The market for air conditioners is changing in Latin America. Consumers with greater purchasing power demand window units of differing sizes and capacities. These are being sold through new, mass distribution channels such as Sears and Wal-mart. This case involves the attempts of one manufacturer, Carrier, to respond to these changes by introducing a new “product delivery system” (PDS) that would enable the company plant to produce all models of window air conditioner each week. Carrier de Mexico, though a subsidiary of a U.S.-based multinational, is very much a Mexican company. It was founded with the purchase of a distributor in the northern city of Monterrey, and the subsequent merger with another Mexican company. Since that merger, there have been nine plant consolidations and a reduction from four factories to one. Manufacturing space was reduced by 32% while production increased by 38%. At the time of the proposed change to PDS, the company was still absorbing the changes of recent years that had been guided by a philosophy of kaizen or continuous improvement.

As consultants, the company had hired a group of ex-Toyota employees who had developed their own version of kaizen, which was carried out through events in which radical change was produced. The new challenge facing the company was to supply the new mass merchandising channels with a full variety of window air conditioners, which was particularly difficult during the peak summer months. Company practice had been to produce long runs of each model, thus reducing set-up times but increasing inventories. The adoption of a weekly mixed-model delivery schedule would necessitate significant changes both within the company and in supplier relations. However, it is no longer a matter of whether Carrier de Mexico (CMX) would adopt PDS, which was being pushed both by Latin American Operations in Miami and Global Manufacturing at company headquarters. The decision facing the President of CMX, Roger Duarte, was how rapidly the PDS was to be implemented. Global Manufacturing had developed a detailed implementation schedule requiring 18 to 24 months, but this would have missed the peak summer sales period. Mr. Duarte was considering an accelerated 12-month program at CMX to have the RAC lines running under PDS by the summer of 1996. The case describes the air conditioner industry, Carrier background, and past change efforts, details the RAC production process, and focuses on the decision to accelerate PDS implementation. An accelerated program would take advantage of the growing demand for a broad variety in mass merchandise outlets, but it would entail some risk of failure. This trade-off between risk and reward is a central issue of the case.

In July of 1995, Walter Kullick, Director of Manufacturing at Carrier Mexico (CMX), was wondering how rapidly the company should implement a major, corporate-wide reengineering program entitled PDS (production delivery system). Both he and the President of CMX, Dr. Roger Duarte, could see the new system’s potential to achieve a jump on competitors in Mexico in the coming year as well as a significant increase in export business in 1997. Furthermore, Dr. Duarte believed PDS could address their “channel management” problem in Mexico: how to sell effectively to both their traditional distributors and the powerful and rapidly growing mass merchandisers? In summarizing the situation, Mr. Kullick commented:

Our current manufacturing system cannot provide the flexibility that our dynamic market requires. We’re not meeting the mass merchandisers’ demands for one-week lead times. Each of our production lines produces a wide variety of models, and because set-up costs are high and suppliers are inflexible, we try to run at least a month’s requirements at a time. Lead times for some of our out-purchased components are six weeks. But with the production capabilities of PDS, we hope that we will be able to deliver any mix of products within one week of the time that we receive the order.

Now, the question was not whether they should proceed with PDS; it was one of speed of implementation. Global Manufacturing, the Carrier corporate resource for PDS deployment, had developed a detailed 18-month to two-year plan for implementation of PDS at a particular site. Eventually, PDS was intended for some 50 Carrier plants around the world. However, the Director of Global Manufacturing, Tom
Table 1. Principal Components to Be Assembled

<table>
<thead>
<tr>
<th>Item</th>
<th>Relative Cost</th>
<th>Technical Sophistication</th>
<th>Gen/Spec</th>
<th>Source</th>
<th>Raw Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor</td>
<td>High</td>
<td>High</td>
<td>S</td>
<td>Purchased</td>
<td>N/A</td>
</tr>
<tr>
<td>Electric motor</td>
<td>High</td>
<td>High</td>
<td>S</td>
<td>Purchased</td>
<td>N/A</td>
</tr>
<tr>
<td>Wire harnesses</td>
<td>Low</td>
<td>Low</td>
<td>S</td>
<td>Purchased</td>
<td>N/A</td>
</tr>
<tr>
<td>Switches</td>
<td>Low</td>
<td>Medium</td>
<td>S</td>
<td>Purchased</td>
<td>N/A</td>
</tr>
<tr>
<td>Electric controllers</td>
<td>Low</td>
<td>Medium</td>
<td>G</td>
<td>Purchased</td>
<td>N/A</td>
</tr>
<tr>
<td>Filters</td>
<td>Low</td>
<td>Low</td>
<td>S</td>
<td>Fabricated</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Coils (evaporators and condensers)</td>
<td>Medium</td>
<td>Medium</td>
<td>S</td>
<td>Fabricated</td>
<td>Copper Tubing</td>
</tr>
<tr>
<td>Covers</td>
<td>Medium</td>
<td>Medium</td>
<td>S</td>
<td>Fabricated</td>
<td>Plastic</td>
</tr>
<tr>
<td>Frames</td>
<td>Low</td>
<td>Low</td>
<td>S</td>
<td>Fabricated</td>
<td>Steel</td>
</tr>
<tr>
<td>Coolant</td>
<td>Medium</td>
<td>Low</td>
<td>G</td>
<td>Purchased</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Abbreviations: Gen., general, commonly available; N/A, not applicable; Spec, specific for application.

Greenwood, was willing to support a more accelerated one-year program at CMX that would have the room air conditioner (RAC) lines running under PDS by the summer of 1996. Sales and marketing at CMX clearly wanted the capabilities and competitive advantages that PDS would offer but at what price? Should CMX adopt the accelerated program or would a more deliberate implementation period, extended out over the next two years, be more effective in the end?

Air Conditioning Systems

Carrier was the world’s leading manufacturer of air conditioning systems, with plants in Asia, Europe, and both North and South America. Unlike many companies in its industry, Carrier manufactured a full range of products, from small, window air conditioners to large, custom-designed units.

Air conditioning systems control the temperature, cleanliness, moisture, and movement of indoor air. They provide a cool climate during hot weather, remove airborne impurities, and dehumidify and circulate air through a room or building. Air conditioning can make an indoor atmosphere healthier and more comfortable and has been shown to improve the efficiency of workers and increase sales in retail establishments. In addition, many industries require air conditioning systems for environments that are dust free or of an exact temperature or humidity. Transport companies use air conditioning to cool their trucks, microelectronic companies use air conditioning so that dust does not contaminate their assembly lines, and the Vatican’s Sistine Chapel uses a custom-designed Carrier system to help preserve Michelangelo’s frescoes.

The major elements of an air conditioner include the following: a compressor with a built-in electric motor, an electric motor to drive air circulating fans, a coolant with the proper boiling point versus pressure characteristics, tubing that will not leak as the coolant flows through the system, fins that attach to the tubing to increase the heating and cooling surfaces, an air filter, and valves, switches, wires, and unit covers (see Table 1).

Although air conditioner technology was mature, manufacturers worked continuously to make units smaller, quieter, and more energy efficient. And, due to a worldwide agreement to eliminate chlorofluorocarbons because of their cumulative impact on the ozone layer of the atmosphere, manufacturers were developing nonchlorinated refrigerants that were more efficient.

Most variations in air conditioners were based on size and capacity. Room air conditioners were unitary in that both the evaporator and condenser were in the same unit, the evaporator protruding into the room and the condenser protruding outside. For larger machines supporting central air conditioners, the condenser was mounted separately outside, and the evaporator was mounted within the building inside the central air handling equipment. Many of these larger machines were custom engineered for a specific application. The small window room air conditioners ranged from .5 to 1 ton capacity (1T = 12,000 BTU per hour), and the larger commercial machines were as large as 20 tons of cooling capacity. CMX had a special problem handling this scope of product since its manufacturing capacity was small relative to other Carrier plants. This case will focus on the manufacture of the high volume, window air conditioners (RACS).

The Market for Air Conditioning Systems

In 1995, the air conditioner market in the developed world was a mature market. Central air conditioners were becoming more predominant in developed regions, and the demand for room air conditioners was actually declining. Air Conditioning and Heating News (June 26, 1995, p. 35) reported that shipments of room air conditioners in the United States declined 20% in the 1980s versus the 1970s and were predicted to decline another 20% in the 1990s.

By contrast, the market for room air conditioners in the developing world was experiencing rapid growth. For exam-
ple, The Economist ("Keeping Cool in China," April 16, 1996, p. 73) reported that room air conditioners in China had increased from 500,000 to 4 million, about the size of the USA market, in the past five years. The rest of “steam Asia” was experiencing similar growth.

Mexico was also an expanding market. CMX’s domestic sales grew 27% from 1993 to 1994, and total sales increased 39%. Although the devaluation of the peso and the resulting recession had seriously hurt domestic business for 1995, further increases in export business largely offset those declines. CMX management expected that domestic sales in 1996 would show a resurgence of demand to prior levels.

The market for CMX products varied seasonally, with a peak demand occurring from April to June before the hottest summer months and a low point in September and October before winter. The sales rate of room air conditioners during the peak months (April, May, and June) was approximately 180% of the annual average, and during the slow months (September and October) it was 75% of the average. However, unusual weather could play havoc with those averages. Hot weather especially could clean out inventory; whereas unusually cool weather would produce a serious slump from expectations. Export sales tended to even out the total demand over the year. During the peak months the total demand was only 25% higher than the average over the rest of the year, and in 1995 they expected to eliminate the trough in demand during September and October altogether.

History of Carrier Mexico

Carrier’s history in Monterrey, Mexico began in 1945 when a furniture store owned by the Elizondo family began selling Carrier window RACs. Within four years, the Elizondo store began assembling and distributing units under contract from Carrier, and in 1969, fan and coil production began at the Elizondo Plant I site. In 1973, Carrier purchased a majority share of the Elizondo company. The renamed company, Elizondo Carrier, opened a second plant in 1979 in Santa Catarina, a suburb north of Monterrey. The new plant specialized in heavy and custom-designed equipment and became known as Plant II. The original Elizondo Plant I was shut down in 1982 and was used as a warehouse. It was reopened three years later, but its production was limited to large condenser and evaporator coils.

In 1986, Carrier acquired its strongest competitor, Freyven, which was a division of a Mexican corn product company, MASECA. Freyven was located in Monterrey and sold RAC’s and other air conditioning systems through a well-developed network of distribution channels throughout Mexico. Some of Freyven’s products were nearly identical to Carrier’s, but Carrier continued producing the Freyven line so as not to disturb customers with brand loyalty. Carrier absorbed both the production facilities and the employees of Freyven. However, the cultural differences between Freyven and Carrier were so strong that relatively few of the Freyven people remained with the company. An employee commented:

The two companies were very different. On the one hand, Freyven had no formal system for quality. On the other hand, the quality of life within Freyven was more comfortable than at Carrier. Teamwork was better. The company was much more paternalistic.

1986 marked a turning point in the history of Carrier Mexico. With the acquisition of Freyven, it became a merger of two relatively small Mexican companies that had traditionally competed for a limited domestic market. Now, CMX was a large, 1,300-employee enterprise that had just completed its first year of exports. CMX managers began to focus their energies toward elevating CMX to a world class operation consistent with other Carrier plants around the world.

Dispersion of Production, Kaizen, and Consolidation

As a result of the Freyven acquisition, CMX found itself with production facilities all over the Monterrey area. There were two plants within the large factory II in Santa Catarina, a second factory in Santa Catarina, and two more plants in other parts of Monterrey. In addition, the main office and a warehouse were in separate locations elsewhere in the city.

CMX’s first move was to organize the production so that each location was responsible for a limited and separate set of product lines. Nevertheless, this many locations produced inefficiencies and made communication more difficult. Many of the top managers, such as the finance and personnel directors, needed to make frequent visits to each plant, but long transit times and traffic delays were wasteful and discouraged such visits.

Simultaneously, Carrier’s corporate headquarters wanted to encourage its plants throughout the world to adopt the practices of Japanese manufacture. They believed that kaizen, a Japanese concept embodying the philosophy of continuous improvement and credited for facilitating Japan’s rise to industrial strength, could be beneficial to Carrier operations worldwide. The challenge, however, was to apply a philosophy developed within the Japanese culture to workforces in other nations. To lead the installation of the kaizen process, Carrier contracted a company made up of ex-Toyota employees called Shingijutsu. Shingijutsu had performed several very successful contracts with Otis Elevator, another holding of Carrier’s parent company, United Technologies Corporation.

Kaizen involved a highly disciplined effort of documenting and analyzing current practice in fine detail, working in teams to devise ways to improve the process, and then implementing immediately the improvements they devised. It implied a never-ending effort by all members of a company to focus on process efficiency and quality, which in turn would lead to better results. In a kaizen process, administrators, managers,
and low skilled employees worked together in small, highly intensive groups to scrutinize every task and redesign the production system. Kaizen groups did not look for one or two “great leaps forward.” Instead, they attempted to install a culture of continuous improvement so that analysis became routine for participants, and they continued to make suggestions for innovation on a daily basis.

The Shingijutsu process was different from pure kaizen. Where kaizen called for continuous improvement, the Shingijutsu consult was based on a very concentrated event of improvement. The whole kaizen process was compressed into only five days, starting with very detailed documentation and analysis of the current system by cross-functional teams and leading to plans by the teams that would improve the principal metrics that the Shingijutsu people had promised to improve (units of production, number of people, square feet of floor space, and work in process inventory). The plans were implemented immediately. In theory, the accomplishment of such tangible improvements in such a short period of time would have been a learning experience for all the employees involved so that they would be able to continue with other kaizen projects once the Japanese consultants had left. In practice, however, the gains achieved in the kaizen events were difficult to sustain.

The typical Shingijutsu event would start with the consultants’ analyzing the company very rapidly, perhaps over a period of only one day. The consultants would then announce to management that if they proceeded with the kaizen teams, they would be able to achieve certain specified improvements, usually astounding in their magnitude. The consultants might claim, for example, that production could be increased by 25% with 40% fewer workers and 20% less floor space. At first, CMX managers would be dubious, but at the end they would be pleasantly surprised with the outcome.

There was some lasting impact of the kaizen events. Their success in developing production systems that were leaner and used less floor space encouraged management to consolidate the production in fewer locations by creating “plants within a plant”. Such an arrangement would not only reduce factory space and the associated fixed overhead; it could facilitate cross-functional communication. Furthermore, it was hoped that if production lines were housed together fewer workers would be needed, and engineers could share expertise and improve product quality. Plant II in Santa Catarina was selected as the central factory that would contain four individually focused manufacturing lines. Headquarters, sales, customer service, and parts offices also would be relocated to the Santa Catarina site.

The consolidation of plants I and III into plant II took place in late 1992 and early 1993. Two more kaizens were devoted to this set of improvements. Plant I’s equipment, which became known as line 1, was shut down for six weeks and reopened in plant II in a space 35% of the original size with 40% fewer workers. Engineers made room for the new equipment in plant II by removing a paint line and several offices. In order to maintain product deliveries while the equipment was not operating, plant I built up an inventory during the first three-quarters of 1992 by running overtime shifts. After the move was completed, the plant I building was sold. By July of 1993, CMX had reduced its facilities to a “compact campus” with one plant containing four lines (plant II); an adjacent complex for research and development, distribution, customer service, and parts; and another nearby plant that specialized in heavy industrial equipment (plant IV).

In 1993 and 1994, there were several more kaizen sessions, all of which were designed to perfect the layout of the four lines within plant II. A senior quality auditor recalled the events:

Determining the most efficient layout for the four lines inside the plant was very difficult, and engineers experimented with 5 to 10 layouts before they finally chose one. Production was never halted, so the equipment was moved during the weekends. Workers would arrive on Monday, and their post would be in a totally different part of the plant than it had been the Friday before. You still have to pay attention as you walk through the aisles of the factory so that you do not stumble over the old equipment foundations in the floor.

One senior manager offered the following opinion of the kaizen process:

The Shingijutsu people were good, and they were very demanding. They were essential to the improvements that we were able to achieve, and they built teamwork and tremendous pride among the line employees.

Another, however, was not so enthusiastic:

The kaizen sessions were frustrating for many workers because it is not easy to adapt Japanese standards to the Mexican culture. The Japanese consultants were speaking through translators, and they treated the Mexican workers like they would Japanese workers, expecting the same kind of discipline. There were yelling and screaming matches. The nature of the Japanese language, especially as it came through to the Mexicans in translation, sounded especially abrupt and authoritarian. There was a need to Mexicanize the kaizen process.

All told, the company made significant progress in a number of indices of performance between 1992 and 1994. Manufacturing space had been reduced by 32% while production increased 37%. Lead time and cycle times had declined 33% from 12 to 8 weeks. Table 2 shows a summary in the change in performance indicators.

**Changes in Organization Structure**

During the years of the consolidation, CMX began to establish a greater degree of autonomy. With the construction of Mexi-
Table 2. Performance Indices

<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>1994</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit production (index)</td>
<td>100</td>
<td>137</td>
<td>37</td>
</tr>
<tr>
<td>Employees</td>
<td>1,248</td>
<td>1,311</td>
<td>5</td>
</tr>
<tr>
<td>Manufacturing lead time (weeks)</td>
<td>12</td>
<td>8</td>
<td>-33</td>
</tr>
<tr>
<td>Manufacturing inventory turnover</td>
<td>8</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>Defects (index)</td>
<td>100</td>
<td>46</td>
<td>-54</td>
</tr>
<tr>
<td>Lost-time accidents</td>
<td>163</td>
<td>18</td>
<td>-89</td>
</tr>
<tr>
<td>Kaizens with shingijutsu</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Kaizens</td>
<td></td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

Source: company records.

Room Air Conditioner Production

Carrier’s manufacturing operation, like most in the air conditioner industry, involved the purchase of some components, the fabrication of others, and assembly of the final products. On average, approximately 86% of CMX’s total costs were materials, 5% was labor, and 9% factory burden. Since one of the issues management was facing was the degree of flexibility they could expect to achieve, the description of the production system of each stage contains data on changeover times from one product to another.

While the consolidation of plants over the past four years had placed all fabrication and assembly in plant II, fabrication and assembly were still separated by buffers of inventory, and there was space devoted to warehousing components ready for assembly. Figure 1 shows the rough location of the various assembly and fabrication areas as well as the areas devoted to inventories of components.

Assembly

Assembly of high volume RACs was a manual process with very little automation. RAC assembly took place on lines 2 and 5, line 2 being devoted to models with metal covers and line 5 to models with plastic covers. Line workers joined fabricated pieces and purchased components to unit frames traveling along roller conveyors. Evaporators and condensers were mounted first and connected to a compressor and an expansion valve by copper tubing. Coolant was added inside the enclosed network of tubes, which was then checked for leaks. A motor and fans were installed, the fabricated outside covers were attached, and the unit was packaged and delivered to a finished goods warehouse. The manual nature of the assembly process allowed for short changeover times for many but not all of the operations of assembly. There were a few operations where changeover times were long and therefore required long assembly runs of a given model. For example, the “charging board” at which the system was charged with the refrigerant required precise calibration of the volume of refrigerant, and the adjustment of that volume required an hour’s setup between different sized air conditioners. On line 5, there were some seven different sizes of charge. Another problem was the requirement for different voltages and different electrical cycles, each of which required an hour’s changeover. CMX manufactured air conditioners within a given size in two voltages (110 and 220) and two cycles (50 Hz and 60 Hz). This line of 28 air conditioners (7 × 2 × 2) would be further broadened by adding a wider selection of outer covers.

Fabrication

The fabrication processes were more technical than the assembly process. The products of fabrication were made in batches representing up to six weeks of assembly requirements or

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do’s first air conditioner research and development (R&D) center in 1991, CMX was able to do its own product developing. Before the center was built, blueprints were received from a design team in Syracuse, NY who had little contact with CMX line engineers. The on-site R&D center coordinated local efforts so that products could be designed for efficient fabrication and assembly. Improvements included reducing the number of parts per unit to simplify assembly, and increasing the number of parts that were common to one or more products so that changeovers were less frequent and inventory was more manageable. In addition, CMX began to develop new products specifically for its markets. For example, many Mexican windows were protected with external bars that did not permit the use of units designed for windows in the United States. In response, CMX introduced the LRAC, a unit that was designed to be installed in a wall. With the R&D center, CMX became more of an independent enterprise rather than a regional Mexican plant in Carrier’s worldwide system.

Carrier Mexico’s top management, however, continued to be controlled by Latin American Operations (LAO) in Miami. The senior leadership in Monterrey consisted of three functional managers—a Director of Manufacturing, a Director of R&D, and a Director of Finance—who each reported to the head of LAO. Cross-functional coordination among the three managers in Monterrey was difficult, and the control and reporting roles of the Director of Finance gave him anordinate power among the resident leadership.

In August of 1993, Dr. Roger Duarte came on board as President of CMX. He had been Director of Latin American Operations for Black and Decker, a multinational manufacturer of electric tools and appliances for mass consumer markets. Dr. Duarte recognized that CMX needed a new style of leadership, with more autonomy as well as management that worked efficiently as a unit. One of his first decisions was to bring back Walter Kullick as Director of Manufacturing. Mr. Kullick had left the old management team at CMX several years before. Dr. Duarte’s goal was to create teamwork within CMX and transform it into “one company.”
economic order quantities, whichever was larger, and warehoused in designated areas until they were needed on the assembly line.

**Covers (Condensers and Evaporators)**

Serpentine coils were constructed of two components—copper tubing and aluminum fins. The aluminum fins were stamped from stacks of very thin aluminum and had holes through which straight copper tubes were inserted. The fins were separated from one another so that they were evenly spaced along the length of the tubes. Intimate contact between the copper and the aluminum was essential for good heat transfer, so a mandrel was inserted through the tube to expand the tube out against the fin. Short, U-shaped tubes (hairpins) were brazed to the ends of the straight tubes so that the tube network formed a serpentine pattern through which the coolant flowed. Since even the tiniest leak was a fatal defect, workers checked for leaks at the end of fabrication, before assembly. Jigs and fixtures were specific for each model, so there was a short setup time when there was a changeover from one size of evaporator or condenser to another.

**Covers**

Covers were made of lexan (thermoplastic) plastic and usually consisted of one large piece plus several smaller snap-on pieces such as control panel doors. A given cover (design, size, and color) might be used for several brands of air conditioners, and the final brand identification label could be attached later. Covers were molded in very large, heavy pieces of machined steel that were carefully designed for pressed injections of melted thermoplastic resin that would completely fill the cavity. With slight cooling, the plastic became solid enough to open the mold and allow the operator to remove the finished piece. Tolerances for such molding were moderate, higher than those required for children’s toys, but not as high as those required for precision molding of parts for copiers, cameras, or computers. Changeover time from one mold to another could be as long as two to four hours, but a change
from one color of plastic to another could be completed in a
matter of minutes as long as they were moving from a lighter to
a darker color. Going in the other direction required extensive
purging of the presses and molds.

CMX had three large injection presses that had a capacity
for producing only two-thirds of the molded pieces that the
company required. Each of these 1,000-ton presses cost app-
proximately $650,000. CMX outsourced the remaining third
to various molders in Monterrey. Each of the three presses
was dedicated to one of the components of the cases, one to
grills, a second to the base stands, and a third to the enclosures.
They ran lots of 4,000 to 5,000 of the plastic cases before
switching to another size. It was estimated that if they were
to make all their plastic covers, they would have to invest in
two more 1,000-ton presses.

**Frames**

Unit frames were made from stamped steel in metal stamping
presses. Most of the metal frame pieces were compact and
were stamped in dies that were smaller and easier for workers
to manipulate than those used for stamping the metal unit
covers used in the production on line 2. The small size of the
stamping dies, coupled with the high level of commonality
of parts across several RAC models, made the flexibility of
fabrication of frame parts of less concern. Some simple presses
could even be dedicated to certain parts, thereby eliminating
changeover considerations.

**Key Outside Purchases**

**Compressors**

CMX purchased its compressors, which in essence were the
“heart” of an air conditioner, from companies in the United
States. These expensive, technically sophisticated pieces con-
tained both a compressor and a built-in electric motor in
one unitized assembly. For years the manufacturers of air
conditioners had encountered problems with delivery of com-
pressors, which, in turn, caused problems with delivery of
their products. In the first place, there was little commonality
of compressors across models of air conditioners. Virtually
every model of air conditioner specified a separate compressor,
and there was no ability to substitute. Second, the compressor
manufacturers had long lead times and relatively little flexibil-
ity to switch from one compressor to another, especially for
the high volume compressors that went into window air condi-
tioners. Over the years, they had reacted to the cost pressures
of mature products by developing automated lines that oper-
ated with long production runs.

Because of this history of long lead times and problems in
obtaining enough compressors during the peak seasons, CMX
purchasing people assumed that the only way in the short
run that they could achieve the product flexibility of supply
needed for flexible delivery would be for either the supplier
or the manufacturer to maintain large inventories. But even
that was problematic, because the compressor suppliers were
running at capacity and frequently putting their customers
on allocation during the peak season. Mixed-model deliveries
on a weekly basis were assumed to be beyond the compressor
manufacturers’ capability.

**Electric Motors**

Carrier also purchased the electric motors that powered the
fans within each unit. Motors, like compressors, were manu-
factured in long, high volume production runs. Unlike com-
pressors, however, a given motor was often common to several
RAC models. Thus the motors were not as problematic for
CMX as the compressors.

**Channel Management**

By the middle of 1995, customer demands were intensifying,
especially from mass merchandisers such as Wal-Mart and
Sears. These mass merchandisers were rapidly becoming the
principal channel to the consumer, buying directly from the
manufacturer rather than through a distributor. While this
change had been going on for some time, the North American
Free Trade Agreement (NAFTA) accelerated the its movement.
Between 1994 and 1995, the mass merchandisers’ share of
CMX domestic RAC sales grew from 30 to 70%.

Mass merchandisers were very demanding customers, both
for low prices and high levels of service. Their goal was to
operate with one-week lead times for all products, and to
accomplish that standard with over 95% reliability. They were
developing sophisticated information systems (EDI or elec-
tronic data interchange) to manage the flow of product from
the manufacturer. To provide that level of service without
substantial improvement in manufacturing flexibility would
require very high inventories.

The power of the mass merchandisers and the consequent
channel revolution was naturally a significant threat to CMX’s
traditional customers, the wholesale distributors who bought
from the manufacturer and maintained inventory to service
small retail stores. The revolution set up a classic channel
management problem: what could Carrier offer to the distribu-
tors who could survive this challenge that would maintain
their loyalty?

One alternative would be to finance the distributors’ inven-
tories. The good distributors could survive the pricing advan-
tage of the mass merchandisers on the basis of service if they
didn’t have the cost of financing inventories. Unfortunately
for CMX, that alternative would constitute a very expensive
demand for capital. On the other hand, if CMX had the capa-
bility of providing immediate availability of product, the dis-
tributors would not need to hold inventory. However, just as
in the case of the mass merchandisers, providing that level of
service with inventory at Carrier would be very expensive.
Lean, flexible manufacturing was a potential substitute.

In summary, surmounting the various marketing chal-
Challenges arising from mass mercandiser demands required significant improvement in the manufacturing systems. To be sure, the recently constructed, modern distribution center with its bar coding and information systems could make a contribution, but it would not be sufficient to accomplish the requirements of this new market. Both Dr. Duarte and Mr. Kullick realized that close coordination between operations and marketing was essential.

PDS

PDS (production delivery system) was a Carrier corporatewide initiative to re-engineer the production systems in Carrier plants around the world. An internal manual described the system as follows:

PDS is a core business process to help achieve these goals (promote growth and increase profitability to maintain industry leadership). It builds upon successful kaizen, lean production, and flexible manufacturing initiatives and extends these concepts across the enterprise from supplier to the customer. It provides a blueprint for improving the process to produce and deliver new and existing products.

PDS was distinctively different from previous efforts in that it required the total involvement of the entire business system, from the supplier through to the final customer, rather than the improvement of just one step along the chain. The movement of goods from supplier to CMX and on to the customer would be managed to produce a lean, flexible, integrated delivery system as though the entire flow were within one company.

PDS was also different from previous efforts in that it was customer based; it started with a full understanding of what constituted value to the customers, not just in aggregate, but by market segments and product lines. This full understanding of customers’ perceptions and needs would drive the design of the product delivery system.

PDS required a combination of process design, information systems design, and planning techniques in order to accomplish this integration. Figure 2 shows a schematic of the process concepts. Key to this system is the notion of “rate-based” planning and management. Rather than planning production and ordering product in large lots, both production planning and ordering would be based on the rate of flow required of each product. The supply and production systems would then have the capability to make every model every week in the quantity and mix required by the customer. Schedule changes necessary to provide the required flexibility for customer service would involve a shift in the mix of the flow, rather than a drastic shift from one product to another. Efficient production was necessary to make this flexibility economical, and information systems would steer the process integration from supplier to the customer.

It was clear that such an integrated approach toward product delivery systems would require special organizational roles. The Global Manufacturing resource group in Syracuse

Figure 2. PDS process. Asterisk indicating rate-based planning provides a technique to balance production with demand variation. Source: company records.
prescribed a team-based organizational structure for each of the Carrier plants, a structure the plant would use to administer the implementation of PDS. The PDS activities constituted work over and above the regular work assignments of the plant employees. Only the PDS site manager, a local employee selected to coordinate the PDS activities, would work full time on PDS. Figure 3 describes the local organization structure for the implementation of PDS. Table 3 describes some of the typical activities of the various process management teams, one of the two major types of teams. The steering committee, consisting of senior managers plus the process management and area team leaders, would be responsible for keeping the implementation project on track. The process management teams were small, core groups of one or two people who worked on designated aspects of the process. The area teams were cross-functional teams, much like the kaizen teams.

Such an effort would require a great deal of planning and training. The whole program had to come together in a coherent manner for it to be effective. But to achieve the required degree of CMX “ownership” of the PDS program, CMX people

**Figure 3.** PDS organizational roles. Source: company records.

**Table 3.** Typical Process Management Team Activities

<table>
<thead>
<tr>
<th>Lean Production</th>
</tr>
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<tbody>
<tr>
<td>Plantwide layout, lean production plans, area team metrics, total process management, mistake proofing, setup reduction, factory simulation, visual factory.</td>
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<table>
<thead>
<tr>
<th>IDS/PDS Integration (integration of distribution and supply/product delivery system)</th>
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<tbody>
<tr>
<td>Complexity reduction, design for manufacturing, modular bill of materials, product cost reduction, lean process documentation.</td>
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<tr>
<th>Materials</th>
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<tbody>
<tr>
<td>Rate-based materials management, point-of-use materials kanban, supplier process integration, kanban planning software, supplier lean production events.</td>
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<table>
<thead>
<tr>
<th>Sales and Operations Planning</th>
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</thead>
<tbody>
<tr>
<td>Market scope, customer profiles, demand planning, rate-based production planning, rate-based order management and scheduling, distribution channel integration.</td>
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<tr>
<th>Training and communications</th>
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<tr>
<td>PDS awareness training, communications meetings, newsletters, train the trainer (advanced topics toolbox), team building, and problem solving.</td>
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<table>
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<tr>
<th>Advanced Topics Toolbox</th>
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<tbody>
<tr>
<td>Mistake proofing, Kanban planning software, factory simulation, complexity reduction, supplier events, process costing, team building, and problem solving.</td>
</tr>
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</table>
would have to carry out the implementation themselves. Global Manufacturing’s role was to provide technical support and an overall framework within which the local plant could carry out the implementation.

Thorough knowledge of these new techniques was crucial. Global Manufacturing had developed a five-day “PDS Institute” that it designed and offered at the University of Tennessee to prepare the administration of the PDS activities. These “graduates” would then provide most of the necessary training in the plant.

The Global Manufacturing activity, under the leadership of Dr. Tom Greenwood, was organized to provide worldwide implementation consulting service to the Carrier plants. It was located at corporate headquarters in Syracuse, NY. Headquarters-based teams consisting of specialists in process management, lean production systems, and information systems were available to support the local plant efforts. These teams would conduct events in the plants committed to a PDS implementation project that would support the local plant’s program. As these projects progressed, the global manufacturing teams would be performing research on what worked and would disseminate that learning throughout the Carrier system.

The resources of Global Manufacturing were limited. Bill Brown, President of Latin American Operations in Miami, had pushed very hard to have those resources available to LAO early in Carrier’s worldwide implementation program. This enthusiasm played an important role in the development of PDS at CMX, but there was a certain risk involved. The early adopters of PDS had much more corporate visibility. Both Global Manufacturing and CMX would be under strong pressure to make the program work. Some of what PDS would require would be:

- Running of all products each week. Rather than running each product once every four to six weeks in a run long enough to cover those four to six week of demand plus a safety buffer, each week they would run each product in the line. Clearly, that would mean making four to six times as many setups. Continuous improvement in cross-functional teams, like the kaizen efforts, which would demand total involvement of all of management.
- Establishment of visual control of reorder. Materials, both those fabricated in house and those purchased from outside, would be stored at the point of use, rather than in warehouse areas, and reorder would be controlled by kanbans. Constant reduction of waste through the elimination of nonvalue added tasks, overproduction, and scrap.
- Close integration of schedules with suppliers. That integration would require a level of cooperation significantly higher than anything they had previously accomplished. For example, the compressor manufacturers would have to ship in weekly, mixed lots. The materials management people at CMX believed that such flexibility was impossible for their suppliers.

PDS had demonstrated great potential. Carrier had had good success in its implementation in the Transicold division, the division that made air conditioning and cooling equipment for the trucking industry. One Transicold plant reported that between 1994 and 1995 the production had increased 49% for units that were mounted on trailers and 117% for those for trucks. At the same time, overtime had declined 70% and scrap 38%. Plantwide inventory turns had increased 59% to over 20 times per year, and productivity had increased 16%.

How Rapidly?

As of July of 1995, Walter Kullick was immersed in the problems of meeting the busy summer season’s customer requirements. As usual, CMX was having trouble obtaining the compressors that they needed to fill production needs, as well as the usual delivery problems of the high demand period. However, Mr. Kullick was aware that if CMX was to be well advanced with PDS before the 1996 peak season, the company needed to immediately start planning the implementation and move rapidly into training and organizing. The one-year implementation alternative allowed no time for deviation from the established schedule. Even though he knew that they would have top management support from both Roger Duarte and Bill Brown for the rapid PDS implementation, there was so much organizational change to accomplish. Even if they decided not to pursue the accelerated implementation, there was still a need to initiate the program, albeit with somewhat less urgency. But was it prudent to accede to the desires of the sales people? Was the organization ready to move so rapidly?

Appendix 1.

Air Conditioner Technology

The technology of air conditioning is mature and well developed. Heat flows from a region of higher temperature to one of lower temperature, like from a flame to a pot of cool water. Air conditioners cool by placing a heat exchanger called an evaporator in the space to be cooled. Inside the heat exchanger is a liquid coolant selected because at atmospheric pressure it boils at a temperature below the desired temperature of the room. Heat then flows from the room to the coolant and vaporizes it. That vapor is then compressed in the compressor to a high pressure. Compressing not only increases the pressure; it also increases the temperature, much as a bicycle pump heats up when one pumps up several bicycle tires rapidly. That hot vapor becomes hotter than the outside air as the compressor pump pushes the vapor into the condenser. At that high pressure, the condensing point (or boiling point) of the vapor is higher than the outside air, and heat flows in the heat exchanger from the hot vapor in the condenser to the outside air. As a result, the vapor condenses to a liquid again, and the “heat of condensation” is expelled. Finally, the liquid flows through a pressure release valve back to the evapo-
carrier side of the air conditioner. The sudden release of pressure causes the liquid to drop in temperature. The cold liquid then flows through the evaporator to be vaporized once again.

Air conditioners also control the moisture and cleanliness of air. Hot air can hold more water vapor than cool air. As coolant absorbs heat from indoor air, moisture in the air condenses into liquid droplets, and the humidity of the air is reduced. This air then passes through a filter to remove airborne particles, and cool, clean, dry air is emitted from the unit.

Teaching Note

Case Situation

The management of Carrier was considering a radical change in its production system in response to opportunities in the marketplace and a worldwide initiative from Global Manufacturing at the corporate headquarters in Syracuse, NY to develop a truly “lean manufacturing” system for the production of air conditioners. The system was called PDS (production delivery system). Walter Kulick, the director of manufacturing, had reason to question the speed with which the president of Carrier Mexico (CMX) wanted to proceed. Both the president and the director of Latin American Operations (LAO) were anxious to see an accelerated implementation of PDS in order to exploit new opportunities in the marketplace. While Global Manufacturing was willing to support the speedy 12-month implementation, its normal program that it was taking to some 50 Carrier plants around the world over the next five years required one and a half to two years. Within the next 12 months, CMX would have to develop the capability of fabricating components and assembling room air conditioners in a mixed-model line in which they would run all items once a week, rather than once every four to six weeks.

Use of the Case

This case could be used in a graduate course in production and operations management to examine the requirements for implementation of lean manufacturing systems. This case also could be used as a final case in the module on planning and scheduling systems. It would fit especially well if the cases in that module included a classic case like Kool King, since Kool King gives the student a good feel for the logistical problems encountered in the traditional systems of managing the planning and scheduling systems in this industry. Finally, when combined with the INCAE series on the Ecuadorian Rubber Company (A), (B), and (C), it provides an interesting package of examining the issue of implementation speed in efforts to achieve world class capabilities.

In this case, we can see something of the dramatic changes in performance that are possible through participation in kaizen-type efforts, without heavy investment in technology, changes that are available to manufacturing companies in many Latin American countries. We also can use this case as a springboard to discuss how to implement dramatic business process changes such as this, changes that require modifications in each of the internal cultures (e.g. production—both workers and managers—engineers, sales and marketing personnel, and top management) as well as accommodations to national cultures that may be required.

For further background on what is involved both in lean manufacturing systems and the Shingijutsu approach to kaizen, see Womack (1996) and Imai (1986).

Discussion Questions

1. What changes would PDS require of the CMX business process? Who would have to do what differently and in what manner?
2. What might be the principal barriers to the implementation of this system? What might be required to overcome these barriers?
3. What is at stake in this implementation. What are the risks inherent in normal and accelerated implementation?
4. If you were Walter Kulick, what would you do? Why?

General Discussion

Over the past nine years, this company has undergone a merger and a series of plant consolidations. While there is no data on why people left over this period, we do know that virtually all the Freyven people had left what would appear to have been a decent job in a country not known for providing employment opportunities. One can only infer that the merger had a disproportionate effect on the Freyven employees, and maybe something in the history of Carrier’s implementation of change had significant casualties. PDS constituted a continuation of change, and it would appear to be a dramatic change.

In addition to the merger, there had been a constant shifting in the facilities. The first step after the merger was to rationalize the production by focusing each plant on a more narrow range of products. By 1992, the company had four manufacturing plants, an office building, and several warehouses scattered around the city of Monterrey. The next major change was a process of physical consolidation, guided by extensive training and development efforts and some 20 kaizens. As a result, by the end of 1994, most of the manufacturing was consolidated into one building with five lines of focused “factories within a factory”. There was a small plant producing a very specialized product outside the main factory, the warehouses were consolidated into a new distribution center across the street from the main factory, and the offices were brought into the main factory building. Between 1992 and 1994, total manufacturing space declined 32% while production increased 38%. Lead time and cycle time decreased 38% from 12 to 8 weeks. Total employees were about the same as at the beginning of this consolidation.
The lean manufacturing system envisioned by the Global Manufacturing in Syracuse, NY had some very ambitious goals. They would involve the integration of fabrication and assembly so that the whole operation would run on a mixed-model line to manufacture all products each week, thereby reducing the lead time from the present eight weeks to one week. The PDS process that Global Manufacturing envisioned required close integration with suppliers to provide mixed order shipments on what was virtually a just-in-time basis, and fabrication had to be similarly flexible.

Implementation of PDS would necessitate significant changes in supplier relations. In particular, according to past experience the suppliers of compressors were notoriously inflexible and often put their customers on allocation; they also required long lead times to adjust their production. A weekly mixed-model delivery schedule would seem quite out of the question without some substantial changes requiring time to implement. Within the company, there were some significant changes required. In some fabrication operations, such as the large injection molding presses supplying the window air conditioner covers, CMX was already running at the equipment capacity, and frequent changeovers, each requiring two hours to accomplish, would only aggravate that bottleneck. To some extent, they had already ameliorated that problem by farming out some of the molding, and there seemed to be adequate capacity in Monterrey, but once again, development of mixed-model capabilities might take a while. But most demanding about the PDS process was the rapidity of implementation. The plans from Global Manufacturing, presumably based on some experience—it was, had allowed at least half again the amount of time to accomplish all the tasks.

Moving so much more rapidly put CMX at risk of not achieving its goals and also of burning out those who would have to work doubly hard to achieve the tighter schedule. The motivational factor that sustained the kaizen events was that they invariably produced significant improvement in the metrics, improvements that everyone involved could see and celebrate. However, the kaizen events, while the team was cross-functional, were focused on a single, short section of the total process. PDS was an organization wide initiative that involved the customers and suppliers as well. A rapid implementation of PDS increased the risk of short-term failure, and that failure would be companywide. That would be a formula for finger pointing and burn-out that could, in the long run, extend out the total time for implementation.

On the other hand, a major initiative such as PDS would require the full support of top management. Both Roger Duarte, president of Carrier Mexico, and Bill Brown, president of Latin American Operations in Miami, saw tremendous opportunities from the implementation of PDS. That would be very interesting in giving the project a continuous press of urgency.

Rapid changes in the distribution channels for window room air conditioners in Mexico leant urgency to these plans to reengineer the manufacturing system at Carrier Mexico. In two short years the proportion of window room air conditioners (WRACs) Carrier sold directly through mass merchandisers such as Wal-Mart and Sears rather than through distributors had increased from approximately 30 to 70%. These merchandisers had sophisticated information systems to manage the flow of product from manufacturer to the store and were implementing EDI (electronic data interchange) projects with their major suppliers. Once these systems were in place, Carrier would have to manage its shipments to these customers with at least 95% reliability on a lead time of one week.

The opportunity to capture more business from the large mass merchandisers created a channel management problem for CMX, which PDS could alleviate. Despite this dramatic shift in room air conditioner sales to those mass merchandisers, Carrier could not afford to ignore its traditional distributors. However, if it could be effective in offering immediate (within one week) shipment of anything in the line to them, they would not have to carry so much inventory, nor would they be demanding expensive financing of their inventories. PDS was an important factor in CMX’s channel management strategy.

The greater capacity that PDS would provide would enable CMX to pursue aggressively opportunities for export sales, sales that had a somewhat different seasonal pattern than the domestic Mexican market. The demand for air conditioners was very seasonal. At its peak, the demand per month was almost three times that for the slow season. Unless the company was going to make each month only what was required that month, it would have to carry significant inventories as it leveled its production. With PDS, it could make product closer to requirements each month for the domestic business and level the production by filling in export business.

Lurking in the background was the general issue of change and its source. Despite the consulting help given by the Shingi-jitsu people, the CMX workers and supervisors had a good sense of ownership for the improvements that the kaizen system had produced. PDS had a much higher profile and greater support from the corporate headquarters in Syracuse. To the degree that there was still lingering resentments from heavy handedness from headquarters, the PDS program would have to bear some of the effects of those feelings.

Answers to Questions for Discussion

1. There were a number of changes that the company would have to put in place to make PDS work. Throughout the product delivery system they would have to create a lean operation. They would have to modify their assembly lines to produce mixed-model schedules, which would require reduced setup times and the development of systems to shift rapidly from one product to the next. The same flexibility would have to be installed in the various fabrication operations, some of which
had rather long setup times. They would have to work closely with their suppliers to bring them to deliver to CMX in mixed-model shipments. Customers would have to be similarly reeducated. They were accustomed to order in larger quantities, perhaps to receive price breaks or to reduce shipping costs. The whole system from initial supplier to the final customer would have to switch to rate based shipping, producing, or receiving, a rather significant reeducation process. Undoubtedly, such shifts in the manner of doing business would lead to changes in the information systems to support them.

One can get a notion of the various areas in which there would be a need for change looking at the names of the “process management teams” in Figure 3 and at the list of “Typical Process Management Team Activities” in Table 3.

2. The principal barrier is the normal, human barrier of resistance to change, especially one as comprehensive as this one. Everyone in the organization would be involved and affected in some way, and some people would see undesirable changes in their particular job. In particular, as Womack and Jones (1996) point out in their book, lean thinking often requires that the professional subordinate the in-depth practice of his/her profession to the requirements of flow through the system. People, even in their individual work, have to be more cross-functional. The latest scheduling algorithm just may not be necessary any longer, when a simple kanban card works more effectively. Furthermore, people have to work across functions with an intensity they never had to before.

It also would be hard work to make these changes. Sometimes it would feel like the company was trying to “repair the airliner while it is flying at 40,000 feet.” People would have to develop great trust in one another to let go of how they had been doing before to take on the new way of doing things.

One of the barriers to implementation in this case might be that the source of so much of the knowledge about the change was coming from Global Manufacturing. The challenge that Tom Greenwood had constantly in these implementations was for the local operation to take ownership of the changes. The enthusiastic advocacy and involvement of Roger Duarte was surely a positive aspect to this implementation, but even Roger Duarte was somewhat an outsider, having arrived only a few years before. There were undoubtedly some old timers in the organization who would not so enthusiastically about PDS.

As to what to do to overcome these barriers, one can say that there is nothing that succeeds like success. It would be extremely important to ensure that there was a steady stream of victories along the way. Second, it had to be clear that these changes were creating opportunity for everyone; these changes cannot result in the loss of a job. Third, it would take very committed leadership at all levels of management, from the front line supervisor all the way to the top to carry out this implementation. Any flagging in this commitment would lead to the emergence of all the centers of resistance mentioned above coming out.

3. On the opportunity side, there is an opportunity for creating a strong position in the market that could ensure the dominant position of Carrier in the market. We don’t have any data on how wide the “window of opportunity” might be, but it does seem clear that the mass merchandisers were moving quite rapidly to dominate the retailing of window air conditioners. On the other hand, failure could be quite demoralizing, especially since the implementation was so organization-wide and required such an extensive commitment over a period of time to implement.

Management of the Class

An effective way to open this class would be to ask: if you were Walter Kulick, would you go ahead with the accelerated implementation of PDS and why? What you hope is that you have people who are on both sides. Push each person to give his/her reasons for the decision. My own sense of the case is that there are enough people who would have doubts about proceeding rapidly that there would be a split in the house. That starting point should give you the basis on which to develop the case.

If everyone is on one side or the other, most likely everyone in favor of rapid PDS implementation, start probing at the negatives of proceeding. In particular, get them to be more specific about what they would gain and what the downside risks might be. The main objective is to get up on the board the full richness of the human side of this decision. Once you have all those issues out, you should be able to move to repeating the original question: What would you have done if you were Walter Kulick and why?

Epilogue

Not too surprisingly, Carrier Mexico decided to go full bore into the rapid implementation of PDS. However, they were slow in getting the program off the ground. Training got behind schedule, and it was not until February of 1996 that CMX appointed the PDS coordinator. By October of 1995, the people in Global Manufacturing were quite concerned about the pace of change and came down to Monterrey to facilitate a kaizen event on line 5 in November. As usual, within a week’s time the team studied the situation, relayed out the equipment and overnight moved the equipment into its new location. The results of the kaizen were favorable, and the participants were proud of their accomplishments.
As of May of 1996, CMX was behind even the longer schedule of the normal implementation. They had had some success in setting up a mixed line production operation on line 2, but there were just too many changes to carry this over into line 5. They were, of course, working on the problems that such a transition entailed. Walter Kulick was concerned about being able to build up to the capacity required to meet the peak of summer demand. They had put on a full second shift and were hiring a third shift. Unless they were able to obtain export business, they would have to lay off most of those new hires. Most of these new hires would have to be laid off when the demand slackened in the fall. They were, however, quite pleased with the results that they have seen on line 2.

Nevertheless, the systems people from Global Manufacturing concluded in May of 1996 that the MRP system that CMX had simply was not capable of supporting the efforts of the PDS implementation, nor were the coordination efforts with the compressor manufacturer far enough along to support mixed-model shipments. Consequently in June of 1996, there was a major effort at reimplementing the MRP system. In addition, they found that the company was trying to provide flexibility of switching orders on a very short-term basis. Since it was the distributors who were unaccustomed to the notions of “rate-based ordering”, having always operated on larger, batched-up orders, it would take time for Carrier to get the message to them and to change their habits. This discovery led to a change in scheduling policies, freezing the schedule for the first couple of weeks.

In summary, although the official decision was to follow the accelerated schedule, when it came to implementing the decision it was clear that the organization was not ready. The de facto decision was to proceed with the normal implementation schedule with potential demoralizing effect of promising acceleration and being unable to deliver on the promise. The very strong personality of Roger Duarte was undoubtedly a major factor in their maintaining commitment to the project. As of August of 1996, he was absolutely convinced that this project was necessary if they were going to meet their customers’ demands.

References