Raychem Corporation
Interconnection Systems Division

"Look, Mike," telephoned Steve Marsland, newly appointed operations manager of Raychem's Interconnection Systems Division (ICD) in Menlo Park, California, one Sunday afternoon in April 1990. "You've *got* to stay with us. I'm determined to turn this division around. It can be done, but we've got to have you with us to do it"

"Sorry, Steve, but I can't," replied Mike Vrcelj (pronounced Vurcell), ICD's head of manufacturing engineering. "I *don't* think the operation can be turned around. Don't get me wrong. There's great potential here. I've been reading about manufacturing cells and zero-inventory manufacturing for years. If we could do some of those things here, we'd mint money. But management doesn't understand this stuff, and every time I've tried to take a step in the right direction they've stopped me. We're stuck in this traditional system. I've banged my head on these walls too many times, and I'm out of here."

"I know you're frustrated, Mike," Steve argued. "But this time, *I'm* in charge, and I can help you do it. In two years, they're gonna come here and write some of those articles about *us*. I even bet the Harvard Business School will come and write a case about Mike Vrcelj and the turnaround at ICD. Stay with us, Mike. We can do it!"

Whether it was the possibility of being deified in an HBS case or the simple attraction of turning the $30 million division around, we may never know. But Mike Vrcelj agreed to stick with Steve Marsland, and within two years they and their colleagues engineered a remarkable performance recovery at ICD. Their achievements, and the problems that remain, are the focus of this case.

The Raychem Interconnection Systems Division

In 1988, Raychem Corporation was a billion-dollar manufacturer of specialty products built around Raychem's core expertise of creating and modifying specialty plastics using electron beam technology. Examples included closures that seal and protect signal-carrying copper and fiber-optic cables for telephone and television networks and aerospace equipment, and conductive polymer

Professor Clayton Christensen prepared this case as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation. Some of the names and data in this case have been disguised, to protect the proprietary interests of the company.

coatings which were found in oil pipelines and mass transit systems. The corporation's revenues came from over 50,000 different products.

Raychem's Interconnection Systems Division designed, manufactured, and marketed specialty connectors. These were grouped in four product lines: (1) multicontact connectors (plugs and receptacles) used to make fly-by-wire connections in aircraft and missiles; (2) data buses, which generally were flat, multiwire cables or wiring harnesses which carried electronic signals; (3) individual wire connectors such as plugs, jacks, and bus terminators used to connect single or coaxial electronic cables—military versions of the connectors many consumers used to connect video recorders to their television sets; and (4) frames that facilitated the secure mounting and soldering of integrated circuit packages directly onto the surface of circuit boards. Photographs of representative products from each of these lines are reproduced in **Exhibit 1**.

ICD focused primarily upon military and aerospace electronics markets, leaving the much larger markets for connectors used in consumer and industrial electronics to giant competitors such as AMP and Thomas & Betts in the United States, Augat in Europe, and Hirose and Fujitsu in Japan. There were two reasons for pursuing this niche strategy. First, there were significant economies of scale in the design, production, and marketing of most interconnection devices, as described in **Exhibit 2**. This graph shows that, all other factors being equal, a company typically suffered a 10% cost disadvantage versus a competitor that was twice as large, because larger-volume producers could amortize fixed costs such as tooling, set up, product design, and manufacturing and marketing overheads over larger volumes. The second reason for ICD's focus was that military customers tended to demand more rugged product designs, and were willing to pay higher prices for that ruggedness, than customers in commercial markets—a barrier that discouraged larger connector manufacturers from selling their commercial products into the military market. **Exhibit 3** shows trends in the estimated size of these broad market segments.

Although gross margins typically were higher in military markets, the costs of doing business were commensurately higher as well—primarily due to the broad product lines required of component suppliers. Military customers tended to keep products in service much longer than counterparts in commercial markets, and insisted that companies supplying components used in these products continue to manufacture replacement parts as long as the products were in use. Hence, it was difficult to prune old models from ICD's product catalog. And advances in electronics technology had facilitated a proliferation in the types of electronic equipment used by the military and also in the number of custom-designed components they used.

Because of its focus, ICD's revenues tracked trends in military spending. The market had grown rapidly in the early 1980s, had been flat in mid-decade, and then began to contract late in the decade as the cold war ended. The strategy ICD management initially had pursued to maintain growth and profits as the market turned down was to diversify into making new types of connectors for other segments of the military market. As a result, the number of product models ICD actively produced increased from an already substantial 700 in 1980, to 1,500 in 1985, and 2,600 in 1990.

These initiatives were rarely profitable, however, for two reasons. First, ICD's overhead burden grew with the task of managing the more complex flow of products through the ICD plant. Second, other connector manufacturers in the military market followed the same growth strategy as ICD—they expanded into ICD's product areas, just as ICD had invaded theirs. Hence, ICD faced more competition in each of its product lines. Pricing pressures forced gross margins down, even as ICD's overhead expenses increased to support its broadening line. Whereas the division had earned $4.6 million in operating profit in 1988, it had lost money on revenues of $36 million in 1990. With no recovery in military spending in sight, Raychem's senior management in 1990 was considering closing or selling the division, since it seemed able to maintain its revenues only at great expense, in terms of cash and profits. The division's recent financial performance is summarized in **Exhibit 4**.

ICD management in 1990 recognized that the complexity of managing ICD's ballooning product line was associated with the trends in inventories, overhead and engineering costs that had driven division profits downward, but there were no obvious solutions to the problem. ICD was surrounded by larger competitors who, because of greater manufacturing volumes, could make similar products at lower cost. One reason customers came to ICD, and paid substantially higher prices, was that ICD was willing and able to make such a wide variety of specialty and custom products. By some estimates, in fact, over 60% of the models that the division produced in 1989 were custom-designed products targeted at single customers.

Manufacturing of Interconnection Devices

In 1990, ICD's operations were housed in five neighboring buildings which comprised about 9,700 square meters (104,000 ft^2) of manufacturing, storage, and office space. ICD was only partially vertically integrated. Its in-house injection molding department made most of the plastic components required in its products. Almost all other parts, including die-cast and stamped metal parts, were designed by ICD engineers and made under contract by external vendors. Because ICD produced such a wide variety of products, many of which required unique process flows, the assembly buildings were laid out according to manufacturing function. This meant that when new products requiring new process sequences were introduced, these could be accommodated without any physical relocation of equipment or workers. Planners simply created a unique routing sheet which traveled with the parts to various fixed stations through the plant, instructed workers at each station what they should do with the parts, and told materials handlers where they should take the parts after each manufacturing step was completed. Plastic injection molding machines were likewise grouped together, in a separate building.

To produce injection-molded plastic components economically, fixed set-up costs needed to be amortized over a relatively large batch of parts. Similar economics in vendors' factories dictated batch sizes for purchased metal parts as well. To avoid high set-up charges, ICD had to buy components in large lots and store them until they were needed in assembly. Amortizing set-up costs was not as important a driver of batch size in assembly, where operators generally used simple tools and fixtures to do their work. But products also were assembled in batches, because it was more economical to transport parts from one department to the next in larger batches, rather than individually. **Exhibit 5** presents a process flow for a typical ICD product across the buildings in which these activities took place.

Changing the System: One Man's Attempt

The person charged with engineering a profitable way to make ICD's plethora of products in 1990 was Mike Vrcelj, 50, ICD's manager of manufacturing engineering. Vrcelj had left his native Yugoslavia in 1969 with a chemical engineering degree from the Technological University of Belgrade. He joined Raychem in 1981. Although he had no formal training in the sorts of low-inventory, just-in-time production systems which had been pioneered at Toyota Motor Company (hereafter called JIT), Vrcelj had first read of Toyota's achievements in the early 1980s, and subsequently had read every book and article on the JIT manufacturing philosophy he could find. Vrcelj had eagerly accepted his transfer to become manager of manufacturing engineering at ICD in 1987, hoping to use his new position to implement these principles at ICD. ICD employed about 285 people in engineering and manufacturing operations when Vrcelj assumed his responsibilities. About half of these were directly involved in assembly and parts manufacturing; the other half performed various supervisory, support, and development roles, as shown in **Exhibit 6**.

> Something needed to change. When you looked at the jobs all of us were doing, it was amazing how many of us weren't directly building products. Most of

> us were, in some way, working to help the direct employees be as productive as possible. But most of our costs were in our overheads, not in our direct labor—and nobody was thinking about how to make the *overhead* people more productive.
>
> The problem with getting our management to attack overhead costs, even though they knew what a large percentage of our total cost was in overhead, was that our overhead people were the busiest people in the division. They were the ones who told us what we should make and when we should make it; who pushed orders through the system and got them shipped; who figured out how to produce new products and how to improve the way we made existing ones.

Vrcelj continued:

> Once I was in a meeting with my boss's boss, and I commented that we needed to reorganize to cut our indirect manufacturing headcount if we wanted to stay competitive. He looked at me like I was crazy. "They're the only ones in the division who are really earning their way. Without them, this place would completely fall apart!" was his answer.
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> Of course, he was partly right—the place *would* have fallen apart in 1990 without those people. Orders rarely got shipped on time unless one of the expediters personally championed the order. And the materials handling and scheduling people were going crazy, keeping track of all those parts. But from what I'd read, I thought if we fundamentally changed our process, to manufacturing cells or a JIT system, the process would work *without* those people.

Convinced that a cellular JIT system could somehow be a useful way to address some of the division's cost problems, Vrcelj decided to run a demonstration experiment by pulling the process for assembling a marginally profitable line of connectors out of the main factory flow, and to produce it in a manufacturing cell situated in a corner of one building. The cell comprised eight stations, each equipped with machines and fixtures Vrcelj had found unused elsewhere in the plant. He pulled six workers out of the main batch operation, cross-trained them in each of the CBA's eight assembly operations, and pressed them into service in the CBA cell. "I felt the CBA cell experiment was a big success," Vrcelj recalled. "It was really amazing. We could move a batch of 300 connectors from start to finish through that cell in less than eight hours, whereas it used to take us four weeks to assemble that number. And the quality was flawless."

But management didn't see it that way. "Sometimes, depending on what product we were running, we didn't utilize all the equipment in the cell. It bothered them to see that equipment sitting there idle," Vrcelj continued. "Besides, the cellular layout didn't change the direct labor content on the job, and I couldn't demonstrate any overhead savings because all those people were still working their heads off in the batch operations. Our throughput time was clearly improved, but management didn't get excited about that. Our customers generally ordered three months in advance of when they needed shipment. I guess they just couldn't see what the big deal was, and I didn't have the numbers to prove to them that this was a better way of making things." Vrcelj abandoned his experiments six months later when management decided to discontinue the product line.

Vrcelj grew increasingly frustrated and ICD's financial performance grew steadily worse through the remainder of 1988 and 1989, as division management tried to stem the declines in revenues and profits by continuing to develop new products for additional market niches. But it didn't work. In late 1989 senior Raychem management began to consider the sale of ICD, and ICD management subsequently dismissed ICD's staff of product development engineers and many of its sales and marketing people, because creating new products was no longer consistent with the division's status. This was the environment in which Vrcelj decided to resign, and into which Steve Marsland arrived in April 1990.

Planning for a Turnaround

Steve Marsland, 37, had joined Raychem in 1980 after earning an MBA at the Harvard Business School. Marsland had studied manufacturing management in Japan prior to joining Raychem, and had worked in several operating and staff positions in the corporation. Marsland had left the company in 1988, but Raychem senior management recruited him back to Raychem in 1990 to become operations manager at ICD, promising to support a new approach to managing the business. Marsland reported to Ann Quinn, who had taken the division general manager's spot in late 1989. "Steve's arrival changed everything," Vrcelj commented. "Finally there was someone in management who could understand what I had been trying to say for three years. We didn't even need to talk about what had to be done to turn this division around. We both knew what needed to be done, and just got busy doing it. Fortunately, Ann Quinn trusted him enough that she gave us pretty free rein to do what we thought best."

Goal-Setting by Benchmarking

Marsland and Vrcelj began their attack on ICD's performance problems by working to forge consensus amongst senior ICD managers about which elements of performance were most important to the division's profit and cash picture. The team defined seven important measures:

1. Reduce manufacturing throughput time (and the lead time required for ordering parts and materials)
2. improve on-time delivery
3. Reduce inventory
4. Reduce cost
5. Improve outgoing quality
6. Utilize space better
7. Reduce absenteeism

Marsland learned that a nearby division of Beckman Instruments Corporation several years earlier had gone through the transformation Marsland hoped to achieve at ICD. Marsland felt that the nature of Beckman's manufacturing and marketing processes was similar enough to ICD's that their performance could serve as reasonable benchmarks for ICD to target. "We learned something about benchmarking," Vrcelj recalled. "Getting Beckman's data was no problem. They were proud of what they'd done. Getting *our* data was the real problem: we didn't have it. Five of us worked like crazy for over a month to generate reasonably accurate data. "When we were finally able to compare Beckman's performance with ours (shown in **Exhibit 7**), we were discouraged by the gap. But once we thought about it, the huge gaps made us more confident that we could make substantial progress—even if we couldn't get all the way there."

Among the most troubling of their findings was that on average, in spite of ICD's efforts to carry inventories of long-lead-time parts, it took ICD 123 days to fill a customer's order. (Because it produced such a wide variety of custom products, ICD found producing to finished-goods inventory to be impractical.) And at each of the functional manufacturing departments in the plant, there were on average 50,000 to 60,000 partially completed units in inventory. ICD's quality inspectors typically sent 10% of the plant's output back into the plant to be reworked.

Redesigning Material and Information Flow

With their goals in place, Vrcelj's next step was to flow-chart the route each of ICD's key, highest-volume products took through the plant, and then to compare by computer the routings of each of ICD's other products to these high-volume routings. Much to his surprise, despite the fact that ICD produced over 2,600 different stock-keeping units (SKUs), over 95% of these products flowed along one of 12 distinct assembly routings, or sequence of processes, through the plant. Because of this, Marsland and Vrcelj determined that organizing ICD's assembly operations into manufacturing cells, with at least one focused on each of these process routings, might be feasible despite the division's complex product line. Marsland and Vrcelj sketched a preliminary floor plan for this new system, laying out the cells with enough space that workers wouldn't be cramped, but with sequential process steps close enough that parts could be passed easily to the next process step individually, or in very small batches. They established a preliminary WIP inventory limit of 300 parts for each of the cells. This effectively represented an assembly batch size. Batches smaller than this were deemed impractical, because of the need to maximize the utilization of several large curing ovens in which most of Raychem's products needed to be processed.

No capital was available to purchase additional component manufacturing equipment so that each cell would have a dedicated set. Marsland and Vrcelj therefore decided to continue producing plastic injection molded parts in batch mode, with a molding department feeding parts into a common inventory buffer, from which all assembly cells could pull parts as needed. Assembly workers were given fixtures dubbed *kanban squares*—trays holding 300 parts—to carry parts out of inventory into the assembly cells. No more than one square of parts could be pulled into the assembly area at a time. The team also scheduled component production with kanban squares. The number of compartments in each of these squares was equal to the economic order quantity for each particular part—generally about three weeks' supply. When the kanban square carrying one economic order quantity of parts inventory was emptied, it would be sent back to the molding department to signal that an additional batch needed to be run. Assemblers would then start to pull parts from the other kanban square in the inventory buffer. ICD established a similar ordering system for parts supplied by vendors—one economic order quantity was held in a kanban square as parts inventory at ICD, while the other kanban square was at the vendor, being filled (or scheduled to be filled). In this case, the number of parts held in these squares was equal to the economic order quantity for each part from each vendor.

Once the cells and the equipment required for each had been defined, Marsland and Vrcelj laid them out on a floorplan of one of ICD's assembly buildings, in a way that minimized travel distance to the centrally located ovens. They pinned this floor map to a conference room wall. "When we compared what we were then using, versus what we really needed to manufacture with low inventories in cells, we realized that we could do without *three* of the five buildings we were using! One building could house assembly, and the other could handle molding and parts storage."

Marsland was committed to what he called "open manufacturing"—an operation in which there were no interior walls separating different parts of the manufacturing process, or separating the offices of managers and engineers from the manufacturing floor. Once he had convinced Ann Quinn that substantial cash would be freed up through inventory reduction, she agreed to let Marsland spend $1.3 million to tear out all interior walls in the assembly and office area, and to install an air conditioning system in the entire building (previously, only the office area had been air conditioned). Marsland and Vrcelj then moved their desks into the middle of the manufacturing floor, reasoning, "You don't have to worry about keeping your fingers on the pulse of an operation when you're sitting in the heart of it."

Organizing Teams

"The most difficult part of this process," according to Vrcelj, "occurred when we started assigning people to teams." Assigning the direct workforce was not a difficult problem. Many of them would be using the same skills in the new cells as they'd used in the batch operation—it was easy to decide where most of them should work. "The really hard problems," Vrcelj continued, "related to all those overhead people."

> I had read about how the JIT system required many fewer overhead workers than traditional batch operations, but I never internalized the magnitude of the difference until we started the detailed planning—how material would be handled, how production would get scheduled, where and how information needed to flow, and so on. In our old system we had designed a very complex, expensive solution to a very complex problem. For example, in the batch system there are a *lot* of people working on information problems—figuring out and communicating where each batch of parts should go next; where orders had gotten held up in the process; where bottlenecks were cropping up; and so on. In the cell system, all this information is embedded in the process flow itself—so much of the information flow problem is permanently solved. There literally was *no need* for a lot of those people who had seemed so indispensable just a few months earlier. Rather than building a complex solution to a complex problem, this approach simplifies the problem dramatically.

The management team together decided they would disband the manufacturing engineering, maintenance, production control, and quality control groups, and integrate those employees into one of the teams that would operate each cell. For example, they placed one quality control inspector, a maintenance person, and a manufacturing engineer in each cell. "We felt that once the system was up and running, the assembly workers would do their own quality inspections, process improvements, and equipment maintenance. But we knew these things wouldn't happen all at once, and we wanted to be sure we still shipped good products." These specialists who were assigned to cell teams were given assembly assignments with the hourly workforce, however—there were to be no non-manufacturing personnel on the plant floor.

The most wrenching change was converting the ICD managerial structure from a functional to a team orientation. As the cells were defined, every member of the management team agreed that each cell team needed a leader. But who would the leaders be? "We couldn't afford to lose our key functional leaders, with their expert knowledge in production control, quality, stores and so on," Vrcelj said. "But the functions were being eliminated. Finally as functional managers, we decided it was *we* who would have to lead the cells—we would have to change our jobs—in fact the way we thought of ourselves as professionals—to the very core. It took us two months of soul-searching, but we all agreed to become cell team leaders." So each manufacturing engineer, and the supervisors of what formerly had been the quality control, production control, and parts stores groups became cell leaders.

Starting Production in the Cellular System

The team members spent a weekend in early December 1990, moving equipment and workstations into the new cellular layout—consolidating from three assembly buildings into one—and getting ready to start production. When the team leaders arrived for work the next Monday morning, each was given a single-page production schedule for his or her cell that day. Each cell was equipped with a whiteboard on which the leader wrote the schedule, and two personal computers. These computers contained parts lists and specifications for each of the products assigned to the cell, so that when the day's production requirements were punched in, the computer could generate a bill of material and process instructions which workers could use to pull controlled amounts of material and parts from upstream inventories.

With the cells and teams in place, the next step was to "drain" the WIP inventories out of the plant. This was done by moving all existing WIP inventory out of storage and into the appropriate manufacturing cell, and adopting a build-to-order philosophy for all products. This meant that inventory, and the space it occupied, was visible and accessible to the workers in each cell. Gradually and steadily, finished goods inventories were shipped and not replaced, and WIP inventory was converted to finished product as needed, and not replaced. Soon the cells had only the raw materials and parts inventories needed to cover current orders.[1] Inventory dropped smoothly and steadily by $7 million over the subsequent two years.

Each team had worked out how to allocate the maximum allowance of 300 units of work-in-process inventory between the stations in the cell. When these buffer allowances were full, workers immediately upstream from the full buffer would move down to the next station, if needed, to keep parts flowing.

Marsland was committed to keeping his people employed. “I told our employees that if they would do the work we had, no matter what it was, we would do everything we could to keep them employed," he explained. This commitment was tested in 1991 when a couple of large military programs ended, and volume declined precipitously. ICD asked for volunteers to work temporarily at other Raychem divisions; eliminated all overtime; and took a one-week plantwide shutdown. The approach paid off later that year, when volume rebounded. "We just brought back the volunteers.”

Division employment levels did, however, decline through attrition. Many employees chose to leave when the team structure was implemented. "About a third of our workforce didn't like the team approach, and over time these people went to other parts of Raychem, or left the company altogether," Marsland explained. "This enabled us to realize the financial benefits of cellularization without layoffs. Some people are individual performers and need a functionally structured environment to feel successful or comfortable—and they went to an environment which was more comfortable for them. This included nearly all of our professional employees who had worked in overhead jobs. Although some of them worked temporarily in the cells, all but one eventually quit. **Exhibit 6** shows that through the process of reassignment and attrition, nearly all of the reduction in division employment came from overhead categories.

In contrast, the direct labor employees found their jobs had broadened substantially and were enthusiastic about their work. "They trust us to do the job right," reasoned one woman. "I learn something new every day," was a repeated comment. Ongoing learning, in fact, proved to be a vital element in sustaining the sorts of continuous process improvements Marsland and Vrcelj hoped to achieve. They dedicated two conference rooms to employee education—a "technical room," where direct skills such as computer operation were taught; and an "educational center," where English as a second language, mathematics, statistics, etc., were taught free of charge to employees after regular work hours. Marsland encouraged any employee who would listen to return to college part-time to complete her or his degree. Steve led the way, in fact, by enrolling in a nights-and-weekends program in engineering at nearby San Jose State University.

[1]In addition, many cells carried small safety stocks of some critical parts, in case there were quality problems in parts received from vendors.

Training for Judgment

Although they had worked to cross-train employees to do each of the jobs in their cells, Marsland quickly learned a hard fact of life for managers of "flat" organizations: the problems quickly flowed to him for resolution. "I realized we had cross-trained everyone in the technical aspects of their new jobs, but they hadn't been trained for *judgment*—they needed a sense for how to set priorities and resolve conflicts. Before, resolutions to these issues had been negotiated amongst the functional managers and professional staff. That's where the judgment in the organization had been developed. And now much of that judgment, and the old structure for conflict resolution, was gone."

Marsland's approach was to articulate a set of "ICD Values," which he hoped would help guide team members and leaders in resolving conflicting priorities. He also hammered out with his management team a ranking of ICD priorities—so that when conflicts arose, team members could resolve them autonomously in a consistent manner (see **Exhibits 8A** and **8B**). For example, suppose an employee with expertise in a particular technique was scrambling to ship an order on time, and another employee asked for some training in that skill. Referring to the priorities listing, the skilled employee could see that "Helping ICDers help themselves" was a higher-priority activity than "On-time delivery." Likewise, addressing product quality problems in the field took precedence over every other activity except health and safety.

Results from Implementing Cell-Based JIT Manufacturing

By July 1993, it was clear that despite some struggles and setbacks, Marsland and Vrcelj had successfully engineered a performance turnaround at ICD. **Exhibit 4** chronicles their achievements. Revenues had declined from $36 million to $34 million between 1990 and 1993, in spite of a 40% reduction in the value of connectors purchased by military customers during that time. Revenue per employee had increased 44%, from $125,000 in 1990 to $180,000. Inventory turns had gone from 1.2x to 2.8x, and ICD's order fulfillment cycle had shrunk from 16 to 11 weeks. Profits had rebounded to $6 million. Gross margins had improved somewhat—primarily the result of fewer rejected and reworked parts—but most of the rebound in profits came from overhead reduction. And most important, between 1991 and 1993, ICD generated $13 million in cash.

"These are good results," Vrcelj reflected in the summer of 1993, "but they clearly aren't enough. Our vendor base is the next barrier to continued improvement. They have long equipment set-up times and high tooling costs for the parts they make for us. This means we've got to order parts in large quantities and store them. And their lead times to us are generally eight weeks or so. Since we can't possibly stock all the parts required to complete each order, we really can't squeeze our lead times much below the 11 weeks we currently quote—because of our vendors' lead times to us."

In wrestling with this issue, Marsland and Vrcelj realized the essence of the problem was that ICD had shifted its production within each cell to a continuous flow, but that they were still ordering and shipping in batches. "So we went to our customers and asked them, 'Why do you want 40,000 parts on October 1?' They answered, 'Because that's when we need them.' But we pushed them: 'Do you use *all* 40,000 parts on October 1?' Of course they didn't. They had developed the habit of ordering in batches because the *whole system* worked on a batch basis. We worked out a deal with most of our customers where they forecast their annual needs from us, and then we shipped to them monthly, based on the forecast—which we updated monthly." Raychem then turned around and tried to level parts receipts from its vendors—giving them an annual order, updated monthly, which they shipped in monthly installments. "You're not looking at Toyota here, where deliveries are made every couple of hours. We just aren't dealing in those kinds of volumes," Vrcelj reflected. "But this was a significant move toward continuous flow, and it made the whole system work better. You can't be a continuous flow island in the middle of a batch system. If your vendors and customers can't work with you to create as continuous a flow as possible through the whole chain, you've got to have a big warehouse somewhere."

While some of ICD's vendors adopted the new system readily, others did not. One key vendor of die-cast parts in the Midwest, in particular, seemed to resist. They were a $100 million company, and ICD accounted for less than 1% of their volume. Vrcelj observed, "Their tooling and set-up costs were high, and they preferred doing an EOQ [economic order quantity] batch for us when they set up their machine. They offered to hold inventory for us and ship a portion each month, but they said they'd charge us for holding it." Vrcelj ultimately convinced the supplier to let him present a one-day seminar explaining the principles behind ICD's approach and the results they'd achieved. This whetted their appetite, and Vrcelj returned for a follow-on 8-day working seminar, much of it spent on the factory floor working to reduce equipment set-ups and planning how some processes could be segregated into cells.

"There was a good and bad side to what I did for them," Vrcelj later reflected. "The positive was that we really cut their set-up time, so that they felt better about producing in the smaller lots we needed for monthly deliveries. The downside was that through this process they got a much better feeling for what it *really* cost them to make specialty parts for small customers like us, and they jacked up their price to us! I should have been more discriminating about what I taught them. The other downside of this experience was that I could see much more clearly what an enormous problem we faced helping *all* of our suppliers improve. We have a factory to run in Menlo Park, and I can't spend all of my time helping suppliers run theirs. I never paid much attention to the term *infrastructure* until we started to do this."

In spite of the tortuous road of continuous improvement ahead, Raychem's senior management was pleased with what the ICD team had achieved. Steve Marsland was appointed general manager of ICD in April 1993. In June 1993, Raychem concluded that, given ICD's operating performance, its fair market value was so high that they were unlikely to be able to find a buyer for the business. The corporation reversed its sale decision and signaled again its willingness to invest in attractive product development, capital equipment, and market development initiatives proposed by the division.

The Winner's Dilemma: What Do We Do Now?

In August 1993, freshly returned from summer vacations, the five members of ICD's senior team—Steve Marsland, general manager; Mike Vrcelj, manufacturing manager; Chris Panou, marketing manager; Peter Dutton, engineering manager; and John Ferris, controller, sat around the central conference table in the open office space adjacent to ICD's manufacturing area at 4:30 pm, reflecting on the changes of the past three years and discussing where they wanted to take the division in the future.

Panou, who had worked in various marketing jobs at ICD since 1978, commented, "You newcomers may not appreciate this, but until two years ago nobody around here had the time even to have a *conversation* like this. We were always running around trying to find orders and get them finished and shipped, that we never had time to think about the future. Who ever would have thought that our lives would be so much less hectic, with so many fewer people, doing just as much business!"

"I agree that this is a real luxury," Marsland responded.

> I had my fill of hectic days, too. But I'll tell you what's worrying me now. With all we've put our people through in the past two years, they've learned a lot. Each has more skills and broader responsibility. I worry that if we just stay at $30

million in sales that their rate of learning will level off. Working here won't be as fun. Somehow we've got to keep stretching their talents.

As the group discussed Marsland's concern, it was clear that each member had already thought about the issue, and in the ensuing discussion, the following options, and the rationale supporting them, emerged:

1. View ICD as a source of cash and talent for Raychem The arguments for this position were that ICD was in fact in a declining market, and that investing any cash to build or sustain ICD at its present size was not in the interests of the corporation or its shareholders. The cash ICD was generating certainly could be used in other of Raychem's divisions. In addition, ICD had a group of people with experience at converting slow, cash-consuming operations to more responsive, cash-generating ones. They could be seeded in other Raychem divisions, and other Raychem personnel could be rotated through ICD for training in advanced manufacturing methods.

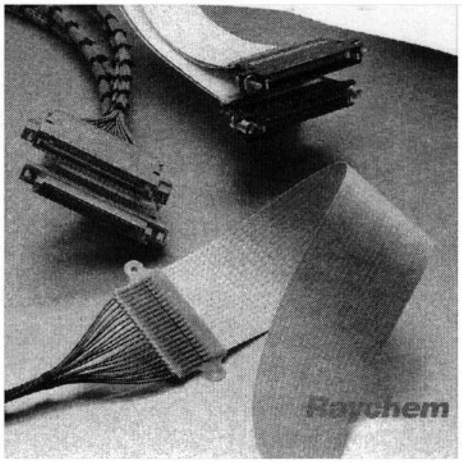
2. Enter the commercial connector market Historically, ICD had avoided head-to-head competition with large firms in commercial markets because of the scale economies described in **Exhibit 2**. However, ICD's unit costs had fallen by over 30% in the past two years. The group speculated that since economies of scale resulted from larger competitors being able to amortize fixed overhead costs over larger volumes, ICD had effectively flattened the connector industry's scale curve by reducing its fixed overhead costs. Unthinkable as it had been only two years earlier, Raychem might have become fully cost-competitive with its much larger rivals, and entering selected segments of the larger and still-growing commercial connector market might now be a viable strategic option for ICD.

The group's concern with this option was less with manufacturing than with its marketing and product engineering capabilities, which had been developed almost exclusively in military markets. Furthermore, its engineering staff had been cut back dramatically as the need for new product designs in the stagnant military market had dwindled.

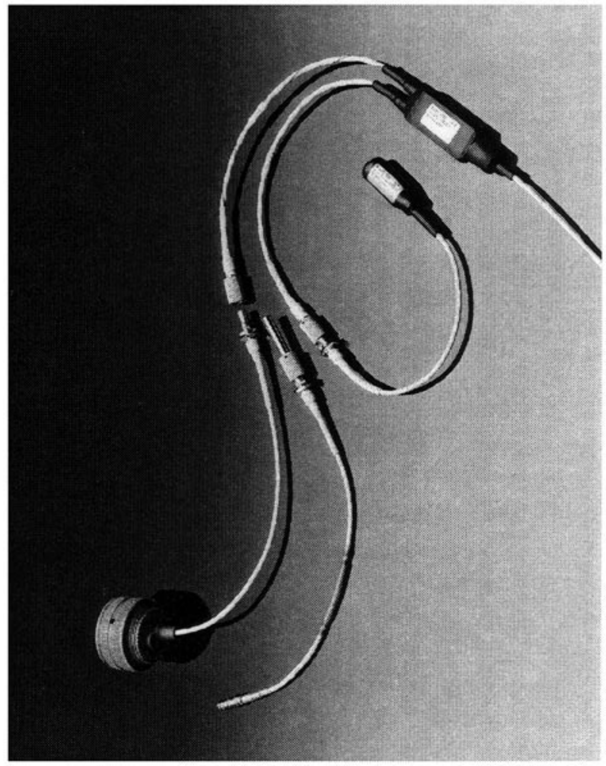
3. Acquire a related company Although this could not be done without approval of corporate management, the group felt there were a number of companies in the $20 million to $50 million revenue range which made broad lines of electronic components similar to ICD's. Many of them manufactured in the same batch mode that ICD had employed through 1990. Several of Marsland's team members speculated that they might be able to purchase such a company for a relatively low price, convert its manufacturing processes to cell-based JIT flows, and generate substantial cash for Raychem in so doing.

Marsland felt no urgency to decide which if any of these courses of action he ought to adopt. Certainly, he needed to collect better intelligence about the commercial connector markets, about potential acquisition candidates, and about the needs and opportunities in other Raychem divisions. In the end, however, Marsland suspected that there would be attractive opportunities related to each of the three options his managers had generated. "I think our decision needs to be guided not so much by our analysis of the external opportunities, but by carefully considering what ICD's capabilities are, and whether and how these can be transferred to other organizations or to activities in other markets," Marsland counseled his colleagues. "These really are the key issues we need to come to grips with."

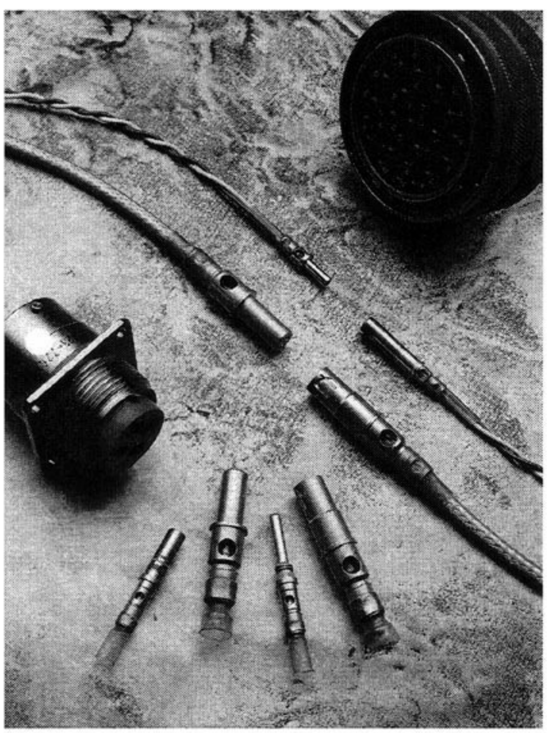
Exhibit 1 Typical Products of the Raychem Interconnection Systems Division



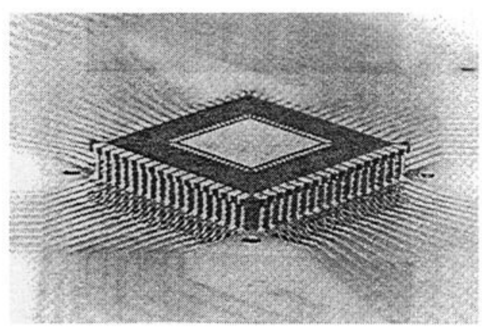
Multi-contact connectors. (these products are similar in appearance and function to the multi-pin plugs and receptacles used to connect desktop peripheral equipment, such as printers and monitors, to their host computers.



Data Bus products

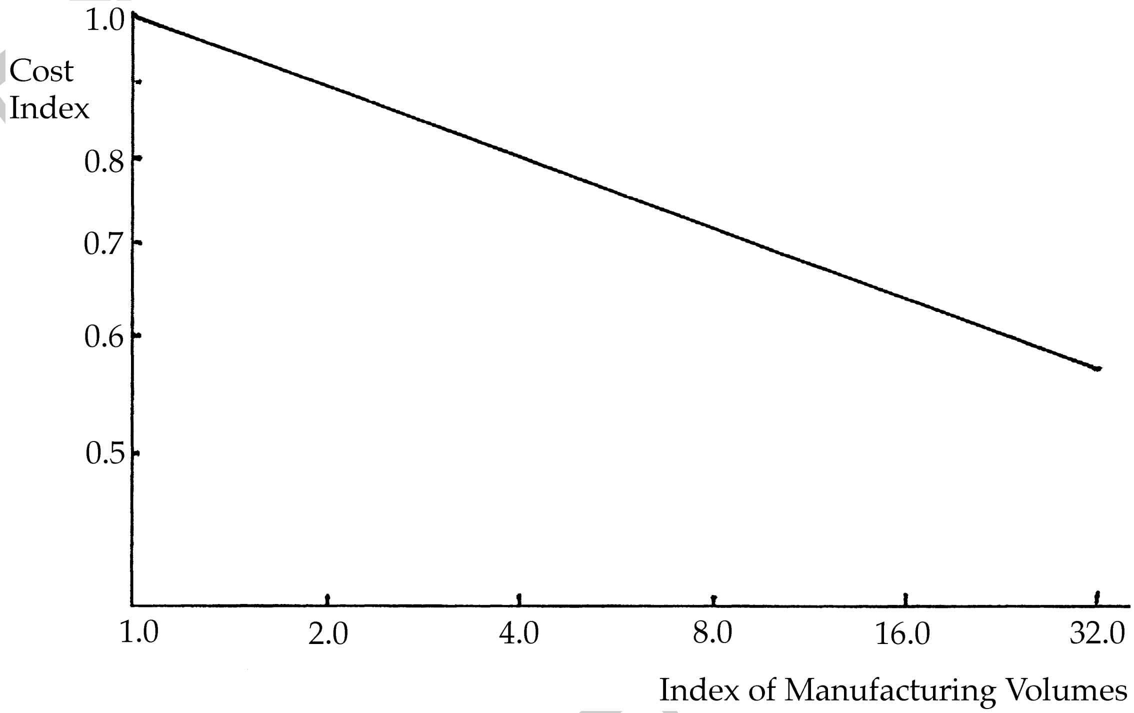


Individual wire or cable connectors



Devices used in surface-mounting of leadless integrated circuit carriers (packages) onto printed circuit boards.

Exhibit 2 Relationship Between Manufacturing Volumes and Total Manufacturing Costs for Typical Interconnection Products (Note: both axes are plotted on logarithmic scales.)



Source: ISD estimates

Exhibit 3 Trends in the Size of Key Interconnection Device Market Segments, 1980-1990 ($ millions)

Segment	1980	1985	1987	1988	1989	1990
Consumer Products	1,100	1,500	1,700	1,800	1,900	2,000
Commercial/Industrial	2,200	4,900	5,900	6,900	8,300	9,000
Military/Aerospace	1,500	2,200	2,600	2,800	2,700	2,500
Total	4,800	8,600	10,200	11,500	12,900	13,500

Exhibit 4 Summary Historical Financial Performance, Interconnection Systems Division ($ in mils.)

	1985	1988	1990	1991	1992	1993
Revenues	$44.3	$48.0	$36.0	$39.9	$35.0	$34.4
Purchased materials	14.4	14.6	12.1	13.4	13.1	11.5
Direct labor	4.5	4.6	3.7	4.2	4.1	4.2
Manufacturing overheads	7.3	7.7	6.9	7.1	7.4	2.8
Cost of goods sold	26.2	26.9	22.7	24.7	24.6	18.5
Gross Profit	18.1	21.1	13.3	15.2	10.4	15.9
(percent)	40.7%	43.8%	37.1%	38.1%	29.7%	46.2%
Engineering and development	4.0	5	5.5	4.8	3.1	0.9
Sales and administrative	10.7	11.5	11.3	11.2	10.0	9.1
Operating income	3.4	4.6	-3.5	-0.8	-2.7	5.9
(percent)	7.7%	9.6%	-9.7%	-2.0%	-7.7%	17.2%
Asset Information						
Receivables	9.7	11.0	8.1	6.0	7.4	6.0
Inventories	16.4	16.9	13.2	13.7	7.2	6.1
Net fixed assets	3.7	3.6	3.2	2.6	2.8	2.0
Number of employees	275	302	289	286	264	183

Exhibit 5 Process Flow for a Typical ICD Connector Process Sequence

1.	Wash received parts	9.	Rinse with de-ionized water
2.	Dry parts	10.	Oven dry
3.	Insert contacts	11.	Visual inspection
4.	Flatten	12.	Mark and date
5.	Inspect	13.	Electrical test
6.	Vapor de-grease	14.	Package
7.	Solder dip	15.	Store
8.	Deflux		

Process flow map through assembly building: numbers at each workstation correspond to the step numbers listed above.

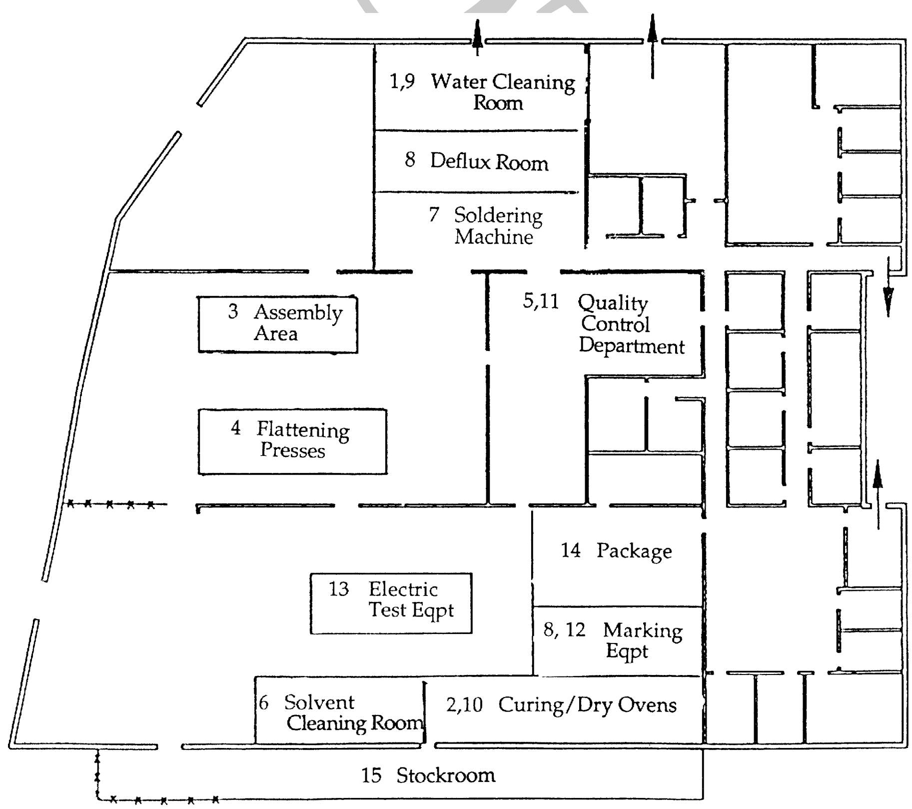


Exhibit 6 Number of ICD Employees, by Function, 1990 and 1993

Function	No. of Employees 1990	1993
Direct labor	152	135
Supervision of direct labor	21	8
Production control:		
Scheduling & planning	6	5
Expediting	2	0
Stockroom	4	2
Materials handling	6	1
Quality inspection	25	9
Facilities & equipment maintenance	15	5
Manufacturing process engineering	10	3
Cost accounting and control	3	2
Product design engineers	20	4
Marketing and product management	25	9
Total	289	183

Exhibit 7 CD Performance vs. Beckman Instruments Benchmark Performance, 1990-93

	Beckman Performance 1990	ICD Performance 1990	1993
Manufacturing throughput time (weeks)	10	40	8
Percent on-time	92	82	82
Inventory turns	9	1.2	2.8
Cost of goods (% sales)	49	57	54
Percent reject/rework	5	10	1
Revenues/square foot	$780	$400	$1,100
Daily absentee rate (%)	NA	4	2

Exhibits 8A ICD Values

People:	We value each individual and treat everyone with respect. We treat others as we ourselves would like to be treated. We encourage and support each other in learning and contributing.
Customers	We are dedicated to customer satisfaction. We standardize, control and continuously improve the process by which we achieve customer satisfaction.
Business	We enter every business transaction with the intention of achieving a "win-win" result. We pay attention to the details because the little things matter.
Integrity	Integrity is never compromised. We are honest. We honor our commitments. We are consistent and fair.
Teamwork	We are a team. We derive strength from individuals working together.
Environment	A safe place to work is our first priority. We are good neighbors to our local community and the environment as a whole.

Exhibit 8B What's Important at ICD—In Priority Sequence

1. Health and safety (immediate problems)
2. Product quality—products in the field
3. Customer problems due to Raychem errors
4. Maintain employment for Raychem personnel
5. Communication within ICD, amongst ourselves
6. Information to customers for corporate field sales force
7. Helping ICDers help themselves
8. On-time delivery
9. Product quality—vendor-related problems
10. Product quality—ICD internal problems
11. Health and safety—long-term improvement
12. Personnel development
13. Process improvement
14. Long-tern profitability
15. Customer problems due to customer errors
16. Personal needs
17. Current profitability