Patterns of Communication Among Marketing, Engineering and Manufacturing--A Comparison Between Two New Product Teams

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ABSTRACT

Scientific evidence suggests that firms are more successful at new product development if there is greater communication among marketing, engineering, and manufacturing. This paper examines communication patterns for two matched product development teams (same manufacturer, same product development stage, similar functions and number of parts, reporting to the same divisional upper manager). The key difference between the groups is that one team used a traditional phase review process and the other used Quality Function Deployment (QFD), a product development process adopted widely at over 100 United States and Japanese firms including such large organizations as General Motors, Ford, IBM, and Procter & Gamble. The comparison is of scientific and managerial interest because QFD is often adopted to enhance cross-functional communication. To our knowledge, this is the first head-to-head comparison of traditional U.S. product development processes with QFD.

We report data collected on communication levels within functions, between functions, within the teams, within the OEM group, between the OEM and supplier groups, and between the teams and external information sources. Our data suggests that QFD enhances communication levels within the core team (marketing, engineering, manufacturing). QFD changes communication patterns from "up-over-down" flows through management to more horizontal "across" routes where core team members communicate directly with one another. The QFD team communicates more on product design, customer needs, and market information than does the phase review team. On the other hand, the QFD team communicates less on planning information and less with members of the firm external to the team. If this paucity of external communication means that the team has the information it needs for product development, and the QFD process has provided an effective means for moving the information through the team, it is a positive impact of QFD. If the result means that QFD induces team insularity, even when the team needs to reach out to external information sources, it is a cause for concern.

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Recent scientific evidence suggests that new product development teams are more successful if their members communicate with one another. In particular, the likelihood of product success is enhanced if marketing, R&D, engineering, and manufacturing share information on customer needs and segments, technology and manufacturing capabilities, competitor strategies, business strategy, and pricing (e.g., Dougherty 1987). But communication is surprisingly difficult to obtain. Almost 60% of the new product teams in one survey reported communication disharmony (Souder 1988).

This paper examines communication patterns within two new product teams working on parallel component projects in the automobile industry. What makes the comparison interesting is that while one team used Quality Function Deployment (QFD), a Japanese product development technique adopted recently by many American firms which purports to enhance interfunctional communication, the other team used a traditional phase-review process practiced by many American firms (e.g., Urban and Hauser 1980, chapter 18). Both teams reported to the same manager, faced similar technical and marketing challenges, and were at similar task stages. Without revealing the sponsor or the specific projects, it was as if one team was working on a headlight subsystem and the other was working on a taillight system, both for the same new-car platform.

Following established communication measuring procedures (e.g., Allen 1984) each team member, contemporaneously during a 15-week period, reported how often during the day, with whom, and about what (from a pre-determined list) they communicated. By matching names to functions we measure intrafunctional, interfunctional, and subordinate-to-manager communication within and between the manufacturer and its supplier. Some of our results may surprise the reader; others will confirm intuition. For example, our evidence suggests that QFD leads to less, but more efficient communication within the team and encourages more manufacturer-to-supplier communication. It also suggests that the phase-review process implies more managerial control and encourages more communication with members of the organization external to the development team. While one set of parallel projects can not establish any result definitively, it suggests some interesting hypotheses and, to our knowledge, represents the first formal comparison of this widely-acclaimed Japanese technique with traditional American processes.

Before describing the comparison, we must set the stage. The next section reviews evidence suggesting that communication enhances new product development. The following section reviews QFD, the Japanese product-development technique.

Communication Enhances New Product Development -- Some Previous Literature

Intuition suggests that communication is important to new product development. We would expect that new products will be more successful if R&D and engineering understand customer needs, marketing understands technological capabilities and constraints, and both understand the implications for manufacturing and competitive strategy.

Scientific evidence clearly supports this intuition. For example, in a ten-year study of 289 projects, Souder (1988) demonstrates that harmony (communication and cooperation) is a strong correlate of new product success. See table 1. Other survey research has identified marketing and technological synergy (Cooper and Kleinschmidt 1987) and communication among functions (de Brentani 1989) as correlates of new product success.

Table 1. Communication vs. Success
(From Souder 1988, Table 3)

Percentage of Projects in Each State Exhibiting Each Outcome

	OUTCOME		
State	Success	Partial Success	Failure
Harmony	52%	35%	13%
Mild Disharmony	32%	45%	23%
Severe Disharmony	11%	21%	68%

Perhaps the most graphic evidence of the impact of communication comes from a study by Cooper (1984a, 1984b). He clustered 122 organizations on 19 strategy dimensions to identify five basic organization types -- technology driven, focused but technologically weak, high-budget shotgun, low-budget conservative, and marketing-and-technology integrated. The only organizations with high percentages of successful projects and sales derived from new products were those integrating technological sophistication and a marketing orientation to develop products with differential advantages for strategic segments. See figure 1.

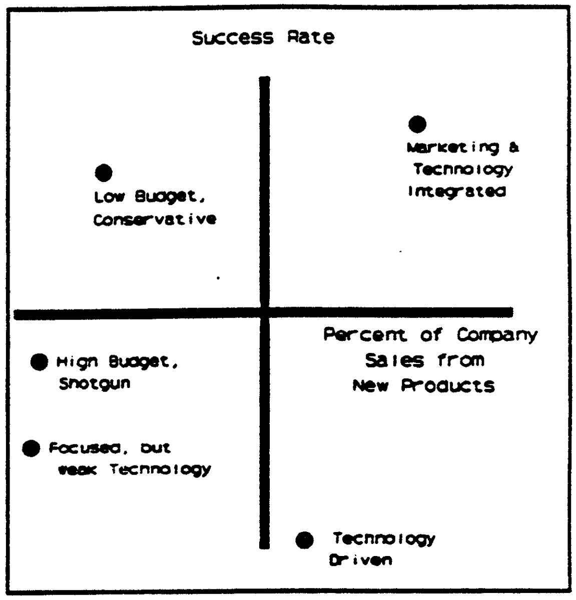

Figure 1
Comparison of New-Product Strategies
(Adapted from Cooper 1984.)

Dougherty (1987) used retrospective interviews and paper trails in in-depth ethnographic studies of 16 projects at five firms. She established a three-point communication measurement scale for nine important product development topics. Figure 2, comparing communication levels for one successful and one failed project at a firm, is indicative of her general findings. Successful projects were characterized not just by a high level of communication, but high levels on each of the nine topics. In almost every case, if communication was low on one or more topics, the project could not be classified as a success[1].

Large sample surveys[2] and in-depth enthnographies suggest that communication is important to new product success. However, it is difficult to achieve. In examining the

[1] Souder's (1988) paper also supports the hypothesis one needs more than just a high level of communication. He reports that problems result when too much social interaction prevents objective criticism.

[2] Souder (1987, 1988): 289 projects at 56 consumer and industrial firms. Cooper and Kleinschmidt (1987): 203 projects at industrial firms. De Brentani (1989): industrial services at 115 Canadian firms. Gupta, et. al. (1985): 216 managers in 167 high-technology firms. Gupta and Wilemon (1988): R&D directors at 80 high-technology firms. Hise, et., al. (1990): 252 Vice Presidents of Marketing at large manufacturing firms. See also discussion in Moenaert and Souder (1990).

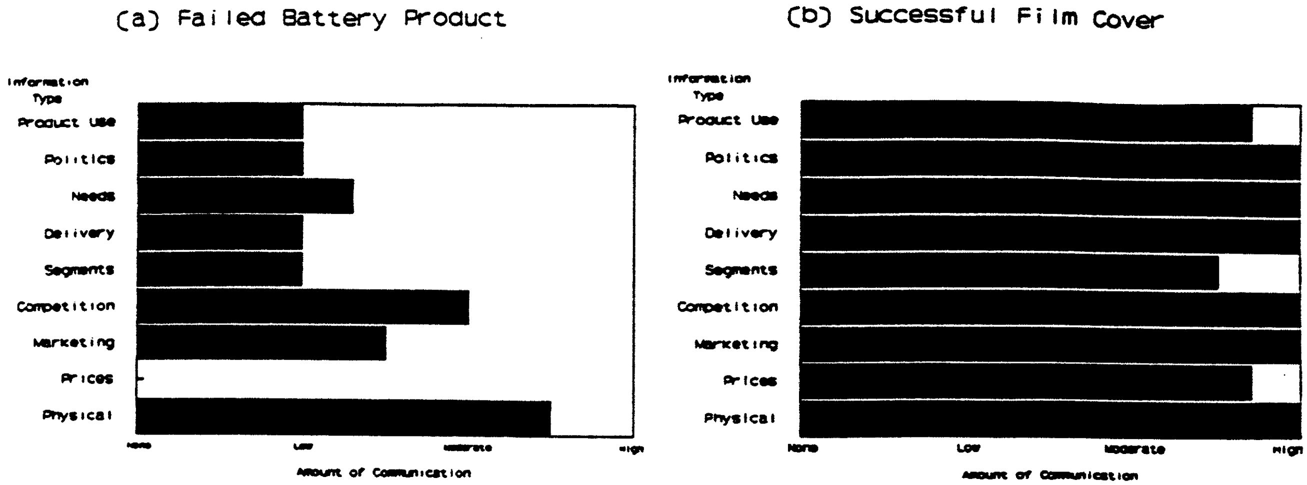

Figure 2. Amount of Communication on Two New Product Projects at the Same Firm (Adapted from Dougherty 1987.)

barriers preventing functional interaction in product development, Gupta, et. al (1985) find that lack of communication is the number one barrier. They also find that marketing and R&D perceptions differ both on their levels of involvement and on the value of the information they each provide to the project. For example, marketing perceives that it provides greater value to R&D than R&D perceives it gets from marketing. In a follow-on study, Gupta and Wilemon (1988) found that only when the marketing and R&D functions are more integrated is marketing information perceived as being of higher quality and utility.

One explanation of the difficulties of achieving cross-functional integration(Dougherty 1987) is that each function resides in its own "thoughtworld" -- engineers (R&D) speak a technical language of product features and specifications and respond to an engineering culture of problem solving while marketers speak in their own language, hopefully that of the customer, and operate in a customer-oriented culture. Communication occurs and projects succeed only if there are bridges between the disparate thoughtworlds of the functional team members. If projects are to succeed, then a product development process must bridge the thoughtworlds of engineering and marketing. Each function must understand the needs of the other functions and provide the right information to meet those needs.

We now describe one management technique that many believe enhances interfunctional communication on the appropriate topics.

QFD -- One Technique to Enhance Communication

Quality Function Deployment (QFD) was developed in 1972 at Mitsubishi's Kobe shipyard and is now used widely in both Japan and the United States[3]. It is particularly

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[3]Among the firms reporting applications are General Motors, Ford, Navistar, Toyota, Mazda, Mitsubishi, Procter & Gamble, Colgate, Campbell's Soup, Gillette, IBM, Xerox, Digital Equipment Corp., Hewlett-Packard, Kodak, Texas Instruments, Hancock Insurance, Fidelity Trust, Cummins Engine, Budd Co., Cirtek, Yasakawa Electric Industries, Matsushita Densko, Komatsu Cast Engineering, Fubota Electronics, Shin-Nippon Steel, Nippon Zeon, and Shimizu Construction.

prevalent in the automotive industry with General Motors, Ford, and many of their suppliers reporting that QFD is now critical to their new product design efforts[4]. By various claims (e.g., Hauser and Clausing 1988), QFD has reduced design time by 40% and design costs by 60% while maintaining and enhancing product design quality.

This section briefly introduces QFD. For a managerial discussion of QFD see Hauser and Clausing (1988); for a participant-observer ethnography of thirty-five projects at nine firms see Griffin (1989); for details and case studies see Clausing (1986), Eureka (1987), King (1987), Kogure and Akao (1983), McElroy (1987), and Sullivan (1986, 1987), as well as collections of articles by Akao (1987), and the American Supplier Institute (1987).

Marketing scientists will recognize the House of Quality, and more generally QFD, as an organizational technique to implement the "lens" model (Brunswick 1952). That is, QFD uses the customer's perceptions as a lens with which to understand how the physical characteristics of the new product affect customer preference, satisfaction, and, ultimately, sales. The advantage of QFD over the lens-model formulation is that the visual techniques of QFD are designed to encourage communication and acceptance by all members of the new product team, not just marketing.

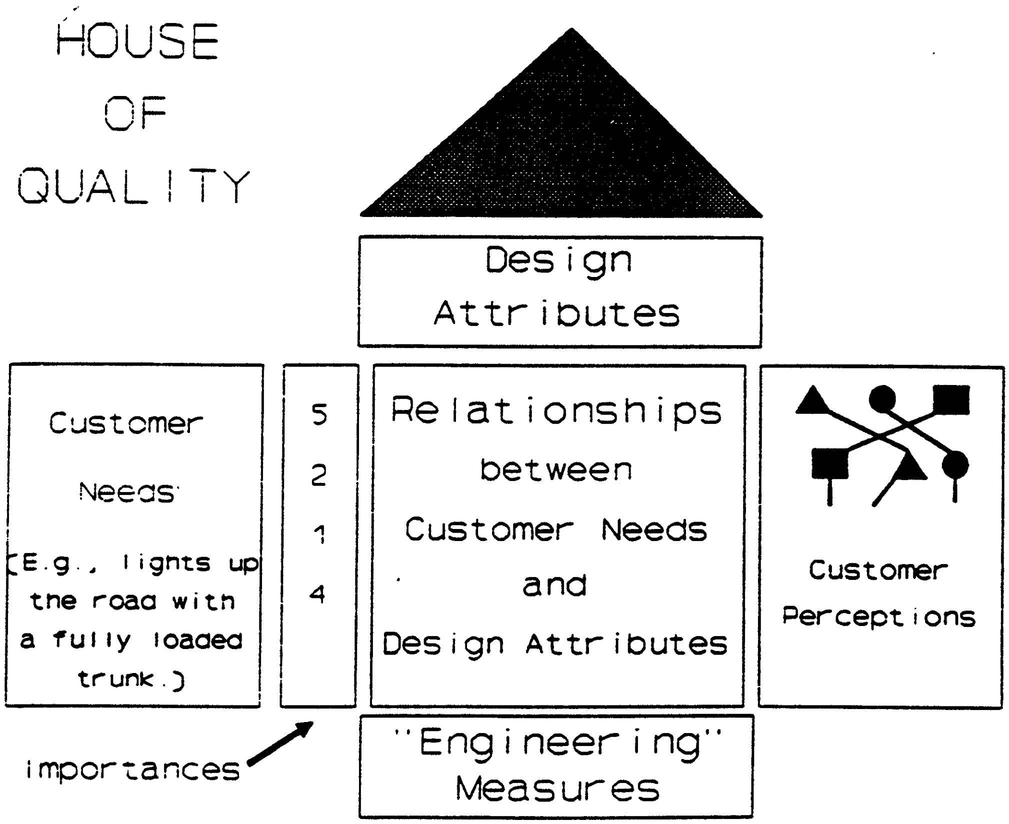

Figure 3. Conceptualization of the First Stage of QFD

[4]Private communications to the authors.

QFD uses four "houses" to integrate the informational needs of marketing, engineering, R&D, manufacturing, and management. It is best known by the first house, the House of Quality, shown conceptually in figure 3. The new product team begins by obtaining the "voice of the customer" in the form of 200-300 detailed customer needs such as (for headlights) "lights up the road with a fully loaded trunk." These customer needs are grouped hierarchically into a relatively few primary needs (to establish the strategic position), 20-30 secondary needs (to design the basic product and its marketing), and 150-250 tertiary needs (to provide specific direction to engineers).

Customer perceptions of competitive products provide goals and opportunities for new products. The importances of customer needs establish design priorities. Design attributes, such as the automatic shut-off time delay, provide the means to satisfy customer needs. The relationship matrix translates the language of marketing, the customer needs, into engineering language, the design attributes. Engineering measures of the design attributes (seconds of delay, etc.) establish competitor capabilities. Finally the "roof matrix" (shown as cross-hatched lines in figure 3) quantifies the physical interrelations among the design attributes -- a brighter headlight requires more electrical power and thus impacts other subsystems in the car.

The House of Quality encourages cooperation and communication among functions by requiring input from marketing (the customer's voice) and engineering (engineering measures and the roof matrix), and agreement on interrelationships. If the entire team participates in the House of Quality all team members understand and accept these inputs and relationships. Once the House of Quality is complete, the other "houses" link design attributes to parts characteristics, parts characteristics to manufacturing processes, and manufacturing processes to the production line. A complete set of QFD houses deploys the customer's concept of needs (the qualities) through every product development function.

QFD's continued acceptance by Japanese and American industry is circumstantial evidence that it might enhance new product success. One reason often cited is enhanced communication. See references cited above. But does QFD really enhance communication? While there have been many QFD case studies, there have been no comparative studies, in part because new product teams have the incentive to develop new products, not compare techniques, and in part because traditional new product development takes place in a variety of guises (see surveys in Duerr 1986). Furthermore, Japanese and American new product development comparisons are confounded by many differences in culture, work force, education, development techniques, manufacturing techniques, organizational structure, and industrial policy, to name just a few. In this paper we undertake the modest goal of one head-to-head U.S. comparison between QFD and the prevalent phase-review process. Through a comparison of parallel projects we hope to eliminate many of the potential confounding factors so that we might understand better QFD's impact on communications in product development.

Comparing Team Performance

Our measures compare two teams within the same organization working on components of comparable technical complexity with about the same number of parts, which serve similar functions in an automobile. Both products are manufactured by outside suppliers, but are designed by the automobile manufacturer (OEM). Both teams report to the same manager two levels up. The supervisors of both teams are committed to the process they are using, QFD or phase review, and are likely to have put considerable effort into using it to design the best possible product. (Their rewards are based on the new product's success, not on any process measures.)

Both components represented primarily applied engineering challenges, thus there was a strong engineering involvement, but little involvement by basic R&D. The other functional groups involved were marketing, manufacturing, and management.

Period of measurement. Communication was measured for one randomly chosen day per week over a period of 15 weeks. On measurement days each member of each team completed a form indicating to whom, about what, and how often he (she) communicated. (The measurement instrument and its reliability is described below.) Prior to the start of data collection, one of us met with each team to introduce the project and to instruct team members on how to complete the forms. Care was taken to avoid revealing any prior hypotheses to avoid any potential compromise to the comparison.

Threats to validity. The choice of comparable projects was under our control, but the assignment of subjects to treatments was not under our control. The team leaders selected the process they used. We selected the teams as the two most comparable within the manufacturer's organization and the best we could obtain from among nine participating firms, but there remains a potential self-selection bias[5]. We can not fully eliminate this threat, so we must be careful in any interpretation of the data.

Another potential threat is self-report bias -- respondents might forget communications or they might over-report communications in an effort to please the experimenter. Such biases should manifest themselves proportionally for both groups resulting in noise but not systematic bias in the *relative* comparisons.

A third threat might be the length of time of the data collection. The number of team person-hours expended in the fifteen weeks was a significant fraction of the development effort for these components and the observation period was during a critical stage of development, but the observation period was not the total development time. Development will continue until the components are integrated into an actual automobile. Thus, while we have not captured communications patterns over the entire development

[5]Thus, our comparison is not a true posttest-only control-group design (Campbell and Stanley 1973, design 6). Nor is our comparison a true nonequivalent-control-group quasi-experiment (Campbell and Stanley 1973, design 10) because the rapid adoption of QFD at the research site made it unfeasible to obtain pre-measures.

cycle, the fact that the two projects are in the same stage of development means that we can interpret relative differences for at least this critical stage of development.

On the whole we feel that, with careful consideration, the comparison provides insights into the relative patterns of communication as they differ between QFD and the phase-review processes. Perhaps our hypotheses will spur further academic-industry cooperation and further research on communication patterns.

The Measurement Instruments

We followed closely a method developed by Allen (1970, 1984). Prior to the data collection one of us visited the site to obtain the names and functions of each team's members and to define the topics about which they were likely to communicate. For simplicity these topics were divided into twelve categories within four content areas chosen to represent a balance between internal (design issues, business planning information) and external (customer needs, market information) topics. The topic list, which represents an expansion of Dougherty's categories, was judged representative of new product development information needs by the sponsor.

The instrument itself is a one-page form on which the potential communication partners are listed (by name) as rows. Communications topics are listed as columns. On each data-collection day each respondent completes the form indicating to whom, about what, and how often they communicated that day about the project. When a respondent communicates with someone not listed on the form, they indicate the person and their functional designation on blank rows of the form. After completing the forms, respondents mailed them to us; respondents did not have the opportunity to review previous responses when completing a new form. Our experience parallels Allen's in the sense that respondents found the forms easy to complete and felt that they provided relevant and accurate information.

Response rate. On the morning of each measured day, most team members[6] received a verbal reminder resulting in an overall response rate of 85%. There was a significant difference in the response rates between the teams -- 77% for the QFD team and 91% for the phase-review team, but we could find no systematic difference that might explain variations in the *patterns* of communication.

Reliability. We say that a response was reliably reported if person i reports communicating with person j **and** person j independently reports communicating with person i. Overall, respondents agreed with one another 94.7% of the time.

Because about 5% of the time the data for respondent i does not agree with the data for respondent j, the respondent-by-respondent data matrix will not be symmetric.

[6]Reminders were delivered successfully 94% of the time.

To obtain a symmetric matrix we computed a matrix of reliability-adjusted communications by weighting each reported communication by the respondents' overall reliabilities[7].

Table 2
Membership by Function on New-Product Teams

	QFD		Phase-Review	
	OEM	Supplier	OEM	Supplier
Engineering	2	1	2	1
Manufacturing	3	0	3	2
Marketing	0	1	0	1
Management	2	0	2	1

Group size adjustment. We are interested in the patterns of communication, for example, in whether QFD encourages more or less communication within the core team of marketing, engineering, and manufacturing. But if there are more (fewer) people within part of the QFD group, they may appear to have a greater (lesser) tendency to communicate. To be less sensitive to group size, we report the data on a per-person, per-week basis by dividing total reported communication by the number of group communication links. Table 2 reports the number of people with each functional designation.[8] Notice that while the two teams are evenly matched within the OEM, there are three more members on the supplier side of the phase-review team. To examine whether this affects the results, we report communication measures for the teams (OEM and supplier) as well as for the OEM only. Naturally, this difference in supplier-side team membership must be considered in any interpretation of OEM-to-supplier communications.

Results

Communication Networks

Figure 4 reports the observed communications links on a per-link, per-week basis for each team. Line widths are proportional to measured communication levels between functions while circle sizes are proportional to the communication levels within functions. In some cases there was no communication circle within a function, because there was one (or no) person in that function. We undertake formal comparisons below, but first notice two qualitative differences. The phase-review team is a more complex diagram with many more links and, in particular, more vertical links to management. On the other hand, the communications of the QFD team are more horizontal, perhaps circumventing the up-over-down communication through management for the more-efficient "across" communication within and between functions. We suggest below that this result holds even considering the lack of supplier management on the QFD team. Also note that both diagrams exhibit strong communications within and between engineers. This is natural for the portion of new product development that we observed.

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[7] If R_i (R_j) is the overall reliability for respondent i (j) and if C_{ij} (C_{ji}) is the reported communications from i-to-j (j-to-i), then the reliability-adjusted communications, C'_{ij} is given by $C'_{ij} = (C_{ij} * R_i + C_{ji} * R_j)/(R_i + R_j)$. Notice that $C'_{ij} = C'_{ji}$. When a respondent communicated with a person, k, not on the team, we simply weight that communication by the known reliability divided by the overall reliability, $C'_{ik} = C_{ik} * (R_i/R_{overall})$.

[8] If there are N_n members with functional designation n and N_m members with functional designation m, then the total number of links between those functions is $N_n * N_m$. The total number of links within a functional designation is $N_n * (N_n - 1)/2$.

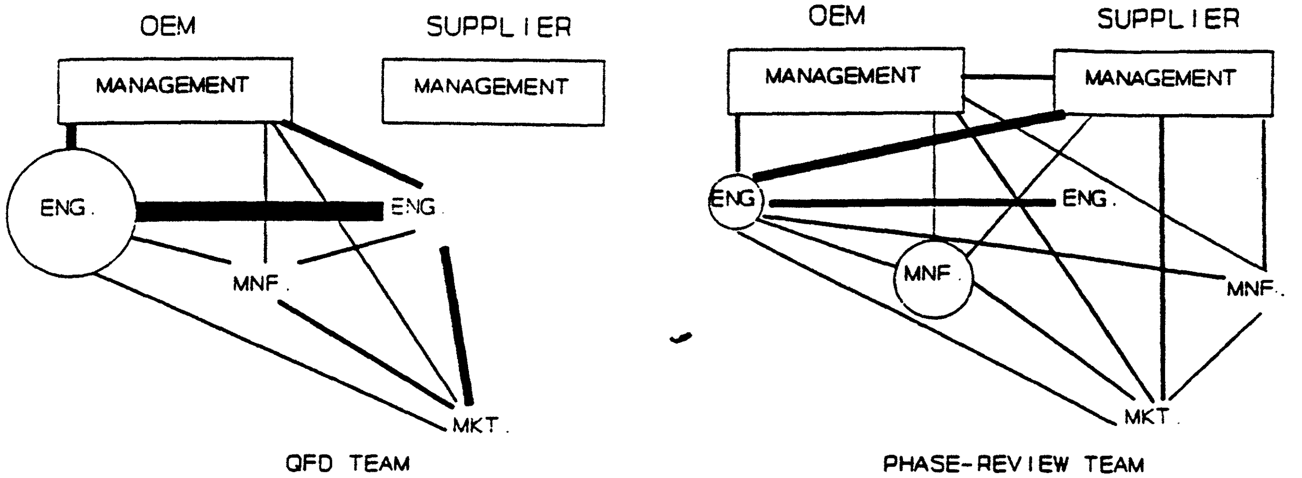

Figure 4. Graphical Representation of Communication Patterns (Line widths indicate levels of interfunctional communication; circle sizes indicate intrafunctional levels of communication. Some functions had one or no people in them.)

Formal Comparisons

Theoretically the greatest influence of QFD should be to enhance communication among the functional groups -- marketing, engineering, and manufacturing. We define the core team as team members from these three groups. As figure 5 indicates QFD led to more overall communication, more communication within functions, and more communication between functions. However, QFD appeared to reduce communication from the core team to management. Together these results suggest a picture of team members who talk directly to one another rather than through management.

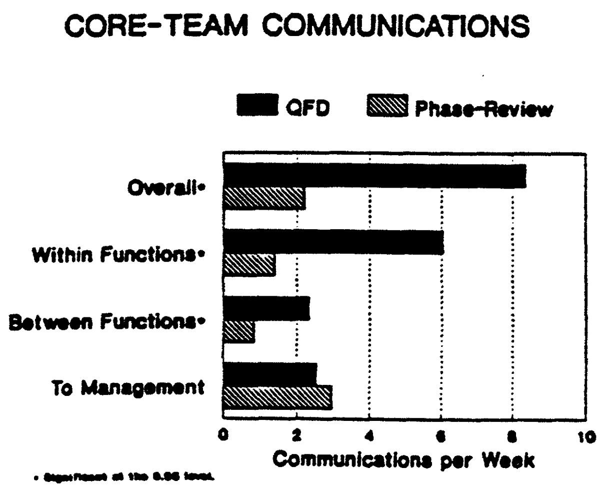

Figure 5
Comparisons for the Core-Team

Naturally team members may need to obtain information from other parts of the organizations. For example, a team engineer might find that his task requires input from an engineer working on a different component, say the interior light. We define the "extended-core" as team members in engineering, marketing, and manufacturing *plus* non-team members in these functional areas. To examine the sensitivity of the results in figure 5, we plotted communications for the extended core and, as discussed under the section on group size, for the core-team (OEM only). In general, the qualitative results were the same. QFD increases communications for both the extended core and for the OEM-limited core. The only difference from the results for the core team is that within the OEM, QFD seems to increase rather than decrease communication to management -- however this result is not significant.

Communication Across Boundaries

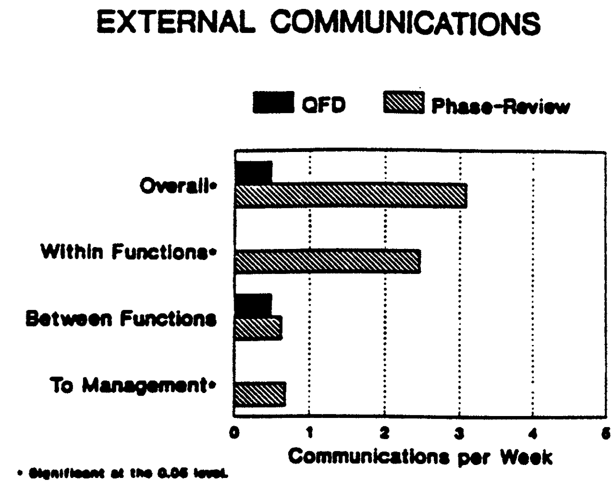

Figure 6
Communications Outside the Team within the Organization

Judging how much information should be imported into a new product team is an issue of balance. It is unreasonable to expect that all the information necessary to new product development will be contained within the team, even for experienced new product teams. Allen (1984), Allen, et. al. (1980), Baker, et. al. (1967), and Pelz and Andrews (1976) present evidence that the best sources for project information often are located elsewhere within an organization and that more successful projects tap those sources. Thus, we might be concerned if one team seems to be self-oriented and does not seek outside counsel.

On the other hand, Allen (1984) has also found that information sources outside the team are sometimes substituted for internal sources as personal risk-reducing strategies for team members. Thus we might be concerned if one team's communications are focused primarily on outside sources.

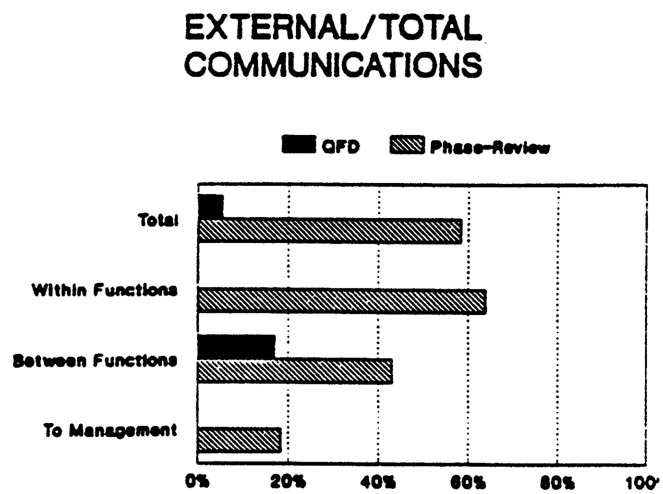

Figure 7
External as a Percent of Total Communications

As indicated in figure 6, QFD appears to reduce communication outside the team. If this is part of a not-invented-here syndrome (Katz and Allen 1982), then we have cause for concern and should seek to improve this aspect of QFD. If figure 6 means that the phase-review team is substituting outside information as a personal risk-reducing strategy, then QFD may promote more efficient use of internal information. Figure 7 provides some indication that this may in fact obtain, since over 40% of the phase review team's total communication is to personnel external to the project. Deciding definitively among these alternative explanations is beyond the scope of our data, but, at minimum, figures 6 and 7 raise interesting questions for future research.

In addition to team boundaries, there are also organizational boundaries between the OEM and the supplier. Because the component ultimately must be integrated into the automobile, we expect a good product-development process to enhance OEM-supplier communication. Figure 8 suggests that there is greater OEM-to-supplier communication (per link) for the QFD team than the phase-review team. However, as discussed earlier, we must interpret figure 8 cautiously in light of the fact that the phase-review team had more members on the supplier side.

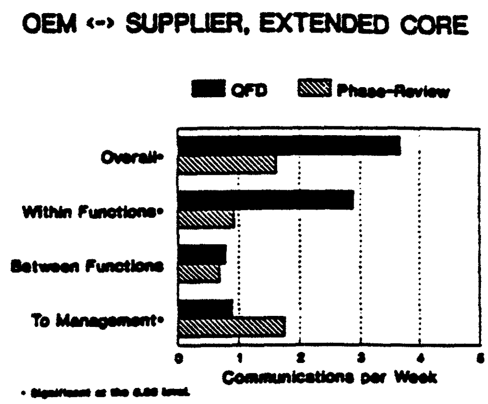

Figure 8
OEM-to-Supplier Communications

Types of Communication

Dougherty's (1987) research indicated that new products were more successful if communication covered a number of different topics. To examine this issue, we asked each team member to indicate the topic(s) they discussed. Figure 9 reports the number of times per week each topic entered a conversation[9].

Both teams focus primarily on design issues. This is likely due to the fact that our data collection took place in the early portion of the development process. Furthermore there is evidence (Hise, et. al. 1990) that communication on design issues is a correlate of new product success. While it is beyond the scope of our data to clarify which types of communication are most appropriate at which stages of the development process, we can, however, examine the differences between teams.

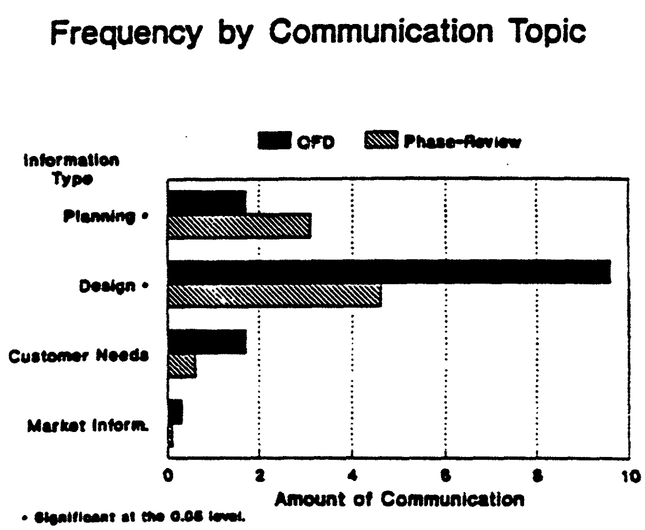

Figure 9
Team Communication by Content Type

On the major topical categories other than planning, the QFD team communicated more than the phase-review team. Even though the QFD team communicated less with external information sources, they discussed more information on external topics (customer needs, market information). This suggests a hypothesis that QFD enhances the efficient use of internal communication links to spread information within the team. On the other hand, the phase-review team spent more conversations disseminating administrative and logistical information ("Planning") than the QFD team. This suggests a greater administrative

[9] Due to multiple topics per conversation, total weekly topic counts are larger than the total number of conversations per week (figure 5). These results would be comparable to Dougherty's measures if these patterns hold up for the lifetime of the project.

overhead associated with the team using the phase-review process. It is consistent with the greater management involvement hypothesized earlier.

Summary of Results

When we put together the results summarized in figures 4 through 9, a picture begins to emerge of the QFD team. QFD appears to encourage the team to become more integrated and cooperative, but perhaps more inward looking. There is more communication within the team (figures 5 and 7), even when the team crosses corporate boundaries. Furthermore the team seems to be more self-sufficient, solving their problems through horizontal communication rather than through management (figure 5) or by seeking information within the organization but outside the team (figure 6). Most importantly, this new pattern of communication appears to increase team communication on all non-administrative aspects of new product development (figure 9).

If we are to believe the body of literature cited earlier, this enhanced, more-efficient pattern of communication should lead to more successful new products and break down some cross-functional barriers. However, we must face the issue of a decrease in communication outside the team. If this decrease results in a siege mentality it could prevent the team from obtaining relevant project-related information available elsewhere within the organization. On the other hand, if this decrease simply reflects QFD's ability to tap internal information more effectively, it may be an advantage of QFD. Future research may decide this issue, but in the meantime QFD implementors should be aware of this potential caveat.

Discussion and Future Directions

Communication within and between functions enhances new product development -- the scientific evidence is strong. American industry has a strong interest in QFD -- the large number of adoptions can not be dismissed lightly. But is QFD effective, at least to the extent that it enhances communication?

This paper represents the first field comparison, to our knowledge, of QFD and the traditional phase-review product-development process. We selected the best set of matched groups available and used equivalent communication measures for each group. Our design does not allow us to rule out unobserved group differences, but our knowledge of the groups, our interviews with the sponsor, and our experience observing almost 40 QFD projects leads us to believe that the effects we measure are real.

Furthermore, if the effects in figures 4 through 8 are real, they have profound implications for the firms adopting QFD. The results suggest that QFD leads to greater horizontal communication that, hopefully, provides new product teams with the information they need. This effect holds for the core-team, for the extended core team, within the OEM, and for OEM-to-supplier links. QFD also allows management to delegate in the sense that less information need flow through management. The only concern seems to be the degradation of communications external to the team -- a concern that warrants further investigation.

Future Directions

There are many possible directions for the future. Beyond replication we hope to identify sponsors willing to consider a quasi-experimental design that includes pre-measures prior to the adoption of QFD and/or a field experiment in which teams are assigned randomly to QFD. Given the large amount of corporate interest, such designs may prove feasible in the future.

We must also consider the impact of QFD on new product success. As more experience is obtained with QFD over the next five years, correlational or experimental studies might be able to link the adoption of QFD to output measures such as sales, success rates, reduced costs, or reduced time.

Finally, the issues of OEM-to-supplier links (not fully answered in our comparison) and the degradation of external communications are important to new product design.

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