When Jack Calderon signed on as CEO of EFTC Corp. in 1996, he needed a strategy to ensure that his small company could survive in a business obsessed with size and economies of scale. The then-$56 million (1996 revenue), Denver company faced competition from billion-dollar giants, all gobbling up high-volume OEM outsource contracts that were fueling the manufacturing services boom.

To catch that outsourcing wave, Calderon decided to buck the conventional wisdom and think small. He adopted a "high-mix" strategy, going after a variety of projects, many in small production lots. The strategy depended crucially on winning many small orders and devising a manufacturing process flexible enough to allow lightning-fast reconfiguration of assembly lines and equipment.

The high-mix business model can be way more demanding than low-mix, high-volume manufacturing runs, but it pays off because you can charge premium prices. "High-mix, is a business that has long been under served," Calderon says.

This isn't the first time the veteran manufacturing executive identified a growth opportunity and stole a march on the market. At Honeywell Inc., Minneapolis, Calderon helped win the outsource contract for Armonk, NY-based IBM's PC XT in the early 1980s, an exercise that became a model for today's manufacturing services business.
At EFTC, Calderon phased out the company's high-volume board-stuffing work and won lucrative, high-mix contracts building circuit boards for telecommunications, medical equipment, avionics and industrial controls OEMs. In the process, the company's revenue rocketed to $227 million in 1998. EFTC jumped from number 51 on the Electronic Business Top Contract Manufacturers’ list in 1997 to number 34 in 1998. Calderon predicts that EFTC will have sales of $350 million to $400 million next year.

**A coming of age**

Manufacturing services has emerged as one of the decade's top performers. The days when manufacturing service companies were considered low-end board stuffing shops have long since passed. With a compound annual growth rate of more than 20%, revenue in the sector reached $90 billion worldwide in 1998. The industry is on track to hit $178 billion by 2001, according to Technology Forecasters Inc., Alameda, CA. Contract manufacturing's growth rate contrasts starkly with the 7.5% annual growth rate of overall electronics equipment production worldwide.

Now the industry stands to catch an enormous windfall. OEMs around the world are focusing on core strengths and have embraced outsourcing. So while OEMs concentrate on product design and marketing, where they can add value, contractors stand to pick up a pile of work.

According to Technology Forecasters, 14% of all electronics production passed through the hands of contract manufacturers in 1998. Within a decade, the industry is expected to account for 50% or more of all electronics production.

Like the OEMs they serve, contractors are also looking to add value. The high-mix business model is attractive because the margins can be better. For example, over the last four quarters the average operating margins for three high-mix players (Jabil Circuit Inc., St. Petersburg, FL, Benchmark Electronics Inc., Angleton, TX, and Sanmina Corp., San Jose) was 9.2%. The average operating margin for three low-mix manufacturers (SCI Systems Inc., Huntsville, AL, Solectron, Milpitas, CA, and Flextronics International Ltd., San Jose) was 4.2%.

**THE TOP FIVE**
The five top manufacturing services companies in 1998, by revenue

<table>
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<tr>
<th>Company</th>
<th>Revenue</th>
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<tr>
<td>SCI Systems</td>
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<td>NatSteel</td>
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**THE TOP FIVE**
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5. Jabil Circuit $1.4 billion

SOURCE: CAHNERS RESEARCH

**METHODOLOGY**
Electronic Business researchers expanded this year's Top 100 Electronics Contract Manufacturers list to include companies from around the world. Data for the Top 100 is collected from secondary sources, and through surveys sent directly to the companies themselves. To be included in this year's list, companies (both public and private) must derive a considerable percent of revenue from electronics contract manufacturing services. The companies were then ranked based on their 1998 contract manufacturing revenue.

**The high-mix niche**

There has always been a good outsourcing business for complex circuit boards, military equipment, avionics and medical equipment as well as big-ticket capital equipment. Consolidating manufacture of these small lots at a specialist contract manufacturer makes sense, analysts say, because the contract manufacturer can combine production from several customers and run production lines at 60% to 80% of capacity or more.

"The automated test industry is a good example of a high-mix customer," says Charles Mullen, director of high-technology consulting at Technology Forecasters. "Companies such as Teradyne need hundreds of PCBAs, but in relatively low volumes." But try to find companies that can do the job--test equipment maker Schlumberger can't find any, says Mullen, one big reason it has yet to use contractors.

Contract manufacturers that focus on low-mix, high-volume work aren't usually interested in these jobs, especially when demand for high-volume production is strong. Low-volume work can be prohibitively expensive for companies that haven't learned to adapt their manufacturing processes to handle the recurrent set-ups required for the changing production mix. Then there's the headache of managing a large supply chain of component and materials vendors.

That means more opportunity for flexible small contractors, thanks to the growing trend toward "mass customization." Oxymoron or not, mass customization is a key marketing strategy of OEMs, says Technology Forecasters' Mullen.

OEMs looking for semi-custom services have to look far and wide to get them cheap, Mullen says. "The sector is attractive to [high-mix, low-volume] contract manufacturers precisely because they can gain a higher profit from this type of work." A few years ago OEMs didn't have these options. They either went to Mom-and-Pop-type shops or to large manufacturers ill-suited to semi-custom
small lot orders.

While custom work has hardly caused a stampede into high-mix manufacturing, more companies are taking advantage of the opportunities in the niche. Companies on this year's Top 100 Contract Manufacturers list (see p.104) that derive significant revenue from high-mix work include Manufacturers' Services Ltd., Concord, MA, which ranked 9th for 1998 at $838 million, and 12th-place Benchmark Electronics Inc. with 1998 revenue of $524 million. There are only a handful of companies above $100 million in revenue after those two; among them: 17th-place Plexus Corp. of Neenah, WI, with $402.6 million, and EM Solutions Inc., Longmont, CO, in 23rd place with $314.8 million.

High mix has proven itself a viable and growing business, but the value of the business remains difficult to gauge, notes Keith Dunne, an analyst with investment bankers BancBoston Robertson Stephens, San Francisco. "It's not limited to companies that focus on the model, but includes many larger companies that do some part of their business in high mix."

Mullen believes that some of the largest companies in manufacturing services--including Solectron, SCI Systems and Celestica Inc., Toronto, ONT--are handling large amounts of high-mix work but don't break out the revenue from that business.

**Listening skills help**

Successful companies doing high-mix work tend to have a strong service orientation. They get involved early in the design to enhance the ease of manufacturing the product. In addition, they have developed flexible, cell-driven and repeatable manufacturing processes.

"You won't succeed in this business unless you build a highly responsive relationship with the customer."
- MARK STEVENSON, EM SOLUTIONS

They can also, as a rule, take over and manage the customer's supply chain. OEMs outsourcing production expect their contract manufacturers to be expert in managing a complex supply chain, according to Kevin Melia, chairman of Manufacturer's Services. "As OEMs outsource more of their production, they are looking for a certain comfort level from EMS [electronic manufacturing services]," he explains.

That means understanding that contract manufacturers are in the service business, not merely in board or computer assembly. "You won't succeed in this business unless you build a highly responsive relationship with the customer," says Mark Stevenson, an IBM and Xerox Corp. veteran who launched high-mix contractor EM Solutions in 1994.

That can be a tough assignment because the logistics can be daunting. The large number of products, not to mention the complexity of some of them, can challenge the inventory and supply skills of the best high-mix operators. Whereas a low-mix, high-volume production line might build products comprised of a couple of dozen parts, a high-mix line might make items that are comprised
of 50 to 60, and sometimes even hundreds, of parts, according to Melia.

Melia honed his manufacturing skills during 17 years at Digital Equipment Corp., Maynard, MA, and, later, as vice president of operations at Sun Microsystems Inc., Palo Alto. "Sun was one of the first to use outsourcing as a strategic weapon," he asserts.

At Sun, Melia began to see the opportunities opening up for contract manufacturers. When he launched Manufacturers' Services in 1994, he decided to target the high-mix business in both small- and medium-lot production. The strategy paid off. Only four years after launch, the company reported sales of $838 million.

High-mix manufacturers have to deal with weighty management issues, such as the logistics and costs involved in tracking perhaps 10,000 parts with all the related warehousing, inventory controls and supplier relationships. The good ones have developed ways of achieving economies of scale in purchasing, established more cost-effective sources of supply and amortized expensive equipment such as testers.

**Flexible production lines**

If there is one thing that manufacturing engineers learn from the high-mix business, it’s flexibility. Profits depend on the ability to move quickly and efficiently from one small, specialized order to another. Equipment knockdowns and reconfiguration are part of the daily routine.

For EFTC's Calderon, the breakthrough in handling high-mix production came while thinking about the Asynchronous Transfer Mode (ATM) network protocol. "The ATM protocol works by making the data packets so small they can quickly be processed by a server. You move the packets to any available server on the network," Calderon says, rising to his punch line. "The location doesn't matter."

He adapted that same concept to the high-mix production line and called the process Asynchronous Process Manufacturing (APM). In APM, a processing point on the production line such as component loading, soldering or test replaces the server. Calderon says small production lots move to any of the standardized production points on the parallel production lines, passing from one line to wherever it's necessary to break bottlenecks and keep products rolling.

On the traditional, continuous-flow line, or so Calderon argues, workers would have to break down lines and set up machines for different production lots. APM, he says, gives EFTC plants the flexibility to keep lines up and running.

At the heart of the APM system is proprietary production software called Assembly Execution System, which directs the flow of production lots across the parallel assembly lines.

Other high-mix manufacturers have found their own versions of the APM concept. In order to build products that are much more complex or are required to be far more reliable, high-mix manufacturers have had to adopt a factory layout that differs markedly from straight-line manufacturing used in high-volume operations.

To succeed, high-mix production must also be cell driven, according to EM Solutions’ Stevenson. "You need manufacturing teams dedicated to a particular customer's product. These dedicated cells enable you to meet the changing demands of different production lots on the line."
"You move the packets to any available server on the network. The location doesn't matter."--JACK CALDERON, EFTC

The efficiency of those cells depends on a corporate IT system that translates each customer's needs and communicates that information from cell to cell along the production line. "The IT system gives you a clear picture of the entire operation," says Stevenson. "The system should provide an overview of the efficiencies and inefficiencies of each cell," he says. And manage hundreds of suppliers while the cells are in a feeding frenzy at the same time.

Staking out a space

The high-mix business cuts across a wide swath of contract manufacturing, producing products that range from low-cost boards to sophisticated IC testers that sell for $3 million apiece. Benchmark Electronics, for example, targets the high-end. "We were a spin-off from a medical equipment maker in 1986, and from the very start we focused on high-complexity products," says Don Nigbor, Benchmark's CEO.

The company's reputation for reliability--a legacy of its roots in the medical equipment market--led to contracts for fault-tolerant computers used for critical applications such as air traffic control. In January, Benchmark acquired the Irish manufacturing assets of Stratus Computer Inc. of Maynard, MA, a maker of fault-tolerant systems.

Perhaps the fastest-growing sector of the business is build-to-order. This variation of mass customization has contractors custom configure products such as personal computers or high-end routers, as orders arrive. Since the aim is rapid order fulfillment, the contractor bypasses the OEM and ships the product directly to the customer. Pioneered by PC makers, today build-to-order is a model accepted by companies throughout the electronics industry.

One trend that every company in the high-mix business subscribes to is an increasing involvement with the customer, according to Manufacturing Services' Melia. "Today, contract manufacturers are involved throughout the product life cycle, all the way to end-of-life and after-market work such as warranty repair," Melia explains.

Aftermarket work, warranty repair work and maintenance, is a business that OEMs have long been keen to hand over to contractors. Dataquest Inc., San Jose, forecasts that the electronic hardware maintenance market alone will be worth $106 billion in 2000, up from $87 billion in 1995.

While many contractors shun such work, EFTC takes the warranty and maintenance business seriously. In 1998, the company set up a repair and warranty division in plants acquired from Circuit Test Inc. in Memphis, and Louisville, KY. The plants are located inside the cargo facilities of major air express companies to ensure lightening-fast turnaround and delivery. Warranty work now accounts for close to 20% of EFTC's revenue.

Size matters

As giant OEMs move increasingly to outsource all production, contract manufacturers are coming
under pressure to grow alongside their customers. "The contract manufacturers need to be large enough to be viable partners for the OEMs," according to Technology Forecasters' Mullen. The contract manufacturers need to have sufficient financial bulk and geographic reach to be taken seriously when they offer to take over an entire product line from a major OEM. This is one of the goals of the rapid growth through acquisitions that manufacturing services--and its high-mix sector--are involved in today.

In the overall manufacturing services industry there were 68 mergers or acquisitions in 1998, up from 50 in 1997. Analysts say the industry could see another 100 mergers or acquisitions this year.

At the same time, OEMs are divesting their manufacturing operations at breakneck speed. In January, Nortel Networks Corp., Brampton, Ontario, announced a restructuring in which 17 of its 24 production sites will be sold or shut down. Outsourcing contacts from Nortel alone could be worth $500 million a year.

It's not only the giants of the manufacturing services world that have been busy acquiring companies. Manufacturers' Services carried out five successful acquisitions in 1994 and 1995, its first two years of business. "We had to grow to get the right locations, and put the right network of companies together," Melia says. The company now has plants in the United States, Ireland, Singapore and Malaysia. At five years old, Melia expects his company will break the $1-billion mark in revenue this year, and expects to conduct an IPO within 18 months.

EM Solutions and EFTC both acquired four companies in as many years. In May, EFTC signed a 10-year manufacturing agreement with Honeywell, to acquire Honeywell's plant in Tijuana, Mexico, which will become EFTC's ninth U.S. plant. The plant could bring Honeywell manufacturing orders worth up to $100 million a year.

The growing trend of OEM outsourcing and the electronics industry's move to mass-customization are strong indications that high-mix contract manufacturers will prosper in the next decade. But managing 20% growth together with the furious pace of mergers and acquisitions in recent years could cause high-mix companies to slip up and lose their focus their on core competence. The temptation to become an OEM may become strong--especially as today's OEMs become virtual companies focused on design and marketing.

"The important thing to remember is that we are in the service business," says EM Solutions' Stevenson.*