ERIC VON HIPPEL

SUCCESSFUL INDUSTRIAL PRODUCTS FROM CUSTOMER IDEAS

Presentation of a new customer-active paradigm with evidence and implications.

SOME OF THE MORE SOPHISTICATED marketing research techniques, such as multidimensional scaling, routinely used in the generation of ideas for new consumer products, have not been extensively applied to the generation of ideas for new industrial products. Under the well-founded assumption that there is at least latent demand for improved need search and idea generation methodologies in the industrial sector,[1] research is being conducted by many[2] to explore differences in the consumer and industrial buying situations, which might be preventing straightforward transfer of consumer marketing research tools to that sector.

This article is intended to contribute to the understanding of the essential differences between industrial and consumer buying, and the reasons for poor utilization of methodologies for generating consumer-product ideas in the industrial-product sector.

About the Author

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The generation of consumer-product ideas is usually "manufacturer-active" (i.e., the manufacturer plays the active role), rather than "customer-active." And it is my contention that the manufacturer-active paradigm (MAP) underlying consumer-need research and product-idea generation methods makes a poor fit with conditions under which ideas for most new industrial products must be generated. Accordingly, I have developed a new "customer-active" paradigm (CAP), which appears better suited to those conditions under which ideas for new industrial products can, in fact, be generated.

The article describes (and compares) the MAP and the new CAP, and proposes a test which will allow determination of how well each paradigm fits actual conditions in the industrial market.

It goes on to test and analyse the hypothesis that the CAP offers a better fit to current practice in the industrial field than does the prevailing MAP.

I then link the CAP to research findings in industrial buying behavior and the engineering problem-solving process; and suggest that the new paradigm better fits the inherent requirements of the industrial idea generation process.

Finally, I provide suggestions for further research derived from the customer-active paradigm.

MAP vs. CAP

Exhibit 1 shows a schematic representation of both MAP (as actually practiced for consumer-product idea generation) and CAP (as hypothesized and empirically observed in industrial product ideas).

In the MAP, the role of the customer is essentially that of respondent, "speaking only when spoken to." It is the role of the manufacturer to select and survey a group of customers to obtain information on needs for new products or modification of existing products; analyze the data; develop a responsive product idea; and test the idea against customer perceptions and purchase decisions.

In the CAP, it is the role of the would-be *customer* to develop the idea for a new product; select a supplier capable of making the product; and take the initiative to send a request to the selected supplier. The role of the manufacturer in this paradigm is: to wait for a potential customer to submit a request (since, as will be discussed later, potential customers for new products are often not known to product manufacturers until they make a request); to screen ideas (not needs) for new products; and to select those for development which seem to offer the most promise from the manufacturer's point of view.

Clearly, in the instance of consumer products—especially so-called packaged goods—the manufacturer-active product idea generation paradigm has been a strikingly successful one. So, when I hypothesize that this paradigm offers a poor fit to the requirements of industrial product idea generation—and that this poor fit, in turn, is a major reason why consumer product need search and idea generation methodologies are so little used in the industrial product arena—I must provide a strong test of the hypothesis before suggesting even provisional acceptance.

Test of the CAP

Happily, a comparison of the two paradigm schematics presented in Exhibit 1 suggests a test by which the goodness of fit of each to current *practice* in industrial product idea generation may be probed. The test: Can a *customer request* for a new product, containing data sufficient to, in effect, constitute the product "idea," be found as a triggering event behind most new industrial products? If the answer is *yes*, then clearly the hypothesized CAP offers a better fit to current industrial product idea generation practice than does the MAP. If, on the other hand, the empirical data do not show such a pattern, then the hypothesized paradigm fails. (Note that the test only addresses the fit of the two paradigms to current *practice*; later I will extend the discussion to a consideration of the potential goodness-of-fit of each paradigm in that happy world where practice could be adjusted to the optimum.)

As an aid to clarity, I propose to divide my test of the hypothesis into two segments:

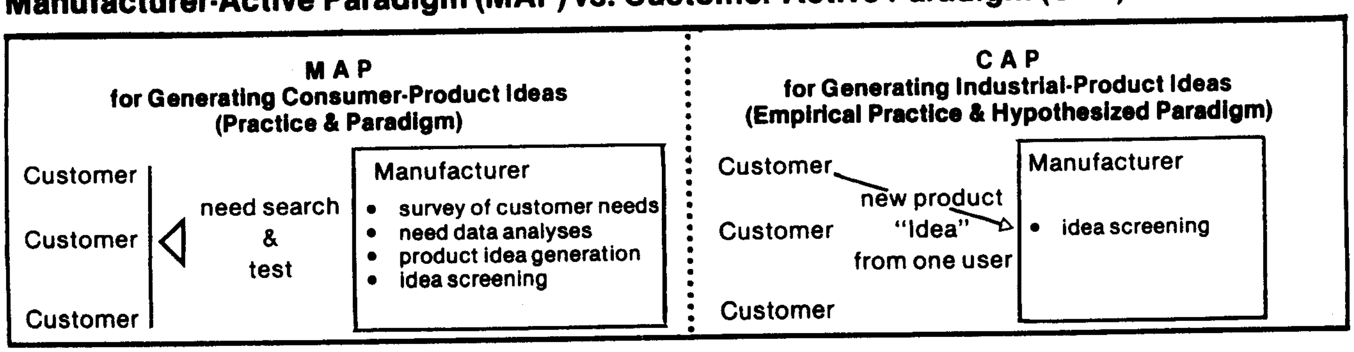
1. Presence (absence) of a customer request.
2. Content of the message when present, and consideration of whether the content observed does (does not) provide the "idea" for the new product to the product manufacturer.

Presence (Absence) of Customer Requests

In Exhibit 2, I have summarized all the data I can find which bears on the frequency with which innovation requests from customers are associated with the decision to (a) develop new industrial products; (b) engage in research which ultimately leads to new industrial and military products. (Note that in b the "customer" for the research results solicited was an engineering group.) The exhibit is largely self-explanatory. A more complete review of the methodologies and findings of these studies is available.[3]

It should be noted that all but two of the studies reviewed in the exhibit examined samples of successful innovations only. Obviously, such samples cannot tell us whether innovations initiated in response

EXHIBIT 1
Manufacturer-Active Paradigm (MAP) vs. Customer-Active Paradigm (CAP)



to customer request are more or less likely to be successful than others. The two studies which did sample both successful and failing innovations, however, give us reason to suspect that innovations requested by customers may in fact be more likely to succeed. Thus:

▶ Meadows[4] found that, in "Chem Lab B" project ideas from customers and marketing both show a higher probability of commercial success than do ideas from the laboratory (P = .08 that customer ideas are not more likely to achieve sales than laboratory ideas).

▶ Peplow, who reviewed all 94 "creative" projects carried out during a six-year period by an R&D group "concerned with designing and improving plant processes, process equipment and techniques," reports that 30 of the 48 successfully implemented jobs were started in response to direct requests from customers, while failures . . . . lie more with basic [sic] jobs started by R&D initiative."[5]

Taken in aggregate, the studies reviewed in Exhibit 2-A provide, I suggest, strong support for the hypothesis that manufacturers of new industrial products and processes often initiate work in response to an explicit customer request for the innovation.

Confidence in this finding in the realm of new industrial products and processes is enhanced by data from studies of "research-engineering interactions" summarized in Exhibit 2-B. In this field too, it appears, successful interactions between engineering groups, which need research results, and the research teams, which provide these, are characteristically initiated by a request from the research "customer."

Does (Does Not) Provide New Product Idea

Conceptually, it is important to recognize that any statement of a need or problem contains information about what a responsive solution should be. Consider the following statements of need of manufacturing Firm X. All statements address the same need, described in the first statement, but each succeeding statement adds on to those preceding and specifies a desired solution more precisely:

a. We need higher profits in our semi-conductor plant

b. . . . which we can get by raising output

c. . . . which we can best do by getting rid of the bottleneck in process Step D

d. . . . which can best be done by designing and installing new equipment

e. . . . which has the following functional specifications

f. . . . and should be built according to these blueprints.

A manufacturer must do a lot of work to convert the first need statement, *higher profits*, into a responsive new product. On the other hand, a manufacturer who receives a request containing the maximum amount of product solution data shown (**a**) through (**f**) need only instruct his manufacturing people to manufacture the product according to the customer-supplied engineering drawings.

A reader accustomed to thinking of customers as supplying product "need" information only, while product manufacturers devise "solutions"—products responsive to the need—might find the concept of product solution data being conveyed *along with* need data a strange one. In some industries, however, I have found that customers typically do provide a great deal of solution data to manufacturers—field-proven new product designs—as well as need data. (Some 77% of a sample of 111 scientific instrument innovations[6] and 67% of a sample of 49 process machinery innovations[7] have been found to display such a pattern.)

An example from my research may help provide the flavor of the concept. Consider the following case of a product innovation for which a product user did most of the innovation work and provided a great deal of product design data to the manufacturer along with information about his need for a new product.

An Example of a User-Developed Product

"Solderless Wrapped Connection" is a means of making a reliable, gas-tight electrical connection by wrapping a wire tightly around a special terminal whose sharp edges press into the wire. The system is much faster than soldering and allows much closer spacing of terminals.

The entire system, including a novel hand tool needed to properly wrap the wire around the terminal, was invented and developed at Bell Labs for use in the Bell System in 1947-48. After several years of testing by the Labs, it was given to Western Electric for implementation. Western Electric decided to have the hand tool portion of the system built by an outside supplier, and Keller Tool (now part of Gardner-Denver Company) bid for and won the job in 1952-53.

Keller had other customers who did electronic assembly work and realized that some of these would also find the solderless wrapped connection system useful. It therefore requested and obtained a license to sell the hand tools on the open market. Currently, the system is a major wire connection technique, and Gardner-Denver (Keller) is the major supplier of solderless wrapped connection equipment.

How Much Solution Content?

Perhaps the most appropriate scale upon which to measure the "amount" of solution content in a customer request is a scale which consists of stages in

EXHIBIT 2
Frequency with which Manufacturers Initiated Work on an Industrial Innovation in Response to a Customer Request

Study	Nature of Innovations and Sample Selection Criteria	N	Data Available Regarding Presence of Customer Requests
A. Studies of Industrial Products			
Meadows[a]	All projects initiated during a two-year period in "Chem Lab B" — Lab of a chemical company with $100-300 million in annual sales in "industrial intermediates."	29	9 of 17 (53%) commercially successful product ideas were from customers.
Peplow[b]	All "creative" projects carried out during a six-year period by an R&D group concerned with plant process, equipment and technique innovations.	94	30 of 48 (62%) successfully implemented projects were initiated in response to direct customer request.
Von Hippel[c]	Semiconductor and electronic sub-assembly manufacturing equipment: first of type used in commercial production (n = 7); major improvements (n = 22); minor improvements (n = 20).	49	Source of initiative for manufacture of equipment developed by users (n = 29) examined. Source clearly indentified as customer request in 21% of cases. In 46% of cases frequent customer-manufacturer interaction made source of initiative unclear.
Berger[d]	All engineering polymers developed in U.S. after 1955 with > 10 million pounds produced in 1975.	5	No project-initiating request from customers found.
Boyden[e]	Chemical additives for plastics: all plasticizers and UV stabilizers developed post-W.W. II for use with four major polymers.	16	No project-initiating request from customers found.
Utterback[f]	All scientific instrument innovations manufactured by Mass. firms which won "IR-100 Awards," 1963-1968 (n = 15); sample of other instruments produced by same firms (n = 17).	32	75% initiated in response to "need input". When need input originated outside product manufacturer (57%), source was "most often" customer.
Robinson et al[g]	Sample of standard and non-standard industrial products purchased by three firms.	NA	Customers recognize need, define functional requirements and specific goods and services needed *before contacting suppliers.*
B. Studies of Research-Engineering Interaction			
Isenson *(Project Hindsight)*[h]	R&D accomplishments judged key to successful development of 20 weapons systems.	710	85% initiated in response to description of problem by application-engineering group.
Materials Advisory Board[i]	Materials innovations "believed to be the result of research-engineering interaction."	10	In "almost all" cases the individual with a well-defined need initiated the communications with the basic researchers.

References

a. Dennis Meadows, "Estimate Accuracy and Project Selection Models in Industrial Research," *Industrial Management Review*, Spring 1969. Also, "Data Appendix: Accuracy of Technical Estimates in Industrial Research Planning," M.I.T. Sloan School of Management, Working Paper #301-67.

b. M.E. Peplow, "Design Acceptance," in *The Design Method*, S.A. Gregory, ed. (London: Butterworth, 1960).

c. E. von Hippel, "Transferring Process Equipment Innovations from User-Innovators to Equipment Manufacturing Firms," *R&D Management*, October 1977; see also M.I.T. Sloan School of Management, Working Paper #857-76, May 1976 (revised January 1977).

d. A. Berger, *Factors Influencing the Locus of Innovation Activity Leading to Scientific Instrument and Plastics Innovations* (unpublished S.M. thesis, M.I.T. Sloan School of Management, June 1975).

e. J. Boyden, *A Study of the Innovation Process in the Plastics Additives Industry* (unpublished S.M. thesis, M.I.T. Sloan School of Management, January 1976).

f. J. Utterback, "The Process of Innovation: A Study of the Origination and Development of Ideas for New Scientific Instruments," *IEEE Transactions on Engineering Management*, November 1971.

g. Robinson, Farris and Wind, *Industrial Buying and Creative Marketing* (Boston: Allyn and Bacon, 1967).

h. R. Isenson, "Project Hindsight: An Empirical Study of the Sources of Ideas Utilized in Operational Weapon Systems," in W. Gruber and D. Marquis, eds., *Factors in the Transfer of Technology* (Cambridge, MA: M.I.T. Press, 1969), pg. 157.

i. Materials Advisory Board, Division of Engineering, National Research Council, *Report of the Ad Hoc Committee on Principles of Research-Engineering Interaction*, Publication MAB-222-M (Washington, D.C.: National Academy of Sciences — National Research Council, July 1966), pp. 15, 16.

the product development process. If one were able to measure the solution content of a request on such a scale, one would be able to say:

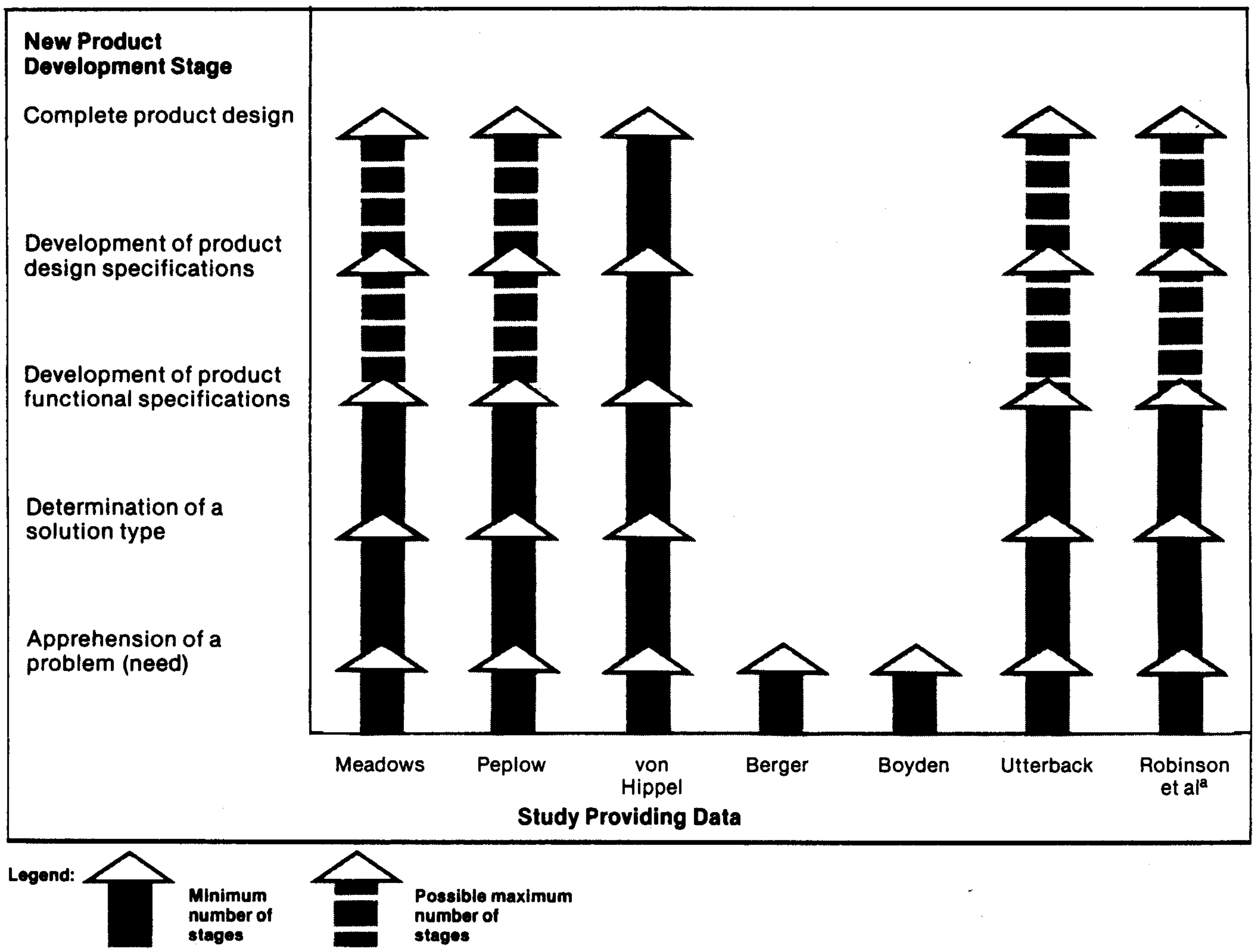
> For "x" product, the customer's request supplied the data normally generated by product development process stages, 1 → x, leaving to the manufacturer the performance of the work of stages, x + 1 → N.

Specifications of linear stages of new product development is somewhat chimerical; researchers in the area have shown that the actual work cannot be said to proceed in clear-cut stages, but for our purposes here, the simple five-stage segmentation shown in Exhibit 3 will be serviceable.

The Meadows, Peplow, Utterback, and Robinson studies reviewed in Exhibit 2-A do not spell out the solution content of the customer requests they observed. And, on the face of it, the content of those messages could have been anything from a simple "Give me a new product—any new product" to an explicit, "Make me some of my compound X according to my process Y." I would argue that at a *minimum* the solution content of those need messages must have included some functional specifications for the requested new industrial products (indicated in Exhibit 3 by the solid arrows); and that there is a strong probability that some provided complete product design data to the manufacturer (combined solid and broken arrows).

My argument that, at a minimum, *the need messages must have included implicit or explicit data on the general type of solution* to be embodied in the desired product is as follows: The need messages observed in the reviewed studies were "narrow-cast" to specific suppliers—not broadcast to all and sundry. Since

EXHIBIT 3
New Product Development Data Supplied by Customer to Manufacturer



a. Scale valid for new product portion of study sample only.

different suppliers specialize in different solution technologies, selection of a particular supplier cannot be made until the customer has recognized his need and has envisioned the general type of solution he wants.

For example, if a customer perceives a need to store corporate data, he may make the need known to Kodak envisioning microfilm storage as an appropriate "type" of solution to the problem. If, on the other hand, he feels physical storage of hard copy is in order, he may contact a manufacturer of file cabinets; or if he feels storage on magnetic tape might be appropriate, he may contact a computer manufacturer, etc.

My belief that *a customer request must also include some functional specifications* for a product responsive to the need is likewise based on simple logic: It is hard to envision a customer calling up a supplier about a problem and not being able to specify at least some of the functional elements required in a responsive solution. In the instance of the corporate data storage example above, therefore, it seems only logical to assume that, in most instances, such a customer would know roughly how much data had to be stored, how often access was needed, etc.

My contention that, at a maximum, *the customer requests* noted in the Meadows, Peplow, Utterback, and Robinson studies *could have included complete product design data* for the industrial product requested, is based on the data from my own studies of scientific instruments and process equipment innovations mentioned previously.[8] The data support the notion that product users (customers) in at least some fields are the source of the designs for most of the functionally significant, first-to-market, industrial product innovations in those fields.

Does Content Mean "Idea"?

Finally, we come to the question: Does the solution content observed in the studies reviewed constitute the "idea" for the new product being sought? Although, as discussed above, most of the studies reviewed indicate only the minimum and maximum, I feel we can safely conclude that the requests did provide the product idea to the manufacturers. Even the minimum solution content of those messages satisfies the definition of a new product idea (a very difficult definition to devise) in the usage of many investigators.

(Rubenstein's working definition of an idea is "an actual or potential proposal for undertaking new technical work which will require the commitment of significant organizational resources such as time, money, manpower, energy."[9] Myers and Marquis suggest that "the idea for an innovation consists of the fusion of a recognized demand and a recognized technical feasibility into a design concept . . . The design concept is only the identification and formulation of a problem worth working on. It is followed by problem solving activity."[10])

Closer Fit of CAP

There are two possible explanations for our finding that the hypothesized CAP fits more closely with industrial product-idea generation *practice* than does the conventionally assumed MAP:

> MAP is *not* appropriate to the requirements of industrial product idea generation.
> MAP *is* appropriate to the requirements of industrial product idea generation, *but* simply has *not* been extensively applied in that field as yet.

I would like to propose that each explanation applies to the situation—but to different portions of the "universe" of new industrial products, as a function of these two constraints:

- The CAP can only be applied in situations where the would-be customer is *overtly* aware of his new product need—while methodologies developed in the context of the manufacturer-active paradigm can be applied to either overt (e.g. conjoint analysis) or latent customer needs.

- The MAP can be applied only under circumstances in which the new product opportunity is "accessible to manufacturer-managed action."

If we display these proposed constraints and their impact in a two-dimensional table, Exhibit 4, we see the conditions under which the customer-active and/or manufacturer-active product idea generation paradigm will be appropriate.

EXHIBIT 4
Characteristics of New Industrial Product Opportunity Appropriate to CAP and/or MAP

Nature of Customer Need	Accessibility of New Product Opportunity to Manufacturer-Managed Action: Low	High
Overt	Customer-Active Only	Customer- and/or Manufacturer-Active
Latent	Neither	Manufacturer-Active Only

The logic behind my proposal that the CAP idea generation paradigm can only be applied in instances where the customer is overtly aware of his need is clear: How can a customer send a message regarding a need of which he is not overtly aware? The purpose and logic of my second proposal—on the face of it a near-tautology—is doubtless opaque to the reader at this point. Clarifying it and reasoning that it discriminates well between consumer and some industrial new product opportunities is my next task.

Low Accessibility to Manufacturer-Managed Action

The hallmark of the MAP is manufacturer-initiation of the process by which the need for a new product is perceived, manufacturer-initiated analysis of those needs, and a generation of a *responsive* product idea. In contrast, the CAP is characterized by a request, communicated at customer initiative to a customer-selected manufacturer, which contains a customer-generated product idea.

When a customer's need for a new product is overt, I suggest that two characteristics of the new product opportunity determine the paradigm most appropriate to the industrial product idea generation process:

1. Easy (low-cost) identification of customers sharing a similar new product need via manufacturer-initiated methods (such as surveys) will be favorable to use of the MAP.
2. Long-duration "new product selling opportunities" will allow application of either paradigm. These opportunities can be defined as starting when a customer first develops a need for a new product, and as ending when that customer is no longer willing to consider purchase of a responsive product offered by a would-be supplier. Very short opportunities (on the order of a few weeks' duration) will only permit application of the customer-active paradigm.

My reasoning is that a few weeks—at least with current methods—is too short a period to allow a manufacturer the necessary time to accomplish the steps prescribed by MAP: need analysis and generation of a responsive new product idea. On the other hand, a few weeks would seem sufficient if a manufacturer only had to accomplish the step prescribed by CAP: acceptance or rejection of a new product idea proposed by a customer.

How may consumer and industrial new product selling opportunities be seen in terms of these two characteristics?

Consumer Product Opportunities

In many categories of consumer packaged goods (and in a few categories of industrial products) the following conditions prevail:

- ▶ The proportion of all consumers using an existing product in the functional category being studied (e.g. toothpaste) is sufficiently large and/or well known to allow economical identification of a sample of users via a survey or another manufacturer initiated technique.
- ▶ A sample of current users of many consumer goods is effectively equivalent to a sample of future buyers—the real category of interest to market researchers—because the products are frequently repurchased.
- ▶ Users/buyers of many consumer goods can be persuaded economically to buy a new brand if they see it as preferable to their present brand because the switch entails little adjustment effort/cost on their part.

Economical Execution

These conditions suggest an economical execution of the manufacturer-active product idea generation paradigm because:

- ▶ Identification of users with a new product need/dissatisfaction with existing products via survey or other manufacturer initiative is economical.
- ▶ The duration of the new product selling opportunity is sufficient to allow execution of the MAP. (Since the products are frequently repurchased and since brand switching involves little changeover cost for the buyer, a "selling opportunity" remains open to a manufacturer as long as the need he has identified remains valid.)

Note that the conditions outlined above also hold for *certain* types of industrial products. In the case of electronic components such as resistors, for example, electronics firms using these components are easily identified, the parts are frequently repurchased, and their physical and functional characteristics are sometimes so standardized that customer firms can make a relatively costless switch from one brand to another if they wish to do so.

Industrial Product Opportunities

Consider, in contrast, the circumstances which studies of industrial buying and engineering problem-solving behavior suggest are characteristic of the selling opportunity for many or most new industrial goods.

Industrial products (often placed in the categories of materials, components and capital equipment) are "needed" and specified largely by engineers. Brand,[11] Robinson, Farris and Wind,[12] and the Research Department of *Scientific American*[13] are unanimous in concluding that R&D personnel, primarily engineers, within the product buying firms are the primary decision makers in the key early stages of the buying process in which the kind of product to be purchased and its specifications are determined.

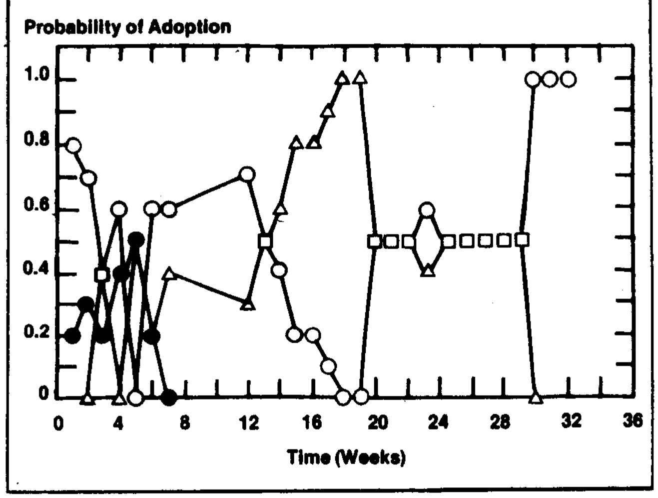
Such engineers are engaged in "engineering problem solving," and *derive* their need for the product from a particular approach to a particular problem. Thus, if you ask an engineer what he needs in the way of an equipment-cooling fan, his answer may properly be that it depends *entirely* on the application—the engineer himself has *no* long-term criteria for what *he* would like to see in a fan. Since engineers are constantly working on different problems, the result is that an engineer's "need" for an equipment-cooling fan may well change from problem to problem. And, even within the context of a particular problem, the engineer's need will very likely change from moment to moment as the work of problem-solving proceeds.

As an example, suppose that an engineer is assigned the problem of stabilizing a circuit whose electrical parameters "drift" unacceptably because it gets too hot when operating. The engineer may decide to redesign the circuit in such a way as to make it stable at the operating temperatures encountered—in which case he has *no* need for a fan. Or he may decide he will stabilize the circuit by cooling it—in which case he will have a very specific need for a fan, possibly meeting very tight cost, size and performance parameters.

Needs change rapidly because the engineering problem-solving process proceeds rapidly. Studies of the engineering design process by Allen[14] and Marples[15] show that radical changes in preferred solutions—and therefore in needed materials and/or process equipment—occur within the span of a few weeks. Allen displays this rapid change in preferred solutions very graphically via "solution development records" based on data from real-time monitoring of the engineering problem-solving process (see Exhibit 5).

If the above characterization of needs for new industrial products and the process by which they are generated is correct, one can see that such needs arise quickly within a particular customer firm, and may disappear or change just as quickly. Further, while present, the needs may be very precise—e.g., "Yesterday I didn't want a fan, but today I want one which must be less than 5⅜ inches in diameter, must cost less than $5 in lots of 10,000."

EXHIBIT 5
Solution Development Record of Engineering Team Designing an "Antenna Radiation Subsystem" Showing Changes in Probability that Various Solutions Will be Adopted vs. Time



Legend
△ Technical Approach a
○ Technical Approach b
● Technical Approach c

Source: Redrawn from T. Allen, "Studies of the Problem-Solving Process in Engineering Design," *IEEE Transactions on Engineering Management*, June 1966, pg. 75.

The conditions described above are appropriate for application of the *customer*-active paradigm because:

- *Customers who need the product are difficult to identify through manufacturer-initiated action.* (This assertion is only logical, given that the buyer is a not-very-accessible engineer in the midst of a corporation. He may never before have expressed any interest in the type of product which he now needs. It is a common observation in studies of industrial marketing.[16])

- *The selling opportunity—measured as starting when the customer first develops the need for the new product and ending when the customer selects an initial supplier—is brief (perhaps only weeks).* As we noted above, such an interval is probably too short to accomplish the steps prescribed for the manufacturer in MAP, but it would appear appropriate to the manufacturer's role in CAP.

The selling opportunity noted above is only the *initial* selling opportunity. Such initial selling opportunities are very important to would-be manufacturers of new industrial products, however, for two reasons:

1. For any given customer, the initial selling opportunity is often the *only* selling opportunity because, after an initial supplier is settled upon, changeover to a new supplier often involves considerable cost to the buyer. Selection of a new supplier to fill repeat orders under such circumstances is unlikely.
2. A manufacturer who becomes the supplier to the *first* buyer of a new industrial product often has an advantage in obtaining orders from new customers for the same product because (a) he is down the experience curve relative to would-be competitors; and (b) he is a known supplier of the item and thus increases his chances of obtaining "product requests" from additional customers.

In sum, the CAP appears to fit current industrial product idea generation practice and to offer a good fit to the requirements of such idea generation as well. (Recall here the data from the Meadows and Peplow studies reviewed earlier, which suggest that products initiated via direct customer request tend to be among the commercially *more* successful of all new industrial products.) Perhaps, therefore, CAP offers a useful base on which to build new methodologies for the generation of ideas for new industrial products.

Suggestions for Further Research

A useful new paradigm should suggest useful new questions. If idea transmission at user initiative is to form the basis for a paradigm describing how manufacturers often acquire ideas for new industrial products, the questions made pertinent for research and practice should be most useful. Among these are the following:

Communications Strategy

The manufacturer switches from a paradigm in which his ability to perceive needs is under his control to one in which the customer must see the manufacturer as relevant for his problem and go on to "narrow-cast" an idea to that manufacturer. Until and unless the customer does this, the manufacturer is unable to see the idea. Thus the question arises: How does the manufacturer get the customer—whom he cannot specifically identify—to see him as a potential supplier for a new product and contact him?

Manufacturers have already worked out many strategies to this end empirically. They advertise the types of technology they are skilled in—e.g., *"Brazing problem? Call us."* They advertise products they have made to solve other's problems, hoping to strike a spark in a customer engineer who may be, even now, solving a problem they could contribute to—but who is, frustratingly, invisible to them until he initiates contact, etc.

But how is it best done? Studies of what makes a customer engineer see a manufacturer as relevant for his problem are clearly in order. For example, studies of problem-solving behavior by engineers[17] and others show that problem solvers when faced with a new problem tend to return to a technique they have previously used successfully. In the present context this finding suggests that customers will tend to transmit their needs to suppliers of old, familiar technologies (e.g., faced with a fastening problem, they would tend to turn to a supplier of a familiar hardware-based fastening technology rather than a new, adhesive-based one).

If further study shows this hypothesis to be correct, an interesting strategy implication exists for suppliers of new technology (such as adhesives), i.e., that they should acquire a "window on need" by buying into an established company which specializes in an older technology of analogous function.

Organizational Issues

The manufacturer switches from a paradigm in which he was set up to perceive needs, analyze them and generate product ideas to one in which he must efficiently perceive and screen ideas. Such a change raises major organizational issues for the firm. While, in the CAP, marketing research was the locus of need perception and analysis activity (and was presumably organized and staffed for that role), in the new paradigm, sales becomes the new-need/new-product idea reception area.

How, in detail, do such messages come to sales? In field contacts with the customer? To the firm's central sales office? Are they transmitted orally or in writing? What incentives do sales people have for sensing these requests and passing them on? (Typically, salesmen's commissions are designed to reward large volume sales in the present—not possible sales of new products in the future.) Are salesmen properly trained to understand new product requests? Is there any incentive or organization which will ensure that the salesmen have someone to pass customer ideas along to for evaluation and action? And so on.

Product Paradigms

Which classes of industrial product fall under the CAP paradigm and which under the MAP? Do these two exhaustively cover the universe of standard industrial products? As a research hypothesis, I would suggest that at least three paradigms, shown schematically in Exhibit 6, will be useful in under-

EXHIBIT 6
Three Proposed Paradigms for Industrial Product Idea Generation

Paradigm	Sequence of Activities			Universe of Standard Industrial Products
1. Customer-Active	Product Request from Customer	"Custom" Industrial Product	Adoption by Others	% NA
2. Manufacturer-Active	Needs Research by Mfr.	Idea Generation	Idea Testing	% NA
3. Unfilled "Known need"	"Generally Known" User Need	Advance in Technology	Development of Responsive Product	% NA

standing how ideas for new industrial products are acquired by their first-to-market manufacturers.

The first two paradigms are the CAP and the MAP that we have discussed to this point.

CAP we know describes the practice of many industrial-product situations, where a manufacturer, receiving an idea (often in the form of a special order), may decide that the potential payout is attractive enough to merit his working on it—by no means a certainty—and then *may* go on to make it a "catalog item," a standard industrial product. We do not, however, know how many of these new industrial products, which start out as special order items, go on to become standard products.

MAP, in turn, is conventional wisdom in the consumer product field. I have suggested that *some* proportion of the universe of standard industrial products may appropriately be addressed by it, but, again, we don't know what proportion.

The third and final paradigm which I hypothesize will be found appropriate to some classes of industrial product—and for which I have anecdotal evidence only—is one in which "everyone knows" what the customer wants, but progress in technology is required before the desired product can be realized. In my work in the computer, plastics, and semiconductor industries, I have often been told that new product needs are not a problem: "Everyone knows" that the customer wants more calculations per second and per dollar in the computer business; "everyone knows" that the customer wants plastics which degrade less quickly in sunlight; and "everyone knows" that the semiconductor customer wants more memory capacity on a single chip of silicon.

Under such circumstances, a customer request is not required to trigger a new product—only an advance in technology. And since many of the "everyone knows" statements are phrased in dimensional terms, a series of new products can be introduced as technology advances, each responsive to the same dimension of need. Thus, computer manufacturers do not stop and rest on their laurels after introducing a faster computer—waiting for a user to approach them with a request for a still faster one. Rather, they continue to move down the clearly defined "dimension of merit" of greater computing speed as quickly as their advancing technology allows.

I suggest that the absence of explicit need messages directly associated with the samples of engineering plastics and plastics additives examined by Berger and Boyden are the result of such an effect: e.g., that the needs were generally known. Conversations with participants in these industries have lent support to this hypothesis, and further research into the matter should be of value.

ENDNOTES

Note: Readers interested in a further exploration of some of the ideas expressed in this paper may wish to refer to Eric von Hippel, "A Customer-Active Paradigm for Industrial Idea Generation," M.I.T. Sloan School of Management, Working Paper #935-77, May 1977 (*Research Policy* publication is forthcoming).

1. Empirical research into the industrial goods innovation process has shown that the level of manufacturer "understanding of user need" co-varies strongly with the level of commercial success attained by an innovative industrial product. See Rothwell, Freeman et al., "Sappho Updated—Project Sappho Phase II," *Research Policy*, Vol. 3 (1974), pg. 261.

2. G. Brand, *The Industrial Buying Decision* (New York: John Wiley & Sons, 1972); J. M. Choffray and G. Lilien, "Models of the Multiperson Choice Process with Application to the Adoption of Industrial Products," M.I.T. Sloan School of Management Working Paper #861-76, June 1976; H. Håkansson and C. Östbert, "Industrial Marketing: An Organizational Problem?" *Industrial Marketing Management*, Vol. 4 (1975); L. G. Mattsson, "Systems Selling as a Strategy on Industrial Markets," *Industrial Marketing Management* Vol. 3 (1973); Robinson, Farris and Wind, *Industrial Buying and Creative Marketing* (Boston: Allyn and Bacon, 1967).

3. E. von Hippel, same as Note above.

4. D. Meadows, "Estimate Accuracy and Project Selection Models in Industrial Research," *Industrial Management Review*, Spring 1969. Also, "Data Appendix: Accuracy of Technical Estimates in Industrial Research Planning," M.I.T. Sloan School of Management Working Paper #301-67.

5. M. E. Peplow, "Design Acceptance," in *The Design Method*, S. A. Gregory, ed. (London: Butterworth, 1960).

6. E. von Hippel, "The Dominant Role of Users in the Scientific Instrument Innovation Process," *Research Policy*, Vol. 5 (1976), pp. 212-39.

7. E. von Hippel, "The Dominant Role of the User in Semiconductor and Electronic Subassembly Process Innovation," *IEEE Transactions on Engineering Management*, May 1977; E. von Hippel, "Transferring Process Equipment Innovations from User-Innovators to Equipment Manufacturing Firms," *R&D Management*, October 1977.

8. E. von Hippel, same as reference 6 above; E. von Hippel, same as reference 7 above.

9. A. H. Rubenstein, "Studies of Idea Flow in Research and Development," presented to the New York Chapter, the Institute of Management Sciences, November 1963, pg. 2. (As cited in Baker, Siegman and Rubenstein, "The Effect of Perceived Needs and Means on the Generation of Ideas for Industrial Research and Development Projects," *IEEE Transactions on Engineering Management*, December 1967, pg. 158.)

10. S. Myers and D. Marquis, *Successful Industrial Innovations* (Washington, D.C.: National Science Foundation, NSF 69-17, 1969), pg. 5.

11. Brand, same as reference 2 above.

12. Robinson et al., same as reference 2 above.

13. Scientific American, *How Industry Buys/1970* (New York: Scientific American, Inc., 1969).

14. T. Allen, "Studies of the Problem-Solving Process in Engineering Design," *IEEE Transactions on Engineering Management*, June 1966.

15. D. Marples, "The Decisions of Engineering Design," *IRE Transactions on Engineering Management*, June 1961.

16. Robinson, same as reference 2 above.

17. T. Allen and D. G. Marquis, "Positive and Negative Biasing Sets: The Effects of Prior Experience on Research Performance," *IEEE Transactions on Engineering Management*, December 1964.