contract manufacturer is an ongoing process during the design phase. You need to use personal meetings, e-mail, video links, and collaborative software to ready your project for the contractor and to work out any problems that arise in the early

stages of production. Even if videoconferencing is a difficult or a special event, you each may want an available high-resolution camera with variable magnification and a reliable still-video link so that you and the contractor can show each other assemblies, components, and pc boards.

Be sure that the contractor assigns a project manager and a backup manager as your primary and secondary points of contact. Look at both your and your contractor's design and development software and tools. A common tool set enables the contractor to track your efforts, suggest changes, and establish a common context for discussion.

These tools can operate and support your design and collaboration on several levels. Standard simulation and layout EDA tools are essential for your design. Such tools establish a foundation for your design by embedding design rules that you and the contractor agree on for factors such as pc-board line width and spacing and minimum size of components. They also establish tolerance bands that you need to stay within on

mechanical and electrical parameters.

The next step is project software, which keeps track of your schedule, highlights gating items and problems, and identifies who is responsible for what. Some of these collaborative software tools also collect and track all e-mails between you and the contractor to ensure that nothing falls through the cracks. If you use collaborative-software tools, make sure they can drill down to BOMs, schedules, engineering-change requests and orders, and individuals responsible for each item. Most contract manufacturers can work with several of the most common collaborative software tools, so check with your contractor to see which tools it prefers.

Ongoing and frequent communication is key to a successful transition of your design to the contractor, assuming that your design is reasonably robust. This communication must take place at various levels through automated design and collaboration tools and through e-mail and phone calls. No mode is sufficient by itself.

Traditional OEMs that want to work

with contract manufacturers should note that these contractors are migrating back along the engineering chain to provide design services (see **sidebar** "Going all the way"). This news is either bad or good, depending on your perspective. The contract manufacturer, in effect, takes on some of your job responsibilities and even your job. Alternatively, working as a designer for a contract manufacturer can give you the opportunity to participate in a variety of designs, make lots of industry contacts, and increase your skills in various application areas.

Don't forget the manual, even if you think users won't read it. The contract manufacturers expect you to write it. However, for the right price, you can get someone else to also perform that task. □

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