THE EXPANDING FUNCTIONAL INTEGRATION OF MANUFACTURING

by

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ABSTRACT

This paper looks at the historical role and status of the Manufacturing function in its relationships with the Design Engineering and Marketing functions in three major minicomputer companies. The focus of the study is how Manufacturing's role and status have been affected by the recent change in the character of the minicomputer marketplace from rapid growth and light competition to modest growth and more intense competition. Information was collected through a series of interviews with Manufacturing executives in the three firms, conducted by the author in the spring of 1983.

It is observed that these companies' organizational structures have always been "market-driven", i.e. they emphasize only those skills required by the market they face. Two of the firms, which expanded during the early rapid growth phase developed organizations where the status and influence of Design Engineering was quite high and that of other functions including Manufacturing was quite low. The third firm developed later when competitive pressures on new entrants required superior competence in several areas including such things as fast delivery, reliability and price, which are largely the province of Manufacturing, while placing less emphasis on absolute technological leadership. This environment resulted in an organization where Manufacturing had higher status and played a larger role in final product design. All these firms were observed to have relatively dysfunctional Marketing/Manufacturing interfaces, which resulted from a variety of environmental conditions which made dependable market forecasting and scheduling operations difficult but also less necessary.

The more intense competition of the 1980s, faced now by all firms, is seen to place a premium on efficient manufacturing in particular and on multiple competencies in general. Thus the two older Engineering-focused firms have had to undergo substantial organizational change in expanding the integration of Engineering with Manufacturing and Marketing. The third, newer, firm has also had to revamp Marketing relations, while finding itself with a fairly well-adapted Engineering/Manufacturing interface.

(continued)

Given observations by industry executives that markets facing the minicomputer industry will only remain intensely competitive in the future, a model is presented of a combined Marketing, Manufacturing, Engineering management structure that should result in superior performance in adapting and serving future markets. The general model suggests the more specific notion of a "focused organization" analogous to Wickham Skinner's "focused factory" notion. This is used to suggest that firms split themselves into divisions serving cost, reliability and delivery-based markets and pure technological-sophistication-based markets, with different Engineering/Manufacturing organizations for each. It is noted that in both types of organization, Manufacturing plays a much more influential role and that the era of the low status Manufacturing function is probably gone for good.

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0 INTRODUCTION

0.0 Introduction

If the Sixties was the era of salesmanship and the Seventies the era of portfolio management, then it is beginning to look as if the Eighties is becoming the era of manufacturing. Across a wide range of industries one sees corporations discovering, sometimes "suddenly", a) that their manufacturing operations are much less efficient than desired, b) that manufacturing has become one of the primary variables at the margin between breaking even and not and c) the meaning of the idea of "manufacturing as a competitive weapon."

This new emphasis on manufacturing operations inevitably alters the organizational intercourse between Manufacturing and other functions -- especially Design Engineering (which determines what is made) and Marketing (which handles how many and when). This thesis surveys three companies in the minicomputer industry and their experiences with adjusting to their (re)discovery of the manufacturing function. The three tales which form the bulk of this thesis were derived from a series of interviews conducted by the author with various manufacturing executives in the three companies. As usual, the corporations will be disguised to protect the innocent from editorial misinterpretation or executive candor. I have chosen city names from my native Pacific Northwest, generally reflecting the comparative scale of the firms, along with the official airport codes of those cities for convenient abbreviations.

The three firms constitute a good span of the industry in both scale

and scope. Seattle (SEA) is our largest company, producing a full line of minicomputers and peripherals. Portland (PDX) is about half the size of Seattle and produces a wide-spanning but less full line of minis and peripherals. Eugene (EUG) is, in turn, about half the size of Portland and produces a limited number of more general purpose minicomputers and (until very recently) no peripherals. They also represent a span in age, SEA being founded in the late Sixties, PDX in the early Seventies and EUG in the mid-Seventies.

This span in age will prove important. We will see that the organizational structure and culture at the two oldest firms, SEA and PDX was fundamentally affected by the rapid growth and very light competition of the era in which they were first formed, while the structure and culture at EUG was equally fundamentally based on the tight competition it faced entering the market in a later period. That competition largely consisted of older firms like SEA and PDX who represented tougher competition to little upstarts like EUG than to each other. Thus EUG developed a product engineering system suited to tighter competition which served it well. The success of a number of younger companies like EUG eventually resulted in SEA and PDX in turn facing tough competition for which their organizations were less well suited. We will see, below, the various adaptations being undertaken by SEA and PDX in response to this new competition and will conclude that eventually they may want to develop a structure even closer to that of EUG (who after all grew up under tightly competitive circumstances).

0.1 Changes in the Market

The primary concept relevant to the analysis of the cases is that of manufacturing mission as discussed by Hayes and Schmenner.[1] Since a production system can't do everything for everybody, intrinsic to its design is some more narrow "mission" which excels in one area at the expense of another; this is intrinsic even if no conscious decision has been made. Different missions suit different marketplaces and/or different strategic approaches to a marketplace.

Similarly, organizations are also manufactories, of ideas, product plans and actions. Their "processing layout" implicitly embodies an organizational mission linked with their organization's functional mission. Two primary qualities of organization "layout" as described by Lawrence and Lorsch[2] are integration between functions and differentiation among functions. So we have market needs, a functional mission to address those needs in some way, and an organizational mission to in some way foster the execution of the functional mission. Each are obviously linked, so that when the market changes (or one's attack strategy changes) the functional and therefore the organizational missions must also change. Yet they are not fused, so there are lags and frictions in getting each to respond and adjust to the prior one. In the instance of the minicomputer industry we find that the current and projected marketplace has changed substantially from that in which these firms grew up, with the recession of 1981 and 1982 only amplifying the trends and rendering 1980 a convenient watershed point -- hence my use throughout of the term "the Eighties" to refer to this new environment.

In the Sixties and Seventies the two qualities needed to survive and prosper in the explosive minicomputer market were volume and technology. Without technology there was no volume, so design engineering ruled supreme at most companies in this period, helped by the fact that most corporate founders were engineers themselves. It was felt that it was tough enough to maintain a technological leg-up on the competition and further the state-of-the-art fast enough, without cluttering up engineers' minds and product meetings with concerns over the finer points of manufacturing. Without technology there was no volume, but with technology (and adequate salesmen) you had to fend off customers; so the primary manufacturing mission was to never mind what Engineering was up to and just cope with volume demands, cranking out reasonable facsimiles as fast as possible.

It is generally true that first-time buyers of new technology are interested in playing with the technology themselves for particular custom applications[3], and in this period there was little track record for determining "standard configurations". Hence companies in this period offered a very wide variety of models, options and other permutations to cater to tastes not yet sorted out. This resulted in more of a job-shop kind of manufacturing process in many of the firms.

When your primary mission is to "crank it out" in a job-shop environment alot of traditional manufacturing concerns become irrelevant. Inventory control, for example. With so much overall growth yet such volatile tastes one would miss valuable market opportunities trying to tightly manage inventories. Also, even if your current processing might be viewed as generating "excess" inventories one's booked revenue is

running far enough ahead of the inventories that one remains pretty solid financially. Similarly with capacity planning. The worst thing that can happen in high growth situations is to let capacity lag too far behind sales[4]. So you buy capacity all the time. SEA had a program of automatic continuing capacity purchasing: "if they don't need it now they'll need it in eight months." Similarly with cost-containment and quality control. It cost more to worry about cost containment than to be liberal. Additionally and fortuitously in the minicomputer business, in this period costs were declining and quality improving enough to satisfy the marketplace through componentry improvements and gratis process changes so that belaboured process management was unnecessary. Finally, with some huge amount of growth certain and so much specific volatility the fact that marketing forecasts were usually quite wrong was also unimportant. Marketing was usually over-optimistic about sales force effectiveness and uniformed about capacity effects, while Manufacturing's own extension of historical trends was usually as close as anybody's. In summary, Michael Porter notes: "in many emerging industries the pressure to develop (markets) is so great that bottlenecks and problems are dealt with expediently rather than as a result of (traditional) analyses."[5]

For the Eighties all of this is changing. Indeed the current and forecast market for minicomputers has come to take on many (though not all) of the generic characteristics of a "transition to maturity" market described by Porter.[6] First, the era of explosive growth in the minicomputer market is waining. Growth previously in the 40% to 60% range annually is projected to decline to only 20% to 25% annually.[7] The period of fast growth eventually attracted a sizeable number of companies

to enter the market either as broad producers (SEA and PDX), moderate-width producers (EUG) or niche companies. Now, as predicted, "with companies unable to maintain historical growth rates merely by holding market share, competitive attention turns inward toward attacking the shares of others."[8] This means that in many minicomputer lines the old seller's market has become a buyer's market. One analyst notes that SEA is still selling all of a particular line that it can produce. True. But they aren't expanding capacity and to maintain capacity sales they are having to make price and contractual concessions that wouldn't have been considered a few years ago in order to stave off substantially smaller competitors. An executive at SEA commented: "we are feeling solid competition from (¼ their size) EUG." The recession has amplified this effect, reducing annual growth for our firms from 40% to 90% in the latter Seventies to 9% to 18% in the past three years. During a "transition-to-maturity" period "industry profits often fall, sometimes temporarily and sometimes permanently."[9] Indeed, another industry executive has predicted that continuing "niche wars" will keep earnings lower than traditional throughout the 1980s.

Further, "firms in (a maturing) industry increasingly are selling to...increasingly knowledgeable and experienced repeat buyers."[10] In minicomputers, this growing experience base means that tastes are finally consolidating around a more limited number of standard configurations. On one line at PDX I was told that "where we used to offer six subtle gradations of memory size we now offer just three major jumps." This allows firms to employ more streamlined and automated mass-assembly processes as well as modular final testing (eliminating the need to

gather an entire system together in-house and test it). Both of these substantially reduce needs for capacity and buffer inventories and increase ease of quality control, but to convert to this requires substantial effort and expense.

Also, customers have learned the meaning of "life cycle cost" and have been told to expect mean-time-between-failures on the order of five to six months at just about the time that firms have been discovering that the fully-burdened cost of a field-service call is about $300/hr. All of these above things, slower growth, more knowledgeable and finicky buyers, hotter competition, imply, as Porter notes, that competition will shift towards price, cost, quality and service.[11]

Porter continues: "this development shifts the requirements for success in the industry and may require a dramatic reorientation of the 'way of life' in a company used to competing on other grounds."[12] (emphasis added) Pertinent to this thesis, Porter notes that the "relative importance of process innovations usually increases in maturity as does the payoff for designing the product and its delivery system to facilitate lower-cost manufacturing."[13]

For our cases all of this means that the manufacturing function can no longer afford being slighted by both design engineering and market forecasting. The economies demanded by the competitive market go beyond those obtainable from components or by tidying up current manufacturing procedures. The savings available from more easily or more automatically assemblable or more easily testable designs, the savings available from fast raw material turnover, accurate scheduling, and more even flow-through, these need to be tapped to the fullest measure. Porter points

to Lawrence and Lorsch when he notes that "the organizational transition required to cope with industry maturity may also involve a different structure and different focal points for the key managerial systems."[14] That is, closer linkage, closer integration of the personnel and the missions of these organizations in order to permit the functional and corporate missions to be achieved. We now turn to the tales of our three companies to see how their organizations have coped with having their missions and focal points changed on them.

1 DESIGN ENGINEERING

1.0.0 Introduction

I have chosen to look first at Manufacturing's relationship with the design engineering function. This is undoubtedly the most complex and perhaps the most consequential interface of the Manufacturing function in the minicomputer industry. Both functions involve a complicated task and are under great pressure for high performance; Engineering is driven to achieve breakthroughs in advancing designs already at the limits of knowledge while Manufacturing is required to build these products quickly and in great and rapidly expanding volume as cost-effectively and defect-free as possible. Each function has rather separate core responsibilities, operates with substantially distinct bodies of knowledge and realms of expertise, and (as noted just above) has plenty of challenges within its own province to keep it well occupied. These qualities of organizational and behaviorial division and focus of labor are referred to by Lawrence and Lorsch as differentiation, meaning simply that the groups are somewhat specialized and distinct. They describe the high-technology environment as requiring high differentiation, meaning that the demands on functional performance are intense enough to require a high level of division or distinction of labor and of specialized expertise among functions. (An example of low differentiation might be a tiny architectural office where each architect does everything from sharpen pencils to designing landscaping to preparing service contracts.)

Lawrence and Lorsch also refer to integration, which they define as

the quality of interdependence, need-to-know, and process of achieving unity of effort among different groups. Again they describe the high-technology environment as requiring high integration. The pressure on Engineering is to design very high performance machines which, however, will not perform highly unless they are well-built; Manufacturing is pressed to build machines reliably and swiftly which is substantially easier if their design is conducive to easy assembly. (An example of low integration might be a low-tech plastic doll firm where it makes no difference to the production people as to whether Smurfs or ETs are specified so that their role is "not to reason why but to do or bye".

The intensely focused and specialized attentiveness of high differentiation appears contrary to the requirements of highly interdependent need-to-know. Lawrence and Lorsch's study -- "Differentiation and Integration in Complex Organizations"[1] -- was an attempt to discern how organizations manage to achieve these states simultaneously. I will be using their descriptive framework as my framework for the analysis in this chapter. Underlying some of the forthcoming descriptions is the concept of "environmental certainty". They define this as a combination of rate of change of environmental conditions, certainty of information on the environment at a point in time, and time span of definitive feedback.

They perceived that the Engineering environment was least certain due to relatively uncertain information on new components in development, the rapid rate of change in the state-of-the-art which might obsolete designs before they are finished, and the long delay in definitive feedback -- success is only assured after a project is totally finished.

Marketing was also liable to be "uncertain" due to the capricious nature of high growth markets. Manufacturing was seen as much more certain because process performance could be accurately measured and feedback on costs was almost instant. I have been told that this characterization of Manufacturing is less accurate in the minicomputer industry than in the chemical industry studied by Lawrence and Lorsch.

They chose a few particular organizational attributes as a basis for characterizing a firm's susceptibility to high levels of integration and differentiation (or specialization). First is formalization of structure. They suggest that systems operating in conditions of higher uncertainty will be less formally structured.[2] According to the rough characterization of functional uncertainty above we might expect therefore the design engineering staffs to be less organized than the staffs in manufacturing, presenting possible problems in integration. Indeed, at PDX, we will find multiple design teams competing for the same project. Who should Manufacturing have intercourse with in such a case?

Another attribute is the socially ingrained pattern of interpersonal communication and emotional identity which is referred to in the paper as "task orientation". Lawrence and Lorsch suggest that when the functional environment is characterized by high levels of uncertainty personnel will tend to focus their attention and pattern of interpersonal communication on the overarching goal of accomplishing the task of their functional group, whereas moderate levels of uncertainty will lead to broader "social" and/or integrative subjects of communication.[3] Again, Engineering, as the driving force behind our minicomputer companies, the most "uncertain" field, and discipline of their founders will tend to be the most "task-oriented" or parochial of the functional departments,

whereas Manufacturing can afford to take more interest in other departments, such as Engineering. A third attribute, which did not come out explicitly in my interviews but surely is a backdrop to all that was discussed, is time orientation. Are people short-term or long-term oriented? Lawrence and Lorsch claim that it is generally in the nature of Manufacturing that, even if the staff constantly directs its mind to long term matters, the results of production activities are immediate and immediately visible and often immediately assessed in evaluations whereas (as noted above) success or failure of Engineering efforts is often determined in more distant periods. While there are countervailing tendencies in both functions, there has remained a certain difference in functional time horizon which could, if only subliminally, affect the ease with which functional integration was accepted and furthered by each group.

Finally, the two scholars propose that in situations demanding high differentiation and high integration, separate "integrative subsystems" will tend to emerge to manage and exploit these basically opposing forces.[4] Once the need for integration is recognized and integration is sought after, Lawrence et.al. suggest (at least four relevant) "determinants of effectiveness". First, "that the orientations of members of the integrative subsystem should be intermediate between those found in the subsystems they were to coordinate."[5] A second point, also noted by Tom Allen[6], is that "integrators whose influence stemmed from their professional competence would be more effective than those whose influence was based on their position in the organization."[7] Third,"effective integrators (should) perceive that they are being rewarded (explicitly) for the achievement with others of a superordinate goal."[8] Fourth, that

the locus of influence reside at the appropriate level in each of the subsystems to be integrated. They predict that design engineering decision-making should generally be done at fairly low levels in the Engineering staff, whereas the locus in the manufacturing area should be (fairly) high.[9] An industry executive in another firm suggested to me a fifth determinant -- that the previous four receive the visible blessing of top management.

We will now be looking at how the historical environment of our firms influenced the character of those "attributes" noted above and how the adaptive steps they are currently taking address these "determinants of (integrative) effectiveness".

1.1.1 Originally, at PDX

Historically, the least structured organization among our three companies has been that of PDX. It was begun in the early Seventies by a collection of aggressive computer engineers with a focus on building minicomputers of very advanced design. At that time, the marketplace was lightly populated but technology was beginning to move more swiftly. Naturally, aggressive R&D and design engineering became the primary mission of the firm, while its small size suggested that the locus of engineering management remain in the upper levels of management. The result was an organization with very high differentiation; one highly disaggregated into small project modules, each substantially isolated by complex "internal confidential" restrictions. Engineering not only maintained exclusive sovereignty over projects virtually until the initial procurement stage but indeed there were often several duplicate

product engineering teams competing over final development rights for a product. Each team would constantly claim that some other group -- marketing, another team, manufacturing, etc. -- should not catch word of their work yet, or else the design would be screwed up, or another team would gain advantage, or unsuitable political alliances would form or something.

One of Manufacturing's earliest encounters with a product was when it was presented to the Manufacturing Engineering Group, largely fait accompli, for them to determine how to assemble in quantity and fabricate six or eight sample-builds. This process often involved some ad hoc design adjustments which were done with relatively little feedback to Design Engineering. When the Manufacturing Engineering Group was done, they presented their fait accompli to the actual assembly plant which was to produce it and they, in turn, "would end up changing things they didn't like."

It is claimed that the Manufacturing staff at that time, particularly at the plant level was not terribly knowledgeable in matters of computer engineering. The designers, for their part, were not very cognizant of manufacturability issues nor were they guided in that direction since it was not a priority in the earlier years. In the simplest sense it is correct that "Engineering has always been held responsible for product cost." But in the Seventies, just as customers often looked at the list price only, so also the system engineers looked rather narrowly at simply component menu price summation. For example, a PDX manufacturing executive explained that given a choice between two IC components, one of which cost 7¢ more but had a higher yield or higher lifetime reliability, Engineering would always pick the lower quality one to "save on product

cost."

As expected, high task-orientation and the very loose structure in Engineering did not foster integration. Between Engineering's narrow view of and light emphasis on produceability or testability and Manufacturing's lack of technical acumen there were engendered various degrees of cross-functional tension ranging from "irritations" to "animosity" to "nearly open warfare". Reflecting this, the Vice Presidents of the respective functions were rather parochial in background and outlook and hence had a chilly relationship. Additionally (and this is often typical of high-tech companies, especially young, expanding ones) the VP of Engineering was clearly a member of the corporate inner circle while the the VP of Manufacturing equally clearly was not.

PDX's emphasis on survival-of-the-fitest engineering paid off in a number of industry breakthroughs, an excellent technical reputation and a fifteen-fold increase in sales over ten years. Their growth plus a policy of vertical integration resulted in an almost burdensome expansion of Manufacturing's province to fifteen facilities in the US and overseas. The effects of non-integration with manufacturing plus go-go production, initially trivial as presented in the introduction, over time began to become noticeable. Product introduction delays (though minor) had been expanding. Testing and rework were increasing. Inventories had been becoming an expanding percentage of sales: 16% in 1974, 27% in 1976, 32% in 1978. And there were those "tensions" and "animosities".

So, when the Eighties change-of-life hit, it hit PDX hard. Traditional 50% to 60% sales growth dropped to 15% in 1981 and 9% in 1982. Inventories ballooned to well over 40% of sales led by a 110% increase in work-in-process inventory. Operating incomes, typically in the range of

25% of sales dropped to under 10% in 1981.

1.1.2 PDX Change

Such declines usually produce soul-searching. The initial soul-searching indicated that indeed the required corporate (including manufacturing) mission had changed and was no longer congruent with the company's organizational mission, virtually unchanged since founding. When an alteration in organizational mission seems called for it is common for change to begin at the top -- even before the full extent of the thoroughgoing change is determined. This reflects the earlier observation that one needs top level acknowledgement and validation to help subsequent changes take root. At PDX, the perceived need for more communal effort was acknowledged first by the appointment of new Vice Presidents of Marketing, Manufacturing and Engineering, each designated as equal members of "the inner circle", each with a conspicuously multidisciplinary, broad background, and each conspicuously liking and respecting one another. Pertinent to this thesis, the new VP of Manufacturing was a former engineer who understood the exegencies of the creative design process as well as the current frontiers of production processes.

As they perused the contemporary situation and its need for increased functional integration while maintaining individually strong functions (differentiation), they perceived in PDX most of the problems identified by Lawrence and Lorsch. PDX had no "integrative subsystems". They felt integration had been impeded by the notably lower calibre and perhaps shorter time focus of their manufacturing staff in comparison with their engineering staff. A PDX executive noted: "we had pushed this

loose, scrapy thing about as far as it could go and now had to become a more professional organization." Most engineering decisions were still, as of old, made by upper management, while manufacturing influence was seen as too disperse -- both allegedly "inappropriate" loci of influence. And the redundant project teams did complicate communication efforts with Manufacturing.

The following presentation of remedies is ordered to follow the preceding exposition but should not be construed as indicating a chronological or causal sequence as they really have been happening all together over a period of time.

To fulfill the need for integrative devices a new office of Manufacturing Planning was established and took on a number of functions of a more corporate strategic nature. The office administers two inter-functional disciplining instruments -- the manufacturing/business plan and the product life-cycle plan. The manufacturing/business plan is undertaken by the Manufacturing Planning office the moment a new product moves beyond the idea phase. An all-points-bulletin is sent out to Marketing, Purchasing, plant managers, Finance, etc., seeking their assessment of the product's possible impact and ramifications as far as can be determined at such a hazy stage. As the product concept and then hard design become clearer the plan is updated on a continuing basis. The product life-cycle plan considers a longer time frame yet with more focus just on Manufacturing impacts. The Manufacturing Planning office is responsible for standardizing all assumptions and forecasts and for being a clearinghouse for all cost, volume, compatibility and capacity estimates. Expanding upon these efforts has been the establishment in the product development process of formal, regular review meetings

involving all the various design and various manufacturing functions -- reversing the "internal confidential" regime and instead trying to let as many groups as possible become involved in new products.

A number of steps were taken to upgrade the technical skill and reputation of Manufacturing. The Manufacturing Engineering Group was partially decentralized out to individual plants to build up their knowledge of design manufacturability issues. The general staff were trained in technical matters. Special efforts were made to particularly expand the engineering expertise in the central staff and the Quality Assurance Group. A new Future Factory Design group was established. This group not only serves to in fact keep PDX in the forefront of ever more precious process innovations (recall Porter) but also to expand the time orientation of the overall functional organization and to (by virtue of being itself very high-tech) raise the estime of Manufacturing in the eyes of Engineering. Additionally, recruitment efforts were sharply increased to seek, at the operational level, highly trained engineers who could be induced (see below) to make a career in manufacturing and, at the managerial level, experienced industry executives plus superior new MBA stock.

Rotation of would-be design engineers through a tour of duty in manufacturing such as recommended by some industry executives and practiced by the Japanese is not being considered at PDX. A manufacturing executive there explaind "hot shot circuit designers (or whatever) simply do not have the patience to spend months or years in manufacturing...and that's probably all right. What you can do is get equally sophisticated engineers of broader aspirations and sell them on careers in manufacturing." He continued that this is made much easier by the

rapidly increasing complexity, and hence attractive technical challenge, involved in robotics and automation as well as by the strokes received by being part of a function now recognized and rewarded as a primary strategic activity rather than a thinly suffered necessity.

Continuing down the list, the issue of influence loci was addressed. The Manufacturing Planning office added some higher level control in Manufacturing while in Engineering product decisions were moved from upper management down to lower echelons. And finally, the product development redundancies have been eliminated which (among a host of other benefits) has noticeably helped clarify and strengthen the communications between Engineering and Manufacturing.

So far, PDX is pleased with the results. They have found that "the designers really can accomplish alot (re: integrating manufacturability needs) if you're just able to feed them complete information and they'll accept it." For example, following up the product costing example given above, Engineering is now required to consider full delivered and life-time costs as the costs to be minimized; Manufacturing and Field Service provide data and advice and counsel on the value of a certain amount of increased reliability and the means for achieving easier serviceability. It is a slow process but PDX's most recent products have had somewhat improved manufacturability and the very most recent was introduced ahead of schedule.

PDX does not foresee development of a unified creative design/ manufacturability type of person. "There will be an increasing overlap but they are likely to remain separate." Organizationally, PDX sees that in the distant future Manufacturing and Engineering might in some way be

merged. One of the prime benefits perceived to a formal merger is co-location of functions. Emphasis is based on the benefits derived from physical propinquity,"seeing the environment that the other guy deals with and seeing day to day what is cooking over in the other function" "even if they do not report to the same people", benefits somewhat confirmed by studies of research labs by Tom Allen.[10]

In the near-term, PDX is planning to establish a more formal, thoroughgoing multiple phase project review system, whereby various project milestone check-points are established in policy, requiring specified inputs or agreements, with full multi-functional and higher executive meetings held at the shift-over points between major phases (such as final draft design, announcement-through-pilot-production, retirement, etc.)

PDX is also planning to transfer virtually all the functions of Manufacturing Planning, along with some from Marketing and Finance, to a new Corporate Planning office -- this addressing the point about having integrative subsystems with "intermediate" or superordinate orientations and positions.

1.2.1 Originally, at SEA

The Seattle company has always been more formally organized than the Portland company. Partly by virtue of the fact that by the early Seventies it was much larger and more vertically integrated than PDX at the time, and partly due to management propensities towards having structure, it had at that time already established a formal phase review system as well as formal engineering/manufacturing integration teams

(EMITs). The EMITs consisted of groups from Engineering and from Manufacturing who were assigned as sort of functional ambassadors to a project team and were responsible for handling difficulties, negotiating disagreements and signing off at all phase development steps. There were also new-product planning groups, which coordinated marketing assumptions and forecasts with higher systems-level product groups, developed transfer price/cost committments in conjunction with other SEA sub-assembly groups and their plants and developed configuration plans and assembly-facility assignment plans.

Laying within this rather formal framework, however, were many of the same characteristics of poor communication and functional isolation found in the relative anarchy of Portland. SEA: "it was hard to extract information from Engineering" "they did feasibility analyses off on their own or with limited consultation with individual palnts" "it was very hard to get Engineering to believe that there were other ways of doing things and it was very hard to get them to accept responsibility for asset management."

The reason that the EMITs were less than satisfactory is that lying behind the formal structure were the same environmental biases that influenced PDX. Seattle experienced markets with fast growth and light competition where technological prowess was everything. It was founded by a small group of brilliant engineers intent upon purveying state-of-the-art systems. So, again, the Engineering function became clearly the primary functional group and the prefered focus of corporate attention.

So, we find that the product management organization resided within Engineering, whose performance was, as expected[11], by-and-large not

measured on profit-and-loss but on swift introduction of pioneering designs. We find again that manufacturing was staffed with relatively less technically competent personnel. And, finally, the EMITs weren't even cranked up until well into the second phase of design work by which time many of the major design features had already been largely "agreed upon".

People within the company felt that the design engineers and manufacturing engineers down at "the front line" often had fairly decent rapport, generally had knowledge of the problems faced in the opposite function and were often inclined to provide assistance. However, natural inclination and functionally-based evaluation militated towards an increasingly parochial orientation among higher and higher managers among whom issues transformed into "matters of turf". Lawrence and Lorsch note that where "integrative subsystem" members "feel that their point of view was being given adequate weight by other groups (they) therefore would not feel hostility towards the members of other subsystems."[12] Such was obviously not the case where one side perceived great difficulty in getting the obviously annointed function "to believe that there were other ways of doing things" and "to accept responsibility for asset management."

And again in the fatter times of the Seventies, the emphasis on engineering paid off, with numerous technical advances, strong sales growth and an excellent industry-wide reputation. When the Eighties hit sales declined but not as severely as at Portland -- down from 35% to 45% annual levels to under 18% in 1982. However, between 1979 and 1981 inventories grew over 115% while sales grew under 75%, leading them to a percent-of-sales level of 46% versus a traditional level of around 38%

(the traditional level itself being the highest among our three firms). Operating income margins remained steady at 22%, although there are predictions of declines substantially below 20% for 1983.

Declining levels of reported customer satisfaction, increased complaints about deliveries as well as the troublesome inventory expansion noted (I am told that in particular segments the expansion was even more severe) suggested to the management of Seattle that perhaps indeed the required and extant manufacturing, organizational and corporate missions had grown out of allignment.

1.2.2 SEA Change

Happily there were some precedents at Seattle for possible adjustments. First, at the extreme, a few of SEA's highest-high-tech divisions, such as very-large-scale-integration chips had many years previously merged their Engineering and Manufacturing functions. At the frontiers of physical knowledge (such as VLSI) the product design and process design are mutually self-defining and interdependent, so the merger seemed self-evident and natural. Obviously in such a situation the "manufacturing" people should be just as highly skilled as the "design" people and should share professional respect. Also an adequately challenging mission for the team is simply to execute something workable so the orientation towards and rewards for manufacturing are just as great as for design.

Second, a special project in the latter Seventies tried a more integrative than usual approach. This project, admittedly a few steps back from the frontiers of physical knowledge, was nonetheless a major

technical effort with major corporate strategic consequences to develop a new vastly more sophisticated kind of machine. Apparently there were no edicts, no review sessions, no formal determination as such, but a number of parties to the project independently came to the conclusion that this was a project requiring extraordinary "care and feeding" and needed the nurture of minimum turf fights, minimum mental constipation and maximum cost effectiveness. So they endeavored to counteract the weaknesses alluded to just above. Against the sole-focus-on-Engineering and battles of turf, the concerns of Manufacturing (and other functions) were ordained as <u>important</u> and the engineers were encouraged to be both forthcoming and receptive to suggestions -- even though (or perhaps because) it was one of SEA's most difficult engineering efforts. Further against integrative problems, the EMITs were established fully at the inception of the project. And against calibre differentials, every group's "best people" were placed on the project.

As a result, much adaptation went on. For example, designers were persuaded to use new manufacturability-based designs such as handling configuration variability through optional "boxes" plugged in to a universal "plain vanilla" CPU rather than the then typical route of designing differently assembled CPUs. And overall, the product was developed for introduction more swiftly than previous such products and, importantly, had fewer reliability problems.

As it so happened the product was a <u>huge</u> success, both technically and financially. Somewhat surprisingly, the company-at-large paid little attention to the altered project organization involved; Manufacturing lauded its benefits to little avail until the impact of the Eighties sent people looking for alternatives more in earnest.

Changes at SEA came first at upper levels, as they had done at PDX, to signal to the organization that culture and mission were being altered. A new position of Vice President of Engineering and Manufacturing was established with reporting to him all of the manufacturing and engineering chiefs. Subsequently, in several divisions one saw the promotion of Engineering men into Manufacturing management positions, not to dominate but, as with the Vice President at PDX, to interpolate perspectives and engender more mutual understanding and respect between functional groups.

So far, this is not a functional merger. But a more thoroughgoing functional merger does appear to be on near-the-front burner at SEA. Such a merger would involve unifying management down several more levels but not all the way to the front line engineers. SEA: "there will always be twins, advising one another. You have to teach (designers) a fair bundle about manufacturability but at some point you run the real risk of undermining the integrity of the creative design function...of killing the art...if you try to do too much of the manufacturing stuff." However, having upper-middle and senior managers be dual-function serves the purposes of having "intermediate"-ly oriented integrators and of establishing jointly met superordinate goals.

SEA, apparently unlike PDX, does not emphasize the co-location aspect of merger and is not overly sold on ideas about the communicative advantages of propinquity such as those of Tom Allen.[13] SEA is seeking to decentralize more of design engineering out to the manufacturing plants or close to regional headquarters. But it notes that "you can be just as isolated as you want behind these partitions." "The main benefit of merger is having clearly one set of goals and incentives...and you do not need co-location to effectively achieve this."

Going beyond management changes, SEA has now pushed back commencement of the EMIT system to the very inception of all projects, and is trying to "encourage" more intimate and broad-ranging interaction between engineers and staff of other functions. Recognizing Lawrence and Lorsch's tenet that integrative devices are more effective when the integrators "perceive that they are being rewarded for the achievement with others of a superordinate goal"[14], SEA has "been talking about for years" and may now finally implement a reworking of their incentive bonus structure from one based on functional performance to one explicitly based (in some manner) on exemplary communal effort especially vis-a-vis the EMITs. Next on the agenda is folding in Field Service as a full partner in the design process (thereby creating ESMITs, I suppose).

Finally, addressing the problem of staff calibre, SEA, like PDX, is stepping up its manufacturing recruitment program and raising its sights in an attempt to attract more technically advanced personnel into the Manufacturing organization to help gain "influence by respected technical competence."

1.3.1 Originally, at EUG

In the smaller minicomputer company Eugene we find a firm which does not appear to have any severe manufacturing handicaps, is pleased with many (though not all) elements in its design engineering and manufacturing organization and claims that their organization is virtually unchanged since the firm's founding. This organization is notably different from structures found at Portland or Seattle; it combines elements of functional isolation and functional integration and places an atypical amount of responsibility (especially for the mid-Seventies) on the

manufacturing organization.

The Eugene company itself has developed along different lines than Portland or Seattle. The effect of its different development scenario on its different organizational structure I believe clarify the framework which I have so far been trying to establish.

While EUG has suffered its share from "the impact of the Eighties" analysts tend to agree that it is not so much due to manufacturing vicissitudes but due to poor strategic planning and product positioning. Looking at numbers, as EUG's sales growth rate has declined from a traditional average of 90% annually to 10% annually, inventories have remained at about the traditional level of about 22% of sales (lowest of our three companies) and operating margins have remained about level. The appearance of having been prepared (in a manufacturing sense) for the Eighties is largely correct, because from its unique situation and perspective it was already facing an "Eighties environment" for itself at founding in the mid-Seventies.

At that time the marketplace was more populated with competitors than when either Seattle or Portland began. Several firms, including PDX and SEA, had already established <u>their</u> reputation, infrastructure and customer bases as "major producers". So while they still preceived <u>relatively</u> lighter competition <u>among</u> themselves, little Eugene, from the outside looking in, as it were, saw itself already facing the stiff competition that the other firms felt only later on. EUG saw one primary way of attracting attention and sales (assuming adequate technical prowess) was by offering fast order response, very high quality and reliability and low prices -- all of which depend greatly (though not

totally) upon manufacturing.

Also, the make-up of EUG had a more financial cast to it. While there were the usual brilliant engineers among its founding fathers, there was also a venture capital firm with a significant stock ownership position (it still owns 20%) and one of whose partners was, and still is, Chairman of the Board. While some other minicomputer firms have had very little debt, EUG has been a highly leveraged entity with operations managed for high equity returns. Therefore (among many other things) EUG has "always had a very strong committment to maintaining a low inventory profile" and installed "advanced monitoring systems" while still in its infancy.

It is thus already apparent that the manufacturing mission at EUG would be constituted differently from that (originally) at PDX and SEA -- leaner, tighter, more continually cost conscious, more responsive -- qualities of "the Eighties firm" which PDX and SEA are now trying to become. One final element needs to be introduced to define the organizational mission behind the manufacturing mission.

EUG was founded not with the intent of being technical pioneers but with the intent of getting mileage out of advanced talents in system design and software. This was to be done by assuming responsibility only for those items and out-sourcing all else. Therefore, unlike SEA or PDX, EUG has very low vertical integration. The company buys virtually every component for its products, as many as possible off the shelf, a few built to specification. Until this year it has not manufactured peripherals at all. Therefore its manufacturing tasks were relatively limited and straightforward -- subassembly and CPU final assembly and test. For example, with 50% of PDX's sales volume, EUG operates with

only 35% of PDX's capacity. Also, low vertical integration makes its design engineering efforts and manufacturing interface efforts different. At SEA and PDX there is more latitude for custom layout. At EUG, the primary engineering contribution is in creative adaptation of standard components or designs. Therefore, EUG's engineering is more focused on cleverly thought-through system philosophies, circuitry schematic designs and type-of-component specification. Working with the Engineering schematics, vendor's specifications and knowledge of production processes, Manufacturing in turn becomes best suited to devise the most cost-effective specific layout (or packaging) of the specified circuits and components.

Reflecting these different contributions, the organization structure at EUG is an almost completely decoupled two department system. At the beginning, there is the research and design development group who take a concept from the concept stage through the schematic stage. At that point the project is completely transfered over to the Manufacturing Engineering group who are a part of Manufacturing. They finish the design work in drafting the optimal layouts, prepare the assembly documentation, interact with relevant vendors and in the end hand over the whole package to the particular manufacturing facility which will build the product. The teams who touch the project in design Engineering and Manufacturing Engineering are entirely different. The only continuous oversight comes from a vice-presidential level Program Review Board who evaluate on a continuing basis the project's marketability, manufacturability and potential profitability, as well as (at later stages) certain contingents from Marketing.

The split personality of EUG's developmental organization to which

I referred initially is that on the one hand, in the complete bifurcation of the design process we have the proverbial "wall" o'er which projects are thrown, typically to the great frustration of manufacturing. Yet unlike usual "walled" systems, at EUG the product project is "tossed over" not when 100% or 92% finished but when only 70% to 75% finished. For the remaining 25% to 30% of the designing process the responsibility lies wholly within Manufacturing, in effect, at that point, a complete merger of creative performance design and manufacturability and cost design.

In fact the essense of this system is that the "functions" have been redefined along a schematics versus packaging axis with performance and producibility concerns as merged as is relevant at each stage. So the fact that EUG, unlike PDX or SEA, dismisses the possibility of combining their Engineering and Manufacturing groups is not surprising because their missions are defined so that it is true when the executive at EUG says: "they deal in sufficiently different areas to justify keeping them separate." In the Lawrence and Lorsch language used earlier, Eugene has achieved subsystem differentiation in such a way as to sharply reduce (allegedly) the need for subsystem integration. The missions are focused and distinct enough so the required performance and departmentally-based incentives are fairly clear and effective. Given the larger hardware design (packaging) role given to Manufacturing, its people need to be roughly equally technically competent as the Engineering folk. Thus, EUG does not feel a need to "upgrade" its Manufacturing personnel stock from outside and will instead depend upon internal training and experience to provide the new and/or more advanced managers it will need in the future.

1.3.2 EUG Change

Not unexpectedly, EUG still sees room for improvement in its system and also possible problems. First, for a variety of complex and nebulous marketing reasons, EUG has determined that it must expand itself into peripheral equipment. Self-built terminals are due at the end of 1983 with other peripherals possibly following later. This means Eugene will be coping with more product complexity, more machine compatibility-needs, more technological diversity, integration and potential for customization, and more manufacturing diversity. As it develops into a "full" mini-computer company by moving into hotly competitive terminal and peripheral markets as well as the already competitive CPU markets, it may find itself running into the challenges faced by SEA and PDX, meaning that the problems of the Eighties may not have been predigested but merely deferred.

Perhaps the primary change being made specifically addressing this point is the planned creation of long-term Project Managers such as SEA had formally and PDX rather informally (both residing in the Engineering function, though PDX's may shift through Manufacturing Planning into Corporate Planning). This would be the first time at EUG that an individual manager lived with a project from conception to full production,passing back and forth through the Engineering/Manufacturing partition. This would permit more intimate participation and more focused responsibility than possible via the vice-presidential Review Board and address the point made at the beginning that current performance problems may stem from lack of product focus and management.

Further, Manufacturing has established a new department to lay between Manufacturing Engineering and the assembly facilities. This

separate Pilot Production Group is charged with bringing production processes for all new products up to rate before transferring them to the ultimately assigned facilities.

Finally, a new Productivity Office has been established to manage a whole slew of "fine-tuning" projects throughout Eugene's organization. Even here, it is interesting to note the balance striven for with regard to being kind to manufacturing. The Director of Productivity Programs made an explicit point that the focus of many if not the majority of such programs was not (as typically) on manufacturing assembly but on the design development process: "we used to lump all developmental costs (up to production) together and accept them (but) you know something like only 25% of the built cost of a product now is direct assembler labor. That upfront labor at the design stage is a critical factor now, maybe more critical than the production manufacturing costs."

2 MARKET FORECASTING & SALES

2.0.1 Introduction

In this chapter we turn to look at the other major function closely related to manufacturing in a corporation -- marketing -- the folk who ostensibly provide the why, wherefore and how much for both manufacturing and design engineering. In this region we find more similarity among our three companies because in each, as in most of the minicomputer industry, marketing forecasting has until recently functioned in a state of controlled anarchy.

The framework for this analysis comes from Benson Shapiro and his article "Can Marketing and Manufacturing Coexist?"[1] In it he begins with a generic list of potential problem areas which serves as a good outline for introducing the state of affairs at our three companies.

1. Problem area[2] == capacity planning and long-range sales
   Manufacturing complaint == why didn't we have accurate sales forecasts?

During the Seventies, with annual growth rates typically in the 60% to 100% range, most companies didn't bother to finesse the matter but just automatically and continuously bought capacity whenever they could find it. If it proved unneeded one quarter it would almost certainly be full in the next one. Most companies still found themselves hard pressed to keep up with demand, while few changes occured in processing to reduce square-footage requirements.

2. Problem area == scheduling and short-range forecasts
   Manufacturing complaint == we need realistic commitments and sales forecasts that don't change like wind direction.

In all three of our companies the sales forecasts were generally treated as little better than jokes or optimistic fantasia. At one company 40%

error was considered "pretty decent"; at another Marketing's prognostications were routinely discounted around 30%. Generally, manufacturing groups did their own, intrinsically more conservative, forecasts and only occassionally glanced at those from Marketing.

How can this happen? The considered wisdom is that there are two sources -- inappropriate motivations and the nature of the business (now changed).

The inappropriate motivations consist of lack of product management responsibility, few penalities and some rewards for ebullience. First, in none of our companies does Marketing manage the product line business. At EUG there has been no product management function aside from senior executives, while at PDX although product management technically lives in Marketing, the function, until recently, has also been executed primarily by senior executives. At SEA product management definitely resides in Engineering. The primary function of Marketing is to "generate new products, enter new markets and develop new programs" thus it is generally much "more sales-oriented than (cost- or)profit-oriented."[3] Furthermore, Marketing's rewards are directly and indirectly geared towards a mission of ebullience. Even while managers cynically discount forecasts, they also like being told that they have the greatest thing since... Noted one interviewee: "if Engineering blows it you maybe have an unworkable product or you wind up out of sync with the industry; the Corporation is at most up the creek, at the least, mortified, the President dumps all over you and maybe you're out. If Manufacturing blows it you not only have all of the above but you've probably misinvested millions of dollars. But if Marketing blows it, all they suffer is mild embarassment, everyone rolls their eyes and sighs." And

Marketing could always blame design or fabrication or the large variety of offered models and permutations which made accurate predictions very difficult.

The second point was that the nature of their fast growth market made sales forecasting very difficult. We have already noted the problems caused by configuration proliferation. Additionally, Jay Forrester[4] discusses a number of subtly complex feedback interactions between current and future capacity, perceived and actual backlogs, selling effectiveness and bookings which render unexpected actual sales. Marketing forecasting teams are often unaware of these effects per se or do not have close enough intercourse with Manufacturing to get the relevant enlightening information. As Forrester notes these basically all come down to recognition/communication/adaptation lags, which can blow up to having significant impact in high growth situations. Field sales is emphasizing, say, price and performance when prospects are really worried about your delivery delays. So as backlogs increase, sales decline, salesmen push harder and the few additional bookings garnered only increase backlogs further. Sales then really drop, but then backlogs decrease, so sales increase, etc., etc., etc. There are several other such destabilizing feedbacks that, if misunderstood, can make Marketing look silly and destroy its reputation.

Forrester observes that firms often try to short-circuit this problem by setting goals or forecasts based in some manner upon historical accomplishments. These generally are either neutral or make matters worse. Since Manufacturing tends to be a conservative function and its own primary database is prior production, the separate Manufacturing

forecasts noted earlier were just the sort of historically based forecasts Forrester indicated.

Overall, what companies did generally (given the luxury of the rich market) was simply ignore the problem and build to more abstract figures such as revenue projections or desires and simply absorbing the real variations through inventories or stock-outs.

3. Problem area == distribution

   Manufacturing complaint == we can't keep everything in inventory.

As suggested above, actually they did.

4. Problem area == proliferation

   Manufacturing complaint == why must we always offer options that are troublesome to manufacture and offer little customer utility?

   Marketing response == our customers demand variety

Well, who knows? Apparently, as noted in the introduction, the marketplace in the Seventies did seem to require many options and custom permutations. This resulted in a job-shop manufacturing set-up and in the great forecasting and therefore inventory difficulties noted above. Currently, it appears that as customers are becoming more acquainted with processing capabilities their desires are standardizing around a smaller number of variations. This should begin to help forecasters derive more predictable projections and help assembly plants have a closer link with what's really going on.

5. Problem area[5] == order flow

   Manufacturing gripe == we're always getting a big rush of "must be expedited" orders every so often (usually at the end of a sales quota period). Feast and famine is a terrible way to run a plant.

This problem was also usually ignored by running plants off of abstract figures and letting backlogs or inventories cushion the difference.

Obviously, the tight markets of the Eighties suggest that none of the above situations can be ignored or finessed any longer. As sales expansion slows, capacity growth needs will fall and with new automated production processes requiring significantly less floor space for equivalent output, absolute capacity needs in some sectors may decline. The need for maximum production efficiency with low inventories means that production must be more closely tied with field activity, but, at the same time, that field activity must be more "normalized" without (allegedly) contrived end-of-period booking rushes. On the other side Marketing needs greater information on the impact of manufacturing effects such as Forrester's feedback interactions both to aid factories and to refine their own selling techniques.

2.1.1 EUG Change

The most extreme response to the marketing dilemma is the case of the Eugene company which, in 1982, transfered the market forecasting function wholly within Manufacturing (and, in fact, allied with the inventory control group to focus on one of the primary issues of Eighties manufacturing). Prior to this, the Forecasting Group within Marketing would prepare its own estimate of what it simplistically* believed could be sold over various time periods and then presented this to the corporate management. Management then added its own considered opinion of the state of the economy and discounted Marketing's paid-for optimism as deemed appropriate. This revised version was then sent to

*i.e. not including the feedback effects

Manufacturing in order for them to add separately their projections of what was actually deliverable. This was returned to Management, who adjusted it, confered with Marketing, checked again with Manufacturing, and so on...

Shapiro suggests that the marketing/manufacturing dysfunction can be improved upon by: setting explicit policies on the sales/cost tradeoffs, modifying the evaluation criteria, and be expanding the mandated interdisciplinary horizon in the functional duties.[6]

EUG's merger accomplishes all of these tasks in one fell swoop. By making market forecasting part of Manufacturing, the group is able to become steeped in the concerns of various manufacturing groups and integrally confront the capacity, backlog feedback effects noted, thus accomplishing the expansion of interdisciplinary horizon and mandate -- EUG: "it gives the forecasts more credibility." Also, the group's natural enthusiasm is now partially checked by the fact that its evaluation is now done directly by Manufacturing -- EUG: "it focuses responsibility." And the ability to sort out and promulgate sales/costs tradeoffs is easier both because it is structurally "internal" and because the merger also resulted in physical co-location of forecasting and manufacturing. We have previously seen views pro and neutral regarding co-location. In this instance, EUG comes down very much on the pro side. EUG maintains that this new structure results in a forecasting function with orientation truely "intermediate", in Lawrence's sense, and not one now totally biased towards its functional overseer.

Back in Marketing, a special Strategy group has been established to "beef up" capabilities in intermediate and long-range forecasting as EUG's expanding product range will result in increasing complexity yet need for flexibility in capacity planning efforts.

2.1.2 Further Change

EUG is addressing the problem of factory scheduling from both the Marketing and Manufacturing sides. At Marketing, sales assignments are being altered to emphasize going after larger customers, who will tend to place orders with phased delivery (hence more production certainty).

At Manufacturing EUG is moving seemingly both towards and away from tighter field linkages. In the past, plants were driven primarily off of corporate revenue projections, modified a little by historical data and marketing forecasts. In an effort to balance inventory control with responsiveness, plants assembled the scheduled equipment (actually equipment groups) up through where the machines were about 60% to 65% complete and tested. At that point they were sidelined to await a specific sales request. Upon order arrival, the partials were brought out, differentiating subassemblies installed and tested and the final product shipped, all fairly quickly. Since EUG designed a great deal of compatibility between configurations, demand vacillations caused (allegedly) less of a WIP management problem than one might imagine.

The one side to EUG's proposed new system is the complete decoupling of assembly from sales by assembling 100% of a product without an order. The goal here is to promote more even production processing and flow-through -- a goal reinforced by now measuring plants on meeting monthly

rather than quarterly schedules. The counterbalance is the anticipated ability to adjust production schedules down to only ten to fourteen days in advance which would be done continually as sales trends demand. Several items support this end of the system. First, the more disciplined Manufacturing-based market forecasting "should" yield more accurate forecasts so that adjustments will be fine rather than gross. Second, new advanced manufacturing processes which are due to be installed should reduce required lags and work-in-process and render realistic the fourteen-day freeze horizon. Third, EUG's low vertical integration and multiple source catalogue procurement should give it an advantage in handling fine tuning without extreme inventory consequences. Finally, EUG is moving (as are SEA and PDX) towards sharply reducing the need for final assembly and test. Not only will individual machines be deliverable to site without final system assembly, but as techniques for designing-in self-testing advance, it is anticipated that individual subassemblies could be certified as acceptable and then shipped, along with "empty frames" to the customer site for consolidation. In general and particularly given the compatibility in EUG designs, the potential for direct subassembly shipment would give a different meaning to "100% assembly" with an inventory impact almost less than with the old "60% assembly".

Overall, the risks inherent in such a strategy are perceived by the management to be balanced by the closer control possible with EUG's limited number of plants and the furthering of EUG's competitive reputation for very short delivery lags.

2.2.1 Originally, at SEA

While Eugene took an extreme move with regard to its forecasting activities but made less severe, more adjustive moves with regard to its production/sales interfaces, Seattle engaged in a broader range of adjustive moves and emphasized development of an "integrative subsystem."

Forecasting at SEA for periods from zero to eighteen months was traditionally done by an office of a Marketing group organized by systems applications (laboratories, government, robotics, office, etc.) While a useful orientation for other purposes it only added another level of disaggregation and reaggregation in conversion to plant-specific forecasts. However, there was less pressure on plant-specific forecasts since broadly-equipped plants were able to tolerate ad hoc adjustments -- SEA: "there was a time when it was considered a good thing to shift load around amongst plants to keep them running evenly." One also knew better what one had to work with in shifting load because product-line production schedules were frozen up to nine months in advance.

Once again, at SEA, scheduling was driven by revenue projections and promises. Management enjoyed its reputation "on Wall Street as one of the most predictable of corporations." So they arranged to build and (due to the seller's market) sell exactly what they said they would. The path which booked orders took to the factory floor was a lengthy and circuitous one allowing room for reshuffling: "oh, there are all sorts of ways you can shift orders about in order to meet targets -- delays, speed-ups, renegotiation, substitution, etc. SEA's automatic capacity purchasing policy insulated against many of the pernicious effects of the Forrester feedback effects. Remaining vagaries were insulated by, on the

down side, inventories and, on the up side, by consciously restraining sales. This type of organizational focus (or mission) could develop at SEA because of the seller's market environment it faced until recently, whereas EUG, from its "later entrant" position had to be concerned with order response to gain competitive attention.

In the new environment now, SEA also is finding that "in the market now there just isn't time to play games shifting orders about", that "there was just entirely too much paperwork involved in the order flow" and that capacity decisions must now be analytical rather than automatic. Manufacturing is trying to reduce SEA's traditional burden of inventories -- "you, over time, have to massage all the buffers out of the system" -- and, as part of that, is moving towards even more focused factories with narrow stocks meaning that "we increasingly don't have the luxury of shifting loads like we used to."

2.2.2 SEA Change

In response we first find some of Shapiro's suggested top-down policy explication. SEA management has clearly stated that timely delivery of reliable products and accurate assessments of the pros and cons of the marketplace are high corporate priorities. It has backed this up with the establishment of a limited number of consolidated product management centers which act as clearinghouses for information relating to sales and production scheduling and thereby manage both the immediate bookings and the forecasting interfaces. The management centers are evaluated on the basis of the profit and loss incurred by the product assembly flow over which they have sovereignty. They therefore concern themselves explicitly

with the tradeoffs between sales and backlogs and costs, hence acting as Lawrence's intermediate-ly oriented integrative device and naturally enforcing upon their suppliers of data -- Sales and Marketing -- the broadening of interdisciplinary horizon suggested by Shapiro.

In order to engage the data process "as close to the ground as possible" the Applications team has been taken off forecasting and moved upstairs (noted below). For the immediate period of zero to six months forecasting is done directly by the field sales force reporting to the relevant management centers. For the period from six to eighteen months, the management centers receive forecasts from a new team in Marketing which focuses on the affairs of individual products or product sets in all markets (versus all products in individual markets, previously). The deproliferation of options and configurations of late has proved to be a great help to this forecasting group.

Long range forecasting (increasingly critical for capacity decisions) has been "beefed up" by the assignment there of the old Applications group as well as a different contingent from the new Products group. Proposals are currently afoot to also move the remainder of the Products group forecasting team "up" to long-range planning and let the field sales force do forecasts for the entire zero-to-eighteen month period.

With regard to factory scheduling, SEA is also moving away from basing it on revenue promises though it is moving towards basing it on straight direct linkage with bookings rather than EUG's detached direct linkage. Bypassing the old circuitous paths, orders are now posted directly to the management centers which direct them to the appropriate

facilities. Manufacturing is moving to be able to react to such timely inputs. Various new processes and procedures, especially things like smaller and more frequent parts procurement has allowed frozen horizons to be reduced from nine months to twelve weeks, with some new plants on the boards designed to take that down to three or two weeks. These processes also allow more and faster flexibility in responsing to varying demand. However, as at EUG, the sales force is encouraged (via the management centers) to book orders on a more regular and even volume basis so that these production facilities, while responsive to demand, may also enjoy as much as possible the benefits of smooth production flow.

2.3.1 PDX

While PDX has undergone the most radical change in the relationship between engineering and manufacturing, it has undergone the least in the relationship between marketing, sales and manufacturing. Recalling that PDX was originally a very fragmented company, it is in character that its Marketing function remains split into three "business groups" which each do their own "divisional" forecasts, with no explicit corporate summation. Manufacturing and also Engineering still do parallel forecasts focusing on their own particular needs with their own particular biases as noted in the chapter introduction.

There are few integrative devices yet in this area. The Manufacturing Planning group has undertaken "hand-holding" with Marketing but has not assumed a formal responsibility for short-range forecasting akin to its role in product design or to that of SEA's management centers. While

the "redundant" forecasts remain, Marketing's reputation has been rising, very slowly, to where it now generally tends to be the source lent primary credence for the zero to eighteen month horizon.

The long-range (eighteen months to five years) forecasting function has been fully assumed by the Manufacturing Planning group partly by virtue of its involvement in the closely related product life-cycle plan and the (as noted before) close tie between long-range forecasting and capacity planning activities. However, with forecasting as with such things as the manufacturing/business plan, Manufacturing, having now had its function directly integrated into these areas, is hoping to off-load these now topically-integrated tasks onto new "intermediate" integrative groupings. While the business planning is set to go to a new Corporate Planning office, the long-range forecasting is set to go back to Marketing "at such time as they are fully ready to cope with it."

The order bookings story is quite similar to SEA -- seeing as they shared a similar past and face a similar future (as compared to EUG). Previously, orders spent ages in transit, loads and schedulings were shifted about, plants were run off of more general proposals and had frozen horizons of around six months. Currently orders now flow directly to an office physically and organizationally adjacent to the corporate MRP scheduling office. There the figures are collected and still adjusted somewhat by trends forecast by (still) both Manufacturing and Engineering. Plants are being reconfigured to adopt advanced processing techniques, less final system assembly and test and less inventory needs,which it is hoped will allow those frozen horizons to be reduced ultimately "well under one month".

3 COMMENTARY

3.1 Automobiles

What is the overall picture that we see looking back over the cases of our firms? It seemed to me that in contrasting the two older firms, SEA and PDX, with the younger firm, EUG, there were to be found some interesting and instructive parallels with the familiar recent history of the automobile industry. In both instances one can see clearly how the nature of the marketplace affects the organizational mission and structure of firms and how upbringing in different environments prepares one differently for subsequent global changes.

My first comment is to note that organizations follow the behavior pattern of humans and other organisms by generally not voluntarily doing something extra which is not at the moment required. They, in fact, only do the minimum required to prosper. If the environment demands that primarily one or two functions be very good then there is no incentive to develop high skills in all functions. Therefore competitors in that environment will naturally evolve organizations with narrow competencies. Conversely, if the environment demands that one achieve (perhaps not outstanding but) superior performance in a number of areas at once,i.e. both high differentiation and high integration, then competitors will evolve organizations with multiple and (probably) integrated competencies. That is to say, corporations, even if they don't realize it, are always market-driven. If they appear unresponsive to a need or otherwise "not market-driven" it is only because the market allows them to get away with it.

In our analogy, SEA and PDX parallel the big US automobile firms in the Fifties and Sixties. They both expanded in a period of generous market growth and little competition outside (and hence unlike) themselves. Their customers were generally interested in product performance (particularly speed), were generally less sophisticated about quality and couldn't dicker much on price, it being for both automobiles and minicomputers a seller's market. Both groups slighted manufacturing because the essential contributions of manufacturing -- costs, quality, delivery speed, etc. -- were genuinely and legitimately of minor importance at that time and place. The marketplace let them get away with it.

However the truely interesting industrial dynamic is that differently demanding marketplaces can obtain simultaneously in different corners of the overall playing field. During periods when the "majors" still enjoyed narrowly focused market demands both the Japanese automobile companies and the third wave of minicomputer companies, of which EUG is one, grew up in much more difficult and demanding environments requiring a wider range of skills for achieving growth. The development of multiple competencies, however, immediately provided EUG and the Japanese automobile companies with potential competitive advantages over the majors (since they could offer "enough" performance plus price, quality and service) which sooner (EUG) or later (Japan cars) they couldn't resist introducing into the major's market. When they did, and enough of them prospered thereby, that in itself fundamentally altered the market by introducing the wider range of competencies offered as "basic necessities". This required PDX and SEA and General Motors and Ford to suddenly

scramble to develop these previously unnecessary skills.

Also, one may recall that when the Japanese automobiles first appeared en masse, the US automobile firms tried to meet them on marketing and fuel economy but ignored price, quality and performance -- they failed. They then tried marketing, fuel economy and price -- no luck; then marketing, quality and performance but not price -- no luck. Similarly SEA and PDX have tried to meet performance and price but have done less well in quality and delivery while EUG had price, quality and delivery but (perhaps) less performance or marketing.

Therefore, my second comment is to observe that almost regardless of how "sewn-up" a market is by single-competence corporations, the minute a truely multi-competent firm appears on the scene no matter how remotely located initially, it is thenceforward inevitable that the marketplace will evolve (or devolve) into broader, messier competition where "holding a major position" requires competence in as many fields as the most widely competent firm -- no matter how small (please consider how large were either EUG or Honda Automobile Company fifteen years ago?). This is inevitable because few of the supposed protective barriers really work over the long term (i.e., we're too big, they're too small, they don't know our customers like we do, barriers to entry are too high, our reputation is worth a premium, etc., etc.)[1] If a company can offer ten qualities for the price that a "major producer" offers only six, the entrepreneurial impulse of any good manager will impel him to in some way circumnavigate trade, legal and other entry barriers to sell on the major's home turf. And once he does and a few customer's discover his advantages and sing his praises, the world will ultimately beat a

path to his door and the major's reputation will be quickly devalued. And, even if the first entrepreneur fails, the customer base will become spoiled for anything less and another entrepreneur will pick up where the first one left off and keep chipping away at the complacent major.

3.2 Leadership

Now that all of our three firms are adjusting and fine tuning their organizations and expanding their functional integration to address the need for multiple competencies one may ask if there are any preferable models towards which they might aim. Surely we have seen that as multiple competencies become more important the manufacturing function winds up in the middle of things since virtually every other characteristic besides technical design and pure salesmanship, from delivery to field service to financial soundness in some or another critical way involves the manufacturing process. Therefore the "expanding functional integration of manufacturing" into engineering and marketing as well as finance, service, data processing, etc. is only natural and appropriate. However we have also seen the critical need for superordinate integrative devices to manage simultaneous heavy differentiation and heavy integration. The question is: where should they reside? The case of SEA would suggest that Engineering is not ideal for there may remain a bias towards "trying to hawk the technologies you've created rather than creating the technologies which are marketable." The case of EUG would suggest that Manufacturing may not be ideal as an ultimate arbiter. While Manufacturing's prime position at EUG has resulted in

low-cost flexibility it has not assured them of having the most attractively positioned products available at the right time in the market. Some people would suggest that the case of General Motors, where it is claimed that Finance has been in charge, would argue against Finance. In that situation positioning in the market again became dysfunctional, even though as much short-run profit was extracted as possible.

Just above, you would have noted the recurrance of having problems with the market. Are we then to jump suddenly into the camp of those who purvey "the marketing concept" approach to everything and say that of course Marketing should be at the head of all activity? After all, in the cases of our three firms, Marketing was responsible for the grossly inaccurate forecasts and overly optimistic product plans which caused so many operational and financial problems.

The answer given to me by an executive (in manufacturing) who had worked at two of our three firms was yes to Marketing -- but yes to a carefully defined type of marketing. Much of the following discussion is attributable to this executive with interpretation and extensions added by the author.

The primary problem with the marketing operations in existence previously was that they had basically no business responsibility, as noted in Chapter 2. They helped generate revenue and they helped generate costs but their performance evaluations were tied to neither of those measures. They were true "marketers" rather than mere "peddlers" in the sense that they sought to find out what the customer population needed, rather than seeking to peddle wares (even if they

ended up doing the latter). Indeed, given the burdensome raft of options, configurations and models offered in earlier years some might argue that they were too focused on finding out the unique needs of every conceivable customer. But they lacked the cultural and monetary link back to manufacturing and engineering ramifications. Note the bilateral balance which Philip Kotler, a major Marketing proselyte, gives to his definition of the marketing concept: it says that "the key task of the (corporate) organization is to determine the needs and wants of target markets and to help adapt the organization to delivering the desired satisfactions more effectively and efficiently than its competitors" (emphasis added).[2]

Some advisors suggest following the direction of PDX by establishing an explicitly "intermediate"-positioned strategic corporate planning office above all the traditional functions to organize and manage the determination of technical virtuosity/market/cost/complexity/manufacturing tradeoffs. It seems to me that if one only admits that customer needs are a principal focus of this new office (which advisors usually do) then you are in fact defining the sort of corporate strategic Marketing function which Kotler et.al. have in mind. In which case it may be preferable to simply give Marketing the broader charter and thus encourage the broad outlook in Marketing rather than perhaps discouraging it in limiting the function's scope by placing another function on top of it. I will call this new kind of function corporate strategic marketing or CSM to emphasize its unusual position -- a position described by a quote from Peter Drucker in Kotler's text: "Marketing is so basic that it cannot be considered a separate function...It is the whole business

seen from the point of view of its final result, that is, from the customer's point of view."[3]

3.3 A CSM-lead Scenario

The executive I spoke with explained to me that a CSM-lead scenario is really very simple. You give to Marketing the privilege of controlling all asset deployment regarding product projects and in turn give them full profit and loss responsibility. In this respect, the situation described is an extension of the "management center" entity found at SEA. CSM then uses Engineering and Manufacturing as consultants. CSM tells Engineering what it needs (and what it does not need), while Engineering offers advise on possible applications of new discoveries. But CSM controls the asset deployment and suffers the earnings consequences so it holds that function in check. CSM also is served by and serves Manufacturing. Its market focus tells it when it may be of overall benefit to grind out something, even hand-built, to meet a strategically crucial "launch-window", yet its ever present p&l evaluation keeps it from being too cavalier about doing this. Similar checks and balances help it self-discipline its own marketing forecasting function.

Further, since such a CSM integrative entity is not trying to foster technical excellence per se or minimal inventories per se but optimal corporate operations it is in CSM's self-interest if not intrinsic function to foster the kind of functional intercourse, particularly involving manufacturing, which has been looked upon favorable throughout this thesis.

3.4 Manufacturing Ramifications

Finally, we can conclude by considering the effect of this proposed CSM-led organization on the third-party relationship between Manufacturing and Engineering. The relationships we have seen in this study have varied primarily based upon the different organizational mission and culture of Engineering.

At SEA and PDX, the culture emphasized technological pioneering and performance leadership. At the extreme we saw that in the VLSI chips group at SEA this led to a natural merger of the two functions as product and process were mutually defining each other. We also saw that because of Engineering's need for specialized parts, combined with a strategic intent of garnering additional value-added, and some personal pride, SEA and PDX were led to a fairly high level of vertical integration which made the internal Engineering/Manufacturing relationship much more convoluted.

At EUG the culture emphasized low vertical integration and therefore creative adaptation of existing technologies for superior performance. This made the primary burden of the "design engineering" function the delineation of schematic designs and stock component-types while the "manufacturing" function received responsibility for all subsequent detailing of circuit and board designs plus specifying specific component part numbers -- a simpler, more cut-and-dried relationship.

In our CSM-lead scenario the Engineering function would not be tied to either a high performance, sui generis path or a pragmatic, creative adaptation path, it would vary and become more literally "market-driven".

In some markets, uncompromising olympian technological efforts will continue to be demanded, while in others simpler, more adaptive efforts may be all that is needed for optimization. While I do not purport to have done a marketing survey on this point, general observations suggest that a number of product markets currently served by PDX and SEA do not call for olympic technology and that the proportion of the minicomputer business constituted by simpler-needs markets (some would term them "commodity" markets) will be increasingly expanding in the future. In commenting on generic maturing industries Michael Porter notes: "although past success in the early and growth phases of an industry may have been built on research and on new products, the onset of maturity often means that...it is usually appropriate for the focus of innovative activity to change...(i.e.) reduced attention to introducing new products versus refining old ones."[4] The minicomputer industry deviates from a Porterian maturing industry in that technology and applications are still growing and changing swiftly. However, if you alter the sense of his observation from "new versus refining old" to "sophisticated-new-design versus simpler-new-design" then the observation is very pertinent. Although continually lowered down-time, more compact memory and faster calculations are always on the agenda, perhaps they need not always be the most compact or the very fastest. For example, one major minicomputer company was criticized by a CSM-type executive as recently as early-1983 for still, in their sales and design efforts, making "a big deal about programming languages the average user doesn't need."[5] In many markets now, pure gross lifetime cost is often more important to customers than technical sophistication or supremacy.

In the beginning, firms like SEA and PDX began in narrow and high

performance markets. Later their markets broadened but the high performance culture remained. Recently they have tried to broaden their culture to parallel their broad markets. When discussing fabrication processes that have grown overly complex or broad-stroke, Wickham Skinner prescribes what he terms "focused factories". What I would propose here might be termed "focused organizations", that is, a bifurcation of companies like SEA and PDX into a "Chevrolet" group and a "BMW" group. The essense of the "Chevrolet" group would be to emphasize simple, pragmatic and adaptive designing plus uncompromising cost-competitiveness, not dissimilar to what EUG does. For this group, an EUG type two department schematic/packaging Manufacturing-Engineering integration might be called for. The "BMW" group on the other hand would be working near the frontiers of product and process, like SEA's VLSI group most likely, and therefore might wish to adopt, like them, a total Manufacturing-Engineering merger. This Chevrolet/BMW separation would also draw out more distinctly two separate manufacturing missions and hence manufacturing organizational missions: "Chevrolet" requiring the ultimate in mass-assembly automation and probably less vertical integration, "BMW a carefully nurtured job-shop system with much higher vertical integration.

Companies like SEA and PDX obviously already handle small personal microcomputers and ultra-sophisticated 32-bit superminicomputers through different designers and factories. And yet the culture and organizational structure of things like manufacturing/business plans, EMITs, phase reviews, allotment of responsibilities to various levels, etc. which supports these activities appears (from my limited study) not substantially different across the various product groups. Surely GM and BMW

are organized differently. Even within GM, the design/manufacturing group for the Camaro and Firebird sports cars is managed differently from that for the Impala and Oldsmobile staff cars. I suggest that for large organizations like SEA and PDX (and even EUG as it expands) to survive what a previously cited executive termed "niche wars", they are going to have to simplify and focus large sections of their organizations and hence become niche-like themselves.

This will require that the engineering missions and cultures in the cost-competitive groups be attenuated down from a state-of-the-art orientation to a pragmatically adaptive orientation involving unaccustomed restrictions to more stock catalogue components. This will likely be as difficult to achieve and as necessary as the previous removal of Engineering's exclusive sovereignty over designs by expanding Manufacturing's involvement.

The cost-competitive groups may also require less vertical integration meaning that SEA and PDX may find their current verticality increasingly suboptimal. Executives at both PDX and SEA have indicated that "full-employment policies" are one primary hindrance to reducing vertical integration. But one executive observed that as "niche war" competition forces companies to more thoroughly automate and reduce vertical integration in "Chevrolet" operations, the ability of "BMW" operations to absorb redundant personnel will be limited and they may eventually have to face a naked choice between full employment and breaking even.

And as more and more minicomputer markets grow commodity-like, ever larger sections of older minicomputer firms will need to trim down to more focused operations if they are to avoid, as one person said,

"being niched to death".

Finally, it should be noted that both the cost-competitive and specialty technology operations involve a much higher level of functional integration of Manufacturing than before. The simple integration of EUG and the leading-edge-generated merger of SEA's VLSI are coming together in the middle leaving no room for the kind of Engineering and Marketing autonomy from Manufacturing and each other which we've seen in the history of PDX and SEA. Yet I have not been suggesting that Manufacturing itself dominate the Eighties. We've noted that at the specialized high-end of the market, product and process are mutually self-defining. And at the lower-end, while manufacturing sorts of concerns (speed and cost and accuracy of assembly, etc.) may increasingly predominate overall product planning, many of those conerns will be primarily addressed through pure schematic design engineering advances -- such as built-in test engineering, self-test circuits, fault-tolerant design, etc. Also, since an underlying assumption of the current discussion is leadership by corporate strategic Marketing, there is obviously implied a new recognition of both the role of production operations in achieving marketing goals and the role of Marketing, in turn, supplying guidance and feedback to Manufacturing.

So, in the minicomputer industry, as technical challenges become even more extreme (and exotic) at the high end and as niche competition grows stiffer and more ruthless at the low end, we should expect the organizational missions of successful competitors to develop multiple tight focuses and to develop ever deeper integration of the manufacturing function into the overall corporate organization, mission and culture.

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NOTES

0 INTRODUCTION

1. Hayes and Schmenner
2. Lawrence and Lorsch
3. Porter, p.227
4. Forrester
5. Porter, p.219
6. Porter, pp.238-241
7. Business Week, May 2, p.68
8. Porter, p.238
9. Porter, p.240
10. Porter, p.238
11. Porter, p.239
12. Porter, p.239
13. Porter, p.243
14. Porter, p.250

1 DESIGN ENGINEERING

1. Lawrence and Lorsch
2. Lawrence and Lorsch, p.6
3. Lawrence and Lorsch, pp. 7-8
4. Lawrence and Lorsch, p.12
5. Lawrence and Lorsch, p.31
6. Allen, p.228
7. Lawrence and Lorsch, p.35
8. Lawrence and Lorsch, p.40
9. Lawrence and Lorsch, p.40

10.Allen, p.230

11.Lawrence and Lorsch, p.8

12.Lawrence and Lorsch, p.39

13.Allen, p.231

14.Lawrence and Lorsch, p.37

2 MARKET FORECASTING & SALES

1. Shapiro

2. the following four "problem areas" and "complaints" are taken from Shapiro, p.217

3. Shapiro, p.221

4. Forrester

5. this item is not from Shapiro, but by the author.

6. Shapiro, pp. 225-227

3 COMMENTARY

1. Porter, pp.247-248

2. Kotler, p.31

3. Kotler, p.3

4. Porter, pp.249-250

5. Business Week, March 7, p.83