THE WIREMOLD COMPANY: LISTENING TO THE VOICE OF THE CUSTOMER

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Steve Maynard, vice president of engineering and head of the product development function, was reflecting on a visit from Art Byrne, CEO and president, who had dropped by his office moments ago with a surprise request. Byrne had agreed that senior executives from a large Fortune 500 company could visit Wiremold®[1] to learn more about their Lean process.[2]

The visitors had said that they were already using Quality Function Deployment (QFD) for product development, and that they were using a consultant who had more than once referred to Wiremold's ground-breaking process of market research. Byrne wanted Maynard to put together a presentation demonstrating Wiremold's methods of implementing the Voice of the Customer (VOC) market research in QFD.

Byrne believed very strongly that Lean couldn't succeed without the active support from the CEO, and that Lean was *not* just a factory floor thing. He refused to allow other companies to visit unless the CEO was among the visitors. So, Maynard's presentation needed to be at a very high level.

Company Background

The Wiremold Company was founded in 1900 to provide methods of managing the wires needed to deliver electrical power throughout buildings and homes. The company grew rapidly as the nation adopted electrical power and its products were adapted for all types of construction. By the end of the twentieth century, it was a leading manufacturer of wire management products, but its market share position was under pressure from price-based competition from imports. When the CEO retired, the board of directors named a three-person search committee to find his replacement. Nine months later, Art Byrne became the new CEO.

In selecting Byrne for the post, the board of directors made explicit its decision to convert the company to Lean business practices (then known as just-in-time, or JIT). Byrne had been a very successful group executive at another prominent local company where he was responsible for several subsidiaries using Lean business practices. In an early statement to company employees, Byrne articulated a stretch goal of twenty inventory turns per year. He also stressed the importance of introducing new products, and stated that growth would come 50 percent from acquisitions and 50 percent from new products developed internally.

Byrne believed that respect for people was an essential component of Lean business practices. All work, he believed, had dignity. He referred to all employees, including officers of the company, as "associates." He replaced the company's traditional management hierarchy with a flat team-based structure. Teams were given responsibility for doing work and authority to make decisions about how to do that work. No decision could be made without the agreement of all team members. Lack of agreement required that the team postpone the decision. All teams were expected to adhere to this principle, from the biweekly meetings of the seven vice presidents (Byrne's direct reports) to teams working on the factory floor. At the time of the case, Wiremold was a large, privately owned company.[3]

The Product Line

Wire management is the broad term used for products that bring order to the jumble of electrical and electronic wires that course through buildings. Wire management products provide better access to wires for repairs and upgrades, better protection of wires from physical and electronic damage, and better aesthetics (people didn't have to look at loose wires). Up until Byrne's arrival, the company's product line for use in commercial and industrial buildings was made primarily of metal and included a wide range of surface-mounted raceways and fittings. Wiremold also had a line of plug-in outlet assemblies (marketed under the name Plugmold®) and a line of free-standing pole-type products to distribute electrical wires in open-plan areas (marketed under the name Tele-Power Poles®[4]). The company was beginning to develop variations of its products using hi-tech, heat-resistant plastics. Table 1 shows the company's product map at about the time that Byrne became CEO.

The Marketplace for Electrical Products

The industry in which the company operated was highly competitive. Products were sold exclusively through independent distributors to building contractors who installed them in buildings under construction and in renovations of existing buildings. Building contractors negotiated with distributors for the best price and for quantity discounts. There was intense competition to bring out new products on which a higher price could be charged: at least until the competition matched the features and benefits. For these reasons, the product development function had long been deemed by company management to be very important to sustaining market share, revenues, and profits.

Changes in the marketplace were beginning to occur. Architects, building owners, and mechanical consultants were beginning to influence a contractor's choice of electrical wire management systems: to minimize total product cost over the life cycle of installation, upgrade or repair, and eventual removal. Aesthetics were also becoming more important as building owners increasingly competed to attract tenants. As a result, the company's field sales force (which traditionally had called only on distributors) began to call on architects, building owners, mechanical consultants, and interior designers who could specify Wiremold products for specific building projects. The company began to consider these influencers as additional customers, and began training the sales force to sell to specifiers so that when the contractor placed the order with a distributor, it would be for Wiremold products.

Table 1
The Product Map

Family	Part #s
One-piece raceway	200, 500, 700 series for rewiring, plus boxes[5] and fittings
Pancake (metal)	1500, 2100 for rewiring, plus fittings
Two-piece raceway	2400, 3000, 4000, 6000 series for rewiring, plus fittings
Plugmold	2000, 2100, for rewiring, Powerstrips for new build, plus fittings and boxes
Tele-Power Poles®	25TP, 30TP, 21TP, ALTP Series
ODS	Overhead Distribution System
Chan-L-Wire	Overhead Lighting System

Source: Company records

The New Product Line Strategy

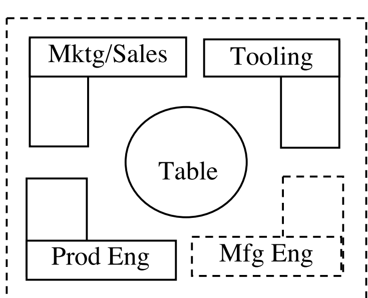
Art Byrne believed that Lean would not result in job losses for company employees if sales grew rapidly. He believed that rapid sales growth could be achieved if new products developed internally were balanced with selective product acquisitions. The goal was to expand the company's product offerings in an integrated way so that it would become a more effective competitor, garnering a larger share of sales to large construction (both new-build and renovation) projects. Byrne's prior experiences had convinced him that Lean was compatible with Quality Function Deployment (QFD) to achieve faster product development cycles than were possible using traditional methods. The reason for this, he said, was that the QFD methodology provided the means to identify and manage the standard work[6] of the product development process. Accordingly, he was pleased to find that there was a group of people under Maynard's leadership who had been learning and practicing QFD on their own time.

Among his first actions, Byrne arranged for Maynard and three team members[7] to attend QFD training provided by the American Supplier Institute (ASI) in Detroit, Michigan. He expanded the definition of the company's product line to include the management of telephone and data communications wiring. He established a new products committee; its first action was to reduce the number of products in development at any one time from over thirty to four. Henceforth, committee approval would be required before a new product idea was turned into a new product development project and a team named to do the work. He also indicated that, when an acquisition was made, it would be necessary to weed its product line and redesign the products that remained. From now on, the product development function was strategically important.

A month after he returned from Detroit, Maynard arranged for ASI to conduct on-site QFD training for a group of thirty people at the company. Byrne had indicated that there would be four product engineers and four product designers working full-time in the product development function. Cross-functional teams would be established to support the product development projects identified to support the company's strategy in each fiscal year. For the upcoming year, the first four projects had already been identified. Although only sixteen people would be needed immediately, their supervisors and some of their colleagues would be among the first to be trained because QFD was now part of the company's culture. People would work in their teams full-time. Projects were expected to require six to twelve months of elapsed time from the first team meeting to marketplace launch, compared to the two to three years that had sometimes been required before QFD.

A team was expected to consist of four persons from the following areas: marketing/sales (one person), product engineering/tool design (two people), and manufacturing engineering (one person). When the first four teams were named, the team members' desks were moved out of their formal departments. Each team was given an area containing their four desks clustered around a conference table with modular partitions encircling the whole. Wiremold's term for this was *co-location* (see Figure 1). However, due to demands for manufacturing engineers to work on the shop floor with manufacturing personnel, these team members ended up working only part-time on their team's project. (The manufacturing engineer's desk is therefore shown in dotted lines in Figure 1 to contrast with the other team members who worked full-time on the team's project.)

Figure 1
Diagram of Co-location



Source: Prepared by authors from interview data

At the same time, Byrne merged the marketing and product engineering functions, and all of the people in those departments were relocated to shared space in the company's West Hartford, Connecticut, facility. He also established a budget for advanced training in specialized methodologies to strengthen the existing QFD process and make it more robust. Table 2 contains summary information about each of these methodologies and how the company used them.

The company had a series of formal policies, some of which were an intrinsic part of Lean business practices and articulated by Art Byrne from his earliest days with the company. Others were adopted at later dates by the executive staff (comprised of the vice presidents, a group that included Maynard). Selected policies relating to product development projects are contained in Table 3. These policies formed the culture of the product development function[8] and were entirely consistent with the culture of the company.

Two Case Histories of Products that Were Developed Using QFD

In reflecting on the two presentations he had been asked to make, Maynard decided that it might be instructive to develop and analyze the case history for each of two very different products that had been developed using QFD. The first of these would be 4000 Raceway, a derivative of a previous generation tried-and-true standard product, and the second would be 5500 Raceway, which had become the platform for an entirely new generation. Because 5500 Raceway provided important new capabilities to customers and had required the company to take an entirely new approach, Maynard believed it to be a breakthrough[9] product. Both were in the market, so post-launch success could be evaluated.

4000 Raceway: A Derivative Product The company's first official QFD project was to improve its G4000 surface metal raceway system. G4000 was a surface-mounted wiring channel made of steel and painted gray. It had one channel for electrical power wiring, but it could be divided into two channels and the second used for telecommunications wiring. In addition, special fittings allowed technicians to install receptacles, switches, and communication devices. The product was used in industrial and commercial buildings. It worked well, but for reasons unknown to the company, it was losing market share to rivals selling competitive products made of aluminum and plastic. (The company's policy had always been to provide the highest-quality product on the market. Steel was more durable than aluminum; the use of plastic in applications involving electrical power was in its infancy due to the increased fire hazard of plastic.)

Fresh from its QFD training, the team enthusiastically attacked the project. Several of the team members later wrote a paper[10] in which they said,

> The first thing that became obvious was all that we *didn't* know. The product had been in the field for at least fifteen years. We believed that our customers were very familiar with it and had a wealth of information to share. Therefore, it was logical to use a survey to gather data about their opinions, but we didn't know who "the customers" were! *Who* was the

Table 2
Supplemental Tools and Techniques

Technique	What It Does	How Wiremold Used It
Taguchi / DOE (Design of Experiments)	Optimizes variables used in conjunction with each other over a variety of experimental conditions	Used to optimize process parameters in plastics manufacturing (injection molding and extrusion processing)
Project Management	Provides control and coordination of various stages of a project as well as coordinates resources used across concurrent projects	Used to teach project engineers the appropriate "level" of project management so as not to micro-manage everything and still keep the projects on track to complete on time
Failure Mode and Effects Analysis (FMEA)	Reviews products and processes to identify likely points of failure before they happen and develops fixes	Used to coordinate with the UL certification requirements and speed the process for new products
Target Costing	Identifies costs of parts and total manufacturing cost	Used to establish a target cost and track it through the development process as iterations were made to the designs
Value Analysis	Identifies value to the customer of product features	Used QFD to facilitate the assignment of value to the various components of the design within the target cost constraint
CAD/CAM	Computer-Aided Design and Computer-Aided Manufacturing	Used to design plastic molds; all mold vendors agreed to accept computer files for preparation of specific molds.
Concurrent Engineering	Conducting the various stages in product development in a parallel versus a sequential time sequence to minimize total elapsed development time	Used for all projects; co-location ensured that concurrent engineering was done
TRIZ[11]	One aspect enables the user to forecast likely future evolutions of product platforms	Used this aspect to forecast future product platforms and to add functionality to current designs
Reliability Engineering	Looks at wear analysis for items such as receptacles and items with repeated use in the installed product	Used on a limited basis for the company's product line

Source: Prepared by authors

Table 3
Summary of Key Company Policies Relating to Product Development

All team members were trained in QFD before they were assigned to a team. To maintain an adequate reserve of QFD-trained individuals who were available for assignment to a product development team, the company required all new hires in the marketing, engineering, and production management functions to be trained as soon as practicable.
All teams were to be cross-functional and to include representation from marketing/sales, product design, manufacturing engineering, and tooling.
All team members were expected to participate actively in all phases of product development. The team was required to complete the initial planning matrix for the product on which it was working. After that phase, it was empowered to draft the product specification. In addition, every team had full budget responsibility for the duration of its project.
The position of team leader would rotate to whoever had the most expertise in the activities required in the current stage of the project.
QFD was a stage-gate (sometimes called a toll-gate) process. There were standard activities that were to be accomplished in each stage. The project could not progress to the next stage without the concurrence of all team members.
A basic company policy applying to all teams throughout the company was that each team member was to consider all effects, both short and long run, of each decision to be made by the team and to make sure that the decision could be implemented (without causing problems) by other people working in the team member's discipline. If the team could not reach agreement, it was required to postpone making any decision *until they were in full agreement*. (Emphasis added by authors. This system is perhaps best described as a type of "jury system," in which one person holding out against the rest can effectively render null and void any decision taken by the majority.) An important consequence of this policy was that QFD team members often felt themselves to be under great pressure to come up with innovative solutions to problems.

Source: Authors, based on interview data

> customer? Was it the distributor, the architect, the specifying engineer, the contractor, or the installer? Not only did we not know who the customers were, we also didn't know how to talk to them. We weren't really sure how to create an effective survey that could get to their root wants (needs and desires for features and benefits from product offerings in a category).

The product development team members talked it over extensively, and decided that for any new building or renovation project, the value chain included influencers, decision makers, and users. They decided that all of these were "customers." Using this decision, they decided to collect information from architects, specifying engineers, contractors, installers, and building owners and occupants. These last would be more difficult to contact, but would not be ignored.

The Questionnaire The team decided to acquire data about the features and benefits that these customers wanted, as well as their other buying practices, through a mailed questionnaire. Working as a group, the team members proceeded to write the survey questions. The product engineer (the designer) became involved in the process as he realized that this was an opportunity for him to ask the questions that typically arose in his mind when he was making choices between design alternatives for the actual product. The tooling team member realized that some designs would be more difficult to make, and the manufacturing engineer realized that some designs might be very expensive to make. So it was important to them to get their questions into the survey. The marketing/sales member took it upon himself to probe the wording of each question, and to add some more questions relating to marketing issues such as pricing, use, and differentiation from products already in the marketplace.

The marketing/sales team member also consulted with the field sales force, various marketing personnel, and others in the company with knowledge of the customer base. From this information, he compiled a list of over one hundred customers to receive the questionnaire. Some customers would be more articulate and frank; some had opinions that would count more in the marketplace because they were known to be in the forefront of important advances in building design and construction. The team then mailed the questionnaire using the United States Postal Service.

Analyzing the Questionnaire Data The team members were almost overwhelmed by the number of returns and the amount of information on them. The first step in this part of the process was to identify the *whats*. Many of the questions had permitted the customers to answer in their own words, so some responses dealt with multiple issues. The team members assembled in a conference room, divided the questionnaires among themselves, and read every survey form (as they had been trained to do in QFD). Each team member wrote every phrase that seemed important on a sticky note and pasted it on the long wall of the room. This resulted in more than one hundred sticky notes going on the wall. The problem was how to simplify the blizzard of *whats* down to a reasonable number, say ten to fifteen, that could be used to build the left side of the Customer Attribute House of Quality (often referred to as the First House of Quality). Also, they dimly perceived that specifying engineers and architects seemed to be saying different things.

At this point, the team members faced a dilemma. They had been trained in the KJ Affinity method[12] for analyzing qualitative data, but they were reluctant to use it. They felt comfortable acting as the panel of evaluators called for by KJ, and they believed that they could identify the high-level design issues as KJ prescribed. However, many of the statements by the customers seemed to deal with aesthetics, not design issues. So the team began debating which of the more than one hundred sticky notes were the most important, and pulling out a few of them. But the problem continued to be customer statements such as: no visible seams; no rough edges; perpendicular cuts; available in many colors; lower installation costs.

The team members felt that these were related to aesthetics. They also judged that Wiremold had no control over them because the visible seams, rough edges, and slanted cuts were all the fault of the installers in the field. Then someone asked the question, "What if we designed the product so that the installers couldn't do this to us in the field?" Someone else said, "Well, that would make these statements that relate to how the product looks into real design issues." The group breathed a sigh of relief, and realized that it would be okay to put aesthetics on the left side of the First (Customer Attribute) House. So the team members started over using the KJ method to work directly from the raw customer statements on the sticky notes on the wall. Those statements were in fact the Voice of the Customer (VOC) required by the KJ method.

The problem then became how to find the high-level *whats*. The team read every statement aloud for clarification of the meaning of what was written on the sticky note. Then, silently, all of the members of the team stood in front of the wall and began moving the stickies around so that they fell into groups. No talking was allowed. If a note moved between two or more locations too many times, someone made enough duplicates of it so that it could be in as many locations as needed. Multiple notes of a single item would mean that the team needed to discuss the issue further. At the end of this silent process, the raw Voice of the Customer existed in categories on the wall.

The next step was for the team to discuss each group of sticky notes and either select a tag or create a tag that captured the essence of the group of notes. Then the tag was written on a sticky and elevated to the top of the column, becoming the heading of the group. At this point, the team had twenty to fifty headings that they could use to fill in the left side of the First House of Quality matrix.

The KJ method has a third step: ranking the *whats* into most important, important, and less important. At this point the team developed a new questionnaire and mailed it to the ninety customers who had responded to the first one. The second questionnaire asked respondents to rank the importance of the twenty to fifty root customer wants that had been developed so far.

<u>Developing a First (Customer Attribute) House of Quality</u> The next step was to identify the *hows*. The *hows* would go across the top of the First House. QFD specifies that there must be at least one *how* for each *what*; usually there are two or three *hows* for each *what*. The *hows* must be measurable and controllable. The *hows* must be based on the technology and manufacturing processes available or soon to be available to the team. At this point, the input of the tooling and manufacturing engineering team members became extremely important to the design engineer. The marketing/sales team member also contributed by asking questions about how various *hows* might affect aesthetics or usability. The essential problem for the team leader was to ensure that the team remained focused on what the customer wanted, not just the easiest way to make the product.

The next challenge was how to generate the specific *measurables* for the *hows*. A *measurable* needed the following attributes: a numeric quantity, a unit value, and a process for measuring. For example, the *measurable* for number of tools included the number of each (2), the units (each), and a method for determining this (a simple count). The questionnaire responses had included statements like "I want the raceway to be available in many colors." How could that statement be quantified into a measurement? What quantity was "many": 10, 20, or even 100? Another customer "want" derived from the mail questionnaire was to "minimize installation time." How long was installation time anyway? A third customer “want” was “I don’t want to see any seams.” Where were the seams, how many was a typical customer seeing, and why were they objectionable?

After the team members discussed the problem of developing *measurables*, they decided to contact customers to learn more. They made phone calls to approximately twenty customers identified by the marketing and sales department. As a result of these telephone conversations, they were able to clarify some of the information they had received, and they were invited to visit job sites.

<u>The Job Site Visits</u> The team selected ten job sites to visit (based on their desire to see a variety of locations). These visits were very productive in terms of understanding what the customers needed. All team members went to each job site and gathered information relating to his or her discipline. Often information was gathered by just watching on-the-job activity. For example, some of the team members focused on the issue of final color. They quickly learned that what this really meant was “We don’t want to paint it (on the job site).” That turned the real issue into “What is the most common wall color being used?” After several job site visits, the team members concluded that aesthetics would be dramatically improved by matching the raceway to the most commonly used color in commercial construction. Ivory would accomplish that need. The product development team turned this last discovery into V4000, a durable finish ivory raceway. The *how* of “many colors” had been resolved, and it was measurable: one color. Other colors could be added later.

As the QFD team members witnessed a typical installation, they observed that installers spent a great deal of time cutting and removing the burrs from the raceway covers. Anything to reduce this time would reduce installation costs. This gave them the idea of developing pre-cut covers in common centerline lengths. Pre-cut covers would provide cost savings for users in three ways. First, the new product would save time (and wages) on the job during installation because fewer cuts would have to be made. Second, owing to each cut normally resulting in scrap on the job site, the extra material that became the scrap end could be saved at the manufacturing plant. Third, if the first cut were crooked or ragged, it might be necessary to try again; in these cases, even more material might become scrap and more time would be wasted. The combined savings of wages on the job site and materials at the factory reduced the installation costs associated with cutting the covers up to 70 percent.

Furthermore, the butt seams were often ugly because it was difficult for the installer to cut the covers squarely. This was what led to the customers’ complaints! A special device mounting plate, which would also conceal the seams (and any seam gaps), could solve this problem; the team would have to design the plates and the manufacturing cells to make them.

The team members saw that there would be additional savings from mounting the device plates on the raceway. Since many more butt joints would now be clean, the time to mount the devices was lower on average, resulting in savings of installation wages and even less materials scrap.

The job site visits produced another, unexpected benefit. When the team members saw how difficult it was to cut the raceway on the job site, they decided that the company should sell shear tools for cutting both base and cover when necessary. The new tools should require no electrical power to operate. This would provide another important source of savings. Electricians working to install a system to run power no longer had to drag around a power saw and a 100-foot extension cord from the nearest temporary power outlet. (It took a surprising amount of time to set up and move the temporary power outlet as the job progressed.)

Revising the First House (Customer Attribute) of Quality The team members returned from the job sites reinvigorated with new ideas. They had seen the unspoken needs firsthand. Now they understood the questionnaire data better, and they had lots more to boot. They had had opportunities to *play catchball*[13] to get to the root customer wants. The original VOC data had contained the customers' ideas for the solutions to their needs, but the team needed to understand the *root wants* driving the customers' proposals. Having been able to ask follow-up questions, the team members believed that they had arrived at the true Voice of the Customer.

When they reviewed and revised the preliminary First House of Quality, they decided that their mandate was not just to redesign a raceway product, but to provide a complete system of raceway solutions, including a broad variety of devices to access the wires within the raceway and special installation tools to save the customers' money. This meant that they needed to add a First House for additional devices and another First House for installation tools.

As a result of job site visits, the team members had accumulated a wealth of data on "time to install" for jobs of various sizes. Analyzing this, they discovered that installation time was primarily a function of raceway footage and the number of devices tapping into it. The team built a "standard" wall with a defined length of raceway and specific fittings. They then hired independent contractors to install the company's product and those of its competitors. They videotaped each installation process. They studied the videotapes and developed *measurables* for many of the *hows*.

With much more in-depth information, the process of revising the First House went quickly and smoothly. The team designed the products (the raceway and a variety of inserts for various power and communication devices), the tools, and the manufacturing processes to make the products.

Finally, the marketing team member asked the team,

> How can we communicate the new functionality of the products and the improvements in installation time to our customers in a credible way?

Using the standard wall as a controlled environment, it was possible to make objective comparisons between new, old, and competitive products. The sales associates would be able to use this information when talking to customers.

What Happened: 4000 Raceway The company transformed its old utilitarian industrial product into a flexible and aesthetically appealing system suitable for many more applications. As a result, sales of total 4000 Raceway systems (a designed package of components) increased by 66 percent and sales of the improved metal device plates increased by 100 percent. The company decided not to abruptly pull the old product off the market but to allow it to decline gradually. The new V4000 Raceway (ivory with plastic device plates) was an almost instant hit, and sales grew rapidly. Although aesthetics turned out to be very important, the installation savings proved significant to architects, building owners, and contractors when they decided wire management specifications.

The project produced an important benefit for the manufacturing plant, too. The team developed standardized components, each with its own SKU. Thus, regardless of the specific wire management solution that the specifier had designed, it could be shipped quickly because the company was making all components daily or weekly, depending on the demand for them.

In reflecting on this experience, Maynard said,

> What we learned from this project was that we had to run the QFD process on two parallel tracks. The base product design QFD process ran on one track, while innovations that could be used in later generations of the product ran on another track. Then, when an innovation was ready to be incorporated into the base product, the appropriate team simply dropped it into its product and brought out the new and improved next generation version. For example, for G4000 some applications needed flush-mounted covers. So a later team developed designs and manufacturing processes for a wider variety of steel device mounting plates and fittings.

5500 Raceway: A Breakthrough Product About a year after its success with 4000 Raceway, the product development area was given a mandate to develop a totally new type of product. It would be new to the customers who needed it, and it would require the company to develop new technical and manufacturing capabilities. The team was given the following objective:

> A multi-channel perimeter raceway system to carry voice, data, and power for large institutions such as hospitals, universities, banks, schools, and financial services companies.

Large institutions typically had a much higher need for attractive aesthetics than did industrial and commercial firms, because their customers were distributed throughout the buildings. (In industrial and commercial firms, customers were usually served in small, specialized areas, or even at other locations.) Traditionally, institutions had run separate wiring for electrical power and voice communications. Data communications was a new priority for institutions that were adopting distributed computing. Thus, the company expected strong demand in both the new-build and the re-wire markets for institutional buildings because the new product would simplify the number of wiring systems from three to one.

For the company's manufacturing processes, the 5500 Raceway product was expected to pose significant new challenges. It would be much larger than anything the company had ever done before (up to five inches high and three inches deep) and would include three separate channels: electrical power, twisted-pair telephone wire, and coaxial cable to support data communications. The entire product would have to be certified by UL[14] before the company could go to market with it. Another challenge was that the close alignment of three types of wiring created the potential for "cross-talk" between them. "Cross-talk" was known to degrade voice and data signals. Finally, the decision to design in plastic or metal would be important. Plastic would provide better aesthetics, but might pose more challenges for the manufacturing process.

The product would become the flagship product for a new product family that was urgently needed to enable the company to enter and compete in the marketplace as a provider of total integrated solutions for wire management. The company could not afford to have the 5500 Raceway project delayed and be late to market.

The team included:

- The future product manager (from marketing and sales) with expertise in working with customers. This was to be his first product development project as he had been trained in QFD only a short time before being assigned to the team. He served as the initial team leader during the Voice of the Customer phase.
- The product designer with expertise in designing products made of plastic. His role was to ensure that knowledge of design shrinkage, snap connectors, etc., was readily available to the team.
- The tool designer with significant expertise in mold making. His role was to ensure that plastics suppliers would provide quality pre-formed materials.
- The project engineer with expertise in obtaining fast-track UL certifications.
- The production manager with expertise in designing manufacturing cells.

The team had five members instead of the usual four because this product was to be designed in plastic and carry electrical power. Both the product designer and project engineer were required if the team were to accomplish its mission on time.

<u>Listening to the Voice of the Customer</u> The team members decided to use the same basic methods for gathering the Voice of the Customer data that had worked so well in earlier QFD projects (including 4000 Raceway). However, they decided to make three changes to the process. First, because this market was new to the company, they decided to gather data by decision-influencing segments: building owners, architects, consulting engineers, and contractors, and to do so by telephone interview. Second, they would ask each person interviewed to rank the importance of their answer to each question using a scale from one to ten. Third, the data would be analyzed by segment. A total of more then 100 telephone interviews were to be conducted (about twenty interviews per team member).

All groups would be asked the same questions. Some of the questions that the team asked are shown in Table 4. Note that these tended to be open-ended, giving respondents a lot of latitude in their answers. Table 5 contains a selection of VOC quotations from architects only. Next, using the KJ method, the team members grouped the responses into ten categories and used the average importance rating for individual statements to rank order the ten categories. (See Table 6.)

Table 4
Some of the 5500 Raceway Market Research Questions

1. What is the material of choice for a raceway system?
2. Given a choice, do you prefer plastic, aluminum, or steel? (The competition was using plastic.)
3. What do you like/dislike about the systems you are presently using?
4. What features would you like to see in a raceway system?
5. How many compartments would be needed in a typical installation?
6. What are the most common wire capacity requirements?

Source: Company records

Table 5
Selected Actual Quotations from between 20 and 30 Interviews with Architects

Availability of product must be guaranteed for a long time	Can accommodate fiber optic cables	Can be installed without regard to trade schedules
Cannot exceed cost of competitive products	Complete specifications available	Components have no lead time
Cords/cables stay neat after changes	Cross-reference components with other manufacturers	Does not need inspection before completing entire wall
Easy to add outlets	Easy to continually expand/change/document	Easy to have change orders
Easy to relocate outlets	Easy to remove unused cable	Generally unobtrusive
Goes around obstacles	Installed wires are protected during servicing	Invisible to others
Minimal disruption to workers when servicing	Modular components	Must accommodate growth
Must be easy to install	Must be foolproof	Must lower total cost
Must meet current needs	Must meet future needs	Must show incremental value
Need to get all components from a single manufacturer	Once installed it never has to be changed	Parts must snap together
Priced like existing products	Product must be guaranteed	Provide accessibility at any point in the system
Wire management blends into furniture		

Source: Company records. Data has been disguised.

As before, the team members visited customer locations, including one hospital, six universities, and twelve contractors. It was difficult to gain access to as many institutions as they would have liked. The team members discovered that most of the organizations in the large institution market had people on staff to perform initial installations, adds, moves, and changes in the workplace. The team members talked extensively to these internal employees and felt that the information they received was accurate and that these employees were an important but hitherto undiscovered segment of decision influencers.

Taking all of the data together, the team discovered that for this product, some segments of decision makers and decision influencers had criteria that were different from the others. So the team developed a Customer Attribute (First) House of Quality for each segment. This was an unexpected fourth change from previous QFD projects.

Table 6
Categories of Architects' Wants and Their Relative Importance

Category	Sample Statements	Absolute Importance Rating	Relative Importance Ranking
Aesthetics	Cords/cables stay neat after changes, Generally unobtrusive, Invisible to others, Wire management blends into furniture	6.68	1
Value	Cannot exceed cost of competitive products, Must lower total cost, Must show incremental value, Priced like existing products	4.88	2
Technology Changes	Can accommodate fiber optic cables, Must accommodate growth, Must meet current needs, Must meet future needs	4.78	3
Service Disruption	Easy to remove unused cable, Installed wires are protected during servicing, Minimal disruption to workers when servicing	4.37	4
Expedite Projects	Can be installed without regard to trade schedules, Components have no lead time, Does not need inspection before completing entire wall, Easy to have change orders	4.23	5
Flexibility	Easy to add outlets, Easy to relocate outlets, Easy to continually expand/change/document, Goes around obstacles, Once installed it never has to be changed	3.90	6
Installation	Modular components, Must be easy to install, Must be foolproof, Parts must snap together	3.00	7
System Guarantee	Availability of product must be guaranteed for a long time, Product must be guaranteed	2.45	8
Accessibility	Provide accessibility at any point in the system	2.30	9
Complete System Service	Complete specifications available, Cross-reference other manufacturers, Need to get all components from a single manufacturer	2.03	10

Source: Company records. Data has been disguised.

After all of the *whats* and the *hows* had been listed, each First House diagram was approximately three feet across by three feet down. Figure 2 contains a synopsis of five of the ten categories of *whats* (down the left side), their importance rankings (from the interviewees), and selected measurable *hows* (across the top). The team members assigned an importance ranking to each *how* for each *what* that it would affect. These importance rankings were limited to 9, 3, and 1. A *9* meant that everyone agreed that the *how-what* combination was a top priority; a *3* meant that it was very important; a *1* meant that it would be nice to have. The importance rankings of the *hows* were then multiplied against the importance rankings of the *whats* (that each would affect) and summed by column to give an "absolute importance" ranking for each *how* (shown at the bottom of the House).[15]

Next, the team considered the right-hand side bar for customer satisfaction (shown in Figure 2) and the bottom bar for technical quality (not shown). Using symbols, the team could plot customer perceptions (ratings from 1 to 5) of the *whats* for Wiremold's product and the comparable data for similar competitors' products. In this way, the team could find weaknesses in their product design based on customer perception.[16] Next, the team compared their own product with competitors' products on the basis of technical specifications. Again, using symbols the team could plot technical ratings (from 1 to 5) for each *how* in the bottom bar (not shown). In this way, the team could find weaknesses in their product design based on technical performance, and areas in which customer perception differed significantly from actual technical criteria.[17]

Finally, the team members discussed the absolute importance rankings for pairs of *hows* and categorized the degree of correlation between each pair as strongly positive, positive, negative, or strongly negative. The degree of correlation for each pair of *hows* was indicated by a symbol in the "roof" of the House. The purpose of assigning the degrees of correlation was to highlight the pairs that were important and where a designer might have to make a trade-off between satisfying both members of the pair. In cases of two important items with a strongly positive correlation, it would be important that both items be achieved, preferably in the simplest possible way. A sample of some of the correlations are shown in the roof of the House in Figure 2.

The team created conceptual designs and physical models using the customer wants as key design criteria. They then returned to the nineteen customers whose job sites they had visited to show the alternative preliminary designs and listen to their reactions. The team members then refined the design criteria by comparing their own preliminary designs, analyzing the customer reactions to them, and comparing their own designs to products already on the market from other companies. This resulted in a phase two design. The next step was to build a prototype and install it on the standard wall (developed in the 4000 Raceway project) along with competitors' products. Then the team members visited the wall as a group to compare all of the designs on the criteria of functionality (how well did they meet the customer wants?), ease of installation, and aesthetics. Using the standard wall, the team members developed specific performance metrics that could be communicated to customers. The metrics for the initial version are shown in Table 7. As before, the team members made a list of features that could not be added immediately and provided it to Maynard.