

250  
102

**PRODUCT-MARKET OPPORTUNITIES FOR FPL SPACEBOARD II**

**MOLDED STRUCTURAL PRODUCTS**

by

Mark W. Trinka

Thesis submitted to the Faculty of

Virginia Polytechnic Institute and State University

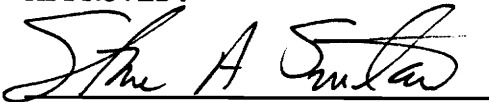
in partial fulfillment of the requirements for the degree of

**MASTER OF SCIENCE**

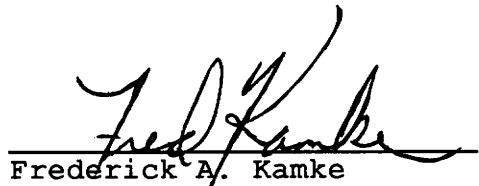
in

**Wood Science and Forest Products**

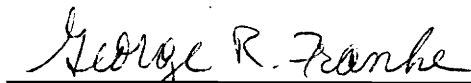
APPROVED:



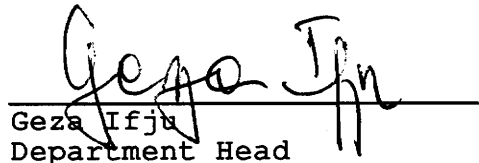
Steven A. Sinclair  
Chairman



Frederick A. Kamke



George R. Franke



Geza Ifju  
Department Head

c.2

LD  
5655  
V855  
1991  
T756  
C.2

PRODUCT-MARKET OPPORTUNITIES FOR FPL SPACEBOARD II  
MOLDED STRUCTURAL PRODUCTS

by

Mark W. Trinka

Committee Chairman: Steven A. Sinclair  
Wood Science and Forest Products

**ABSTRACT**

Two analysis techniques were demonstrated for use in new product development by the wood products industry. A new molded wood structural product developed by the U.S. Forest Service Forest Products Laboratory known as FPL Spaceboard II was used to illustrate the techniques. Determinant attribute analysis was first employed to identify the product attributes most important to purchase decisions regarding substrate materials for the office furniture industry - the most likely target for introduction of Spaceboard II. A matrix-type decision model was then developed and illustrated which assists in selecting the most attractive product-market opportunity for a new product still in the development stages based on market attractiveness and relative competitive advantage of the product.

Surveys were directed to manufacturers of office furniture and to producers of industrial particleboard and medium-density fiberboard which currently are the most common materials utilized as substrates in the office

furniture industry. The furniture survey collected information regarding the perceived importance and variability of an array of physical product characteristics in the selection of a substrate material for office furniture. The survey of industrial particleboard and medium-density fiberboard producers acquired information regarding the importance of factors affecting decisions to enter and compete in a given market and ratings of the office furniture substrate market on those factors.

The results of the determinant attribute analysis indicated that fastener withdrawal strength, surface smoothness, flatness, stiffness (MOE), and edgbanding capability were the product attributes which would most affect the decision to purchase substrate material for office furniture, and consequently are the attributes to focus on in developing a new product for that market.

Use of the decision model was illustrated with Spaceboard II and resulted in a hypothetical matrix with the product positioned based on the attractiveness of the office furniture substrate market and Spaceboard II's relative competitive advantage over existing materials in that market versus its competitive position in other market scenarios.

## **ACKNOWLEDGMENTS**

Although it would be impossible to extend my gratitude to every person involved in the completion of this thesis, several people made invaluable contributions to the effort and deserve recognition and my heartfelt thanks.

First, and foremost, I wish to thank my parents and family for their endless love, support and sacrifices throughout my entire education - especially through the trials and tribulations of graduate school.

I would also like to thank Drs. Sinclair, Kamke, and Franke for their guidance, technical support, and timely criticisms that allowed this research effort to succeed. The Department of Wood Science and Forest Products, its faculty and staff were also invaluable in providing the necessary resources, knowledge, and assistance for completion of my degree.

My fellow and graduate students and friends - Linda Yun, Jeff Carr, Cindi and Duke West, Bob Bush, Vic Mills, Chris Meyer, and Ira Lauer deserve special thanks for the individual inspiration and moral support they gave me, and for making life bearable when I needed it most.

Finally, I would like to thank the Procter & Gamble Cellulose Company and my co-workers for their support and patience while finishing my degree.

## **TABLE OF CONTENTS**

ABSTRACT . . . . .	ii
ACKNOWLEDGMENTS . . . . .	iv
PROBLEM STATEMENT AND JUSTIFICATION . . . . .	1
OBJECTIVES . . . . .	6
LITERATURE REVIEW . . . . .	7
Industrial Product Introduction . . . . .	7
Preliminary Market Assessment . . . . .	9
Office Furniture . . . . .	9
Industrial Particleboard/MDF . . . . .	17
Market Analysis . . . . .	21
Determinant Attribute Analysis . . . . .	22
Decision Matrices . . . . .	24
Summary . . . . .	26
Literature Cited . . . . .	27
Determinant Attribute Analysis: A Tool for New Wood Product Development . . . . .	35
Abstract . . . . .	36
Introduction . . . . .	37
Methods . . . . .	39
Selection of Target Market . . . . .	39
Attribute Selection . . . . .	41
Data Collection . . . . .	41
Determinant Attribute Analysis . . . . .	42
Results . . . . .	44

Importance . . . . .	44
Variability . . . . .	45
Determinance . . . . .	45
Discussion . . . . .	46
Literature cited . . . . .	49
<b>A Competitive Advantage Model for Guiding</b>	
New Industrial Product Development . . . . .	54
Abstract . . . . .	55
Introduction . . . . .	56
Matrix Development . . . . .	59
An Example . . . . .	61
Data Collection . . . . .	61
Competitive Advantage Axis . . . . .	62
Market Attractiveness Axis . . . . .	66
Results . . . . .	68
Interpretation and Discussion . . . . .	71
Literature Cited . . . . .	75
Conclusions . . . . .	85
Opportunities for Further Research . . . . .	87
Vitae . . . . .	89
Appendix 1: Survey Questionnaire . . . . .	90

## **PROBLEM STATEMENT AND JUSTIFICATION**

Recent research conducted at the Forest Products Laboratory suggests the likelihood that a new family of fiber-based structural products may soon be developed. These new products will be produced using a variation of the FPL press-drying concept to produce high-strength molded wood fiber products. Two product types have emerged from this research which have been referred to as Spaceboard I and Spaceboard II. Spaceboard I products are similar in appearance to corrugated container board and would likely compete with it for high strength/stiffness applications. Spaceboard II, the benefactor of this research effort, is a thicker product with enhanced structural characteristics. More information was needed to determine appropriate product/market opportunities for Spaceboard products to provide a basis for further technology-based research and design to speed market acceptance.

Spaceboard II production provides the wood products industry with a unique opportunity to take a basic commodity product (i.e., wood fiber) and convert it to a high-value specialty product. A quick study of almost any major North American wood products firm's annual corporate reports will show an increasing emphasis on developing specialty products and businesses for their corporation, and a move away from the historical emphasis on commodity product production.



Wallis (1987) has defined a specialty business as one which sells a product based on performance standards, has a high value-added and high-value end use, is technology-driven, and has a relatively small and segmented market. Wallis (1987) also reported that from a financial standpoint, specialty businesses have provided a return on investments at a rate up to 50% higher than commodity businesses.

Increased profit is only one reason that forest products firms are turning toward specialty products and businesses. Bennion (1987) noted that firms in basic industries (which includes the wood products industry) can survive and even prosper, but only if they embrace a marketing approach to their businesses, as opposed to the production orientation that has typically characterized many of the basic industries. The wood products industry is one which faces relatively unique problems with regard to product introduction. The nature of the industry dictates not only that large quantities of potentially valuable residues and by-products are the result of normal production of existing products, but also that new uses for existing raw materials bases be found. In other words, many new wood-based products are developed more as a result of an industry need than a market need (Luppold 1988; Rosenberg et al. 1990). Luppold (1988) notes that, due to increasing

demand and higher prices for low-grade softwood timber and sawmill residues, efforts have been made to develop uses for the relatively untapped low-grade hardwood resources. The commercialization of waferboard also occurred because of the industry's need to utilize lower grade and less costly material. This is similar to the situation that spaceboard II is facing, and is likely to occur many more times in the future as pressure increases for more efficient utilization of forest resources.

A well-planned and informed introduction process is critical for new product introduction. This aspect of business is not only important to ensuring a firm's competitiveness, but is also one of the most costly. A recent study on product development expenditures for industrial products found that the average new product development project costs a firm over \$800,000 and more than 900 man/days (Cooper and Kleinschmidt 1987). The fact that nearly half of the resources expended on product innovation goes to products which fail, either commercially or before, lends gravity to this problem (Cooper and Kleinschmidt 1987). Product failure rates are extremely high. Researchers estimate that around one out of every three new products fail at market launch - if they make it to launch! As many as 90% of all new products fail in total (Cooper 1979; Cooper and Kleinschmidt 1987). Studies of this

phenomenon repeatedly point to the need for improvement in a variety of areas, including market research and resource allocation. This study attempted to deal with those problems in terms of the introduction of Spaceboard II into the office furniture industry.

One factor which strongly affects a new product's success as a substitute is its competitive advantage over competing products. To achieve competitive advantage in the marketplace, the new product must possess qualities or characteristics which are perceived by the buyers as not only important, but also superior to those of existing products (Myers and Alpert 1968). Non-product characteristics such as promotion, switch-over costs, and company reputation are also very important; however, the overriding purpose of this research was to aid in further technical research, so physical characteristics were emphasized.

To further complicate matters, the majority of the literature on product introduction focuses on reacting to market needs (Cooper 1979; Cooper and Kleinschmidt 1987; Link 1987; Webster 1969). Therefore, a standardized process to investigate market opportunities for new products converted from previously untapped raw materials, or even by-products, which currently have no recognized market could have a great impact on the future of the wood products

industry. Toward this end, the study described here attempted to demonstrate such a procedure.

This particular study used a marketing approach to investigate the critical product characteristics for introduction of Spaceboard II products to business and institutional furniture manufacturers as a substitute for current wood-based panel substrate materials. By using such techniques, wood products firms may develop new products that are more likely to be commercially successful than if the more common resource-based or technology-driven development methods are utilized.

## **OBJECTIVES**

The objectives of this research were centered around the development and demonstration of market-oriented analysis techniques to support new product development in the wood products industry.

The first objective was to demonstrate the use of determinant attribute analysis in identifying key product attributes which could be focused on during new product development in the wood products industry.

The second objective was to develop and demonstrate a product/market assessment matrix as a tool for use in the early stages of product development. This tool would be used first to select appropriate target markets based on both product and market information, and second to guide product development for successful introduction into the chosen product/market.

## **LITERATURE REVIEW**

### ***Industrial Product Introduction***

Market information is critical at this stage of product development for Spaceboard II. Before a final product is developed, tested, and marketed, the whole concept should go through what Cooper (1988) has termed "predevelopment activities". These stages are, in order: idea generation, screening, project definition, and business analysis. Once these activities are completed, final product development and commercialization activities take place. Although some initial product development has taken place, Spaceboard II is currently in the project definition and business analysis phase.

A Conference Board study indicated that poor market analysis is the leading cause of failure in new products (Hopkins 1980). Within the broad term of market analysis, researching and understanding the market prior to product development, recognizing true needs in the market , and adequate assessment of potential competition are thought to be the keys to successful product introduction (Hopkins 1980; Cooper 1988). With that in mind, a new product must not only be superior to other products in the market, but also must be perceived as such by the target market. Furthermore, that superiority must be in terms of some

product attribute which is important to the customer (Cooper and Kleinschmidt 1987; Link 1987; Cooper 1988).

Another study by Cooper (1988) investigated several activities which discriminated between successful and unsuccessful new product projects. Among the strongest of these discriminators were initial screening, preliminary market assessment, preliminary technical assessment, and detailed marketing research (Cooper 1988, Webster 1969). Further support for more focus on these early marketing activities comes from a study by Cooper and Kleinschmidt (1988) which examined resource allocation in the different stages of new product introduction as a possible determinant of success. The results showed that very weak support, in terms of dollars and man-days, in the early stages product development was strongly linked to new product failure. On average, only seven percent of the dollars and sixteen percent of the man-days allocated to the total projects were spent on the predevelopment activities. Furthermore, the allocations of resources to many of these activities were significantly higher for successful projects than for unsuccessful ones (Cooper and Kleinschmidt 1988). Initial project screening, as well as the preliminary technical assessment of the Spaceboard II project has already been conducted by the staff and scientists of the U.S. Forest Service Forest Products Laboratory in Madison, WI. This

study focused on the preliminary market assessment and detailed market research.

### ***Preliminary Market Assessment***

The preliminary market assessment, according to Cooper, can be fairly limited in scope. The information that is sought at this stage includes market size, growth and growth trends, the structure of the market and industry, and estimates of how readily the market may accept the new product (Cooper 1988). However, Link (1987) emphasizes the importance of completeness of information at this stage in increasing the probability of project success. This information may be accessed primarily through secondary data. Much of the market size and growth data is available through publication of the Department of Commerce, Bureau of Census. Industry experts and organizations such as the Business and Institutional Furniture Manufacturers Association (BIFMA) are also a good source for market and industry information in the case of Spaceboard II. Trade journals within the office furniture industry are also a valuable source for gaining insight into the current industry environment.

### **Office Furniture**

Several product-market opportunities for Spaceboard II have been investigated, including home furniture,



industrialized housing, interior doors, office partitions, and office furniture. After comparing the needs of the products and markets, current competition and industry trends, the office furniture industry was chosen in consultation with U.S. Forest Service scientists to be further investigated (Sinclair and Trinkka 1989). Office furniture is divided into two general categories by the Department of Commerce, Bureau of the Census: wood office furniture and non-wood office furniture. Bureau of Census definitions of these categories are:

*Wood office furniture* - pieces with exposed body material predominately of wood, regardless of the material used on the top.

*Non-wood office furniture* - pieces with exposed body material predominately of material other than wood, regardless of the material used on top.

Given these definitions, Spaceboard II may be targeted toward both the wood and non-wood office furniture makers. The results of early product development work at the Forest Products Laboratory indicated that Spaceboard II is well-suited to relatively high-strength applications; the excellent stiffness characteristics of Spaceboard II are ideal for span-support work such as table or desktops. The forming process, at this point in time, dictates that Spaceboard II be manufactured in a batch process, and be formed in its final size and shape; forming large sheets

from which multiple components would be cut, as is often the case with current substrate materials, is not practical. Therefore, within office furniture, Spaceboard II research was targeted at substrate material for tables, desks, and other flat-surface pieces which are manufactured in standard sizes and often have considerable strength/performance requirements.

### **Materials**

The primary material that Spaceboard II will most likely compete with for the office furniture market appears to be industrial particleboard. The commercial office furniture industry is a major domestic consumer of wood composite panel products, although it is a relatively minor consumer of other wood products (Luppold 1988). In 1982, the industry consumed nearly 25% of the particleboard and 10% of the medium-density fiberboard (MDF) manufactured in the United States (Luppold 1988). The percentage of industrial grade particleboard production which the office and public building furniture sector consumed dropped to around 17% in 1985 and 1986 (Resource Information Systems, Inc. 1987). This relative drop is actually due to consumption increasing at a slower rate than particleboard production. Competition between materials seems to primarily be based on cost, although MDF has had some success in competing with lower-priced particleboard because

of its greater ability to be manipulated by the furniture manufacturer (Luppold 1988). This suggests that although price has historically been the major competitive edge of particleboard, new products which are more costly but provide important benefits may be successfully introduced into this industry.

### **Furniture Industry Segments**

**Office Furniture.** The office furniture segment (SIC code 2521) of the furniture industry has experienced phenomenal growth, and industry experts expect this trend to continue (Yates 1987) (Figure 1). The tremendous growth in office furniture sales has occurred partly because of the growth in the white-collar work force. Between 1972 and 1982, the white-collar work force grew from 25% of the U.S. work force to over 50% (Yates 1987). Desktop computers have also contributed to the increased demand for office furniture because they have increased the need for desk space. Table or desk space is increasingly needed to support computers and their complementary equipment, such as printers and FAX machines (Smith 1985). According to Bureau of Census data, the U.S. office furniture industry shipped over \$7 billion of furniture in 1987; over \$712 million came from desks and extensions, and well over \$434 million were accounted for by tables (Figure 2). These two categories

represent nearly 16% of the total value of shipments for the entire office furniture industry (Bureau of Census 1987).

**Home Office Furniture.** A relatively new segment of the furniture industry is the home-office furniture segment. This segment has emerged due to the rapidly increasing number of people who are now working at home. These workers are often linked to the office by computer and have been termed "telecommuters" in the literature. The number of telecommuters in the U.S. is estimated to be over 7 million. Estimates place the total number of people working at home at over 23 million (Kleeman 1989). This figure is expected to increase at 8.3% annually and reach nearly 31 million home workers by 1992 (Kuhl and Arkush 1989).

Computer support furniture is very important in this market. One study found that 10 million of the 16 million households in which people work away from the office had computers in them, and 20% of those had more than one computer; another study estimated that nearly 21 million home offices had computers (Kleeman 1989).

Several furniture manufacturers whose lines include home office furniture claim that it represents nearly one third of their total sales, and some claim that figure to be as much as 60% (Kleeman 1989, Kuhl and Arkush 1989). Although the actual sales figures for home office furniture alone are difficult to estimate, the total sales of home

office equipment is believed to be approximately \$30 billion annually (Kuhl and Arkush 1989).

**Institutional Furniture.** A third segment of the furniture industry is institutional furniture. This segment is closely related to the office furniture segment in that the types of furniture produced are similar (tables and desks for example), but is separated from office furniture in terms of reporting to the Bureau of Census. This category is listed as "Public building and related furniture", SIC code 2531 in the Annual Survey of Manufacturers series of publications (Bureau of Census 1988). Institutional furniture is that which is made for use in locations such as schools, restaurants, libraries, and other public buildings.

The most recent figures for this segment of the furniture industry estimate that the value of product shipments in 1986 were nearly \$1.5 billion, up 14.7% from 1985 (Bureau of Census 1988). Although growth has apparently been unsteady, the industry has doubled its value of shipments in the period from 1977 to 1986 (Bureau of Census 1988, 1983).

#### **Industry Organization**

The industry is also fairly well organized. The Business and Institutional Furniture Manufacturers' Association (BIFMA), formed in 1973, represented 166

manufacturers of office furniture in 1987, and 68 other firms that supplied materials to the industry (Garet 1988, Yates 1986a). Production appears to be highly concentrated within the industry; organization officials claim that fifteen to twenty of its largest members produce 95% of the office furniture in terms of sales dollars in the U.S. (Garet 1988). This figure is up from the estimated 90% in 1986 (Yates 1987). Other organizations in the industry are the National Office Products Association and the American Furniture Manufacturers Association (Garet 1988).

BIFMA performs a wide variety of functions for the industry. One of the primary functions of BIFMA is to track industry performance statistics and to provide this information to its members (Garet 1988). Assessment of overseas markets and potential competition, as well as market research, is also conducted by BIFMA on behalf of its members (Garet 1988, Yates 1987). Another major function of the association is to develop voluntary product performance and safety standards for the industry. By doing so, control is left in the hands of the industry, not the government (Yates 1986a, Garet 1988). Other duties include acting as liaison with government agencies, conducting management seminars, and leading trade delegations to foreign countries (Yates 1986a, Yates 1987, Garet 1988).

The degree to which a market is organized is an important factor when considering entry into that market. As mentioned above, an existing trade organization provides information to its members, providing them with an advantage in bargaining both with suppliers and customers. Product standards that are adhered to by the majority of the firms in the market also lends power to these firms negotiations with their suppliers (Easton and Latham 1980). Furthermore, the structure of the market has an even greater influence on its attractiveness. A market which is concentrated with a few powerful buyers, or one in which the buyers are more important to the suppliers than the converse may be an unattractive target for new products. As Porter (1985) noted, an imbalance of bargaining power between an industry (in this case the firms that make components for office furniture) and its buyers (manufacturers of office furniture) may lead to strong barriers to entry into that market. Powerful buyers can often force prices down to a level that prohibits acceptable profitability to the suppliers, making the market undesirable.

### **Innovation**

The office furniture industry in recent years has been highly innovative, both in furniture design and materials used. Changing market needs and increased competition has lead to an increasing diversity in products, overall

designs, and the materials used to construct the new designs (Ackerman 1987). Arkush and Kuhl (1989) note that the industry has consistently kept up with changing technologies to meet market needs, not only with product technology, but also manufacturing technology. One example of the industry's commitment to innovation is Steelcase, Inc.'s huge investments into product development facilities (Kaiser 1986; Christianson, Kaufman, and Yates 1987). Materials are now being combined in new ways to meet design and cost requirements. The availability of combination wood and steel laminates has provided the industry with a material which has good performance and lower cost than an all wood system (Garet and Kaufman 1988). The industry seems to be very willing to make the necessary changes to accommodate new technologies, as long as those technologies can provide adequate benefits.

#### **Industrial Particleboard/MDF**

Industrial particleboard and medium-density fiberboard (MDF) are the major products from which tabletops and desktops are fabricated by the furniture industry. In order for Spaceboard II to be used in the manufacture of office and related furniture, it must compete with these materials. In addition, it is assumed that Spaceboard II will likely be produced by a firm or firms which are currently producing one or both of these composite products.



## **Particleboard**

The value of shipments for the total particleboard industry was estimated to be over \$1.2 billion in 1986 (Bureau of Census 1988), and 1988 particleboard shipments were nearly 4 billion square feet, with industrial board accounting for 2.88 billion of that (Kuhl 1989). Figure 3 shows data collected by the National Particleboard Association on the value of shipments of both particleboard and MDF. New capacity was expected to come on line in 1989, increasing capacity to over 4.37 billion square feet (Kuhl 1989).

Given the previously mentioned percentages of particleboard consumed by the furniture industry, it is clear that particleboard manufacturers are very reliant on the production of commercial and office furniture for sales of their products. Some manufacturers, in fact, ship their products exclusively to the furniture industry (Kuhl 1989). Similarly, the furniture industry is strongly affected by the wood products industry, and particleboard in particular. BIFMA reports that wood products account for 30% of the dollars spent on materials by the office furniture industry (Yates 1987).

Much concern has been seen in the wood-based panel industry relating to competition from substitute core materials, such as plastics and steel-reinforced panels, in

the office furniture industry (Yates 1986b). New technology and strong marketing efforts are expected from competing industries (Ackerman 1987). To remain viable, the wood products industry needs to continue to develop new technology and implement marketing programs which are just as aggressive as its competitors'. This marketing emphasis is just beginning to be seen in the wood products industry with respect to structural panel producers (Seward and Sinclair 1988).

#### **MDF**

Shipments of MDF (SIC code 24993) were valued at slightly over \$244 million in 1986 according to the Bureau of Census (1988b). This represents more than a 13% increase over 1985 sales. According to Kuhl (1989), the volume of shipments in 1988 increased nearly 5% over 1987 levels to 943 million square feet. The volume was expected to increase again to around 960 million square feet in 1989. This increase in shipments was accompanied by an increase in capacity (Kuhl 1989). The increase in capacity of both particleboard and MDF could lead to lower prices and more serious price competition in the near future.

#### **Industry Organization**

The particleboard and MDF industry is fairly well organized, although no single organization seems to

dominate. One of the major organizations which specializes in these particular product classes is the National Particleboard Association (NPA). The functions of this organization are similar to those of BIFMA in the furniture industry; industry-wide statistics are kept and disseminated among the producers, the product classes are promoted to end-users, and numerous other services are performed. Many firms are also members of the American Plywood Association (APA) and a large variety of less specialized wood products organizations.

As with the office furniture industry, the bargaining position of firms within the particleboard and MDF industry is enhanced by the presence of the trade associations. The power of the trade association serves to balance the bargaining status between suppliers and buyers, thereby lowering potential barriers to entry into the market with a new product. The market is also fairly concentrated among a few large firms compared to the office furniture industry; such concentration gives the MDF/particleboard industry a collective advantage in dealing with its buyers. This organization and structure makes the office furniture market attractive for wood-based panel producers.

### **Innovation**

The particleboard and MDF industry has engaged in increasing amounts of product innovation in recent years.

Much of this is in recognition of the need to differentiate those products and to compete more successfully in the markets that they are active in. Much of this innovation seems to be in the form of improvements on existing products as opposed to actual development of truly new products. Examples of product improvement are smoother surfaces and tighter panel cores for better machinability; both of these improvements are in reaction to changing needs in the furniture industry (Kuhl 1989). Ackerman (1987) also noted similar changes in this regard. A shift to Spaceboard II production would be major compared to those and may be regarded with some skepticism by the industry. However, a product of this type may be the next logical step in competition with non-wood substitute materials in the furniture industry. New core materials such as steel-reinforced particleboard and a plastic honeycomb product are currently gaining more acceptance and use in the office furniture market (Yates 1986b).

### ***Market Analysis***

Once an initial market assessment is conducted, the information gained can be used to conduct a detailed market assessment. Within the literature there is considerable confusion concerning a single best method for conducting a strategic/competitive product-market analysis (Day et al. 1979). Statistical analysis may be used to explore the

importances of the various product attributes to the customer, and one technique which was useful for this purpose is known as "determinant attribute analysis". Manufacturers attempting to penetrate a new market , or an old market with a new product, must understand the product attributes that are most critical in materials purchase decisions (Cooper and Kleinschmidt 1987). These are the characteristics around which a sound marketing strategy must be developed. Researchers must also understand these attributes when developing new products to compete in a given product/market. Determinant attribute analysis is a method which can isolate these critical product characteristics.

Multi-attribute attitude models (i.e. Fishbein 1967; Wilkie and Pessemier 1973) are commonly used to measure consumers' attitudes. Underlying these models is the assumption that consumers view products as a bundle of attributes, features or benefits, and that the attributes differ in the contribution to the product evaluation and choice.

### **Determinant Attribute Analysis**

Myers and Alpert (1968) suggest that those attributes which directly influence choices are "determinant". Their notion is that an attribute may be important to a consumer, but if the consumer feels that alternative products are

equal in regard to that attribute, then the attribute is not a determinant factor in purchase decisions. In other words, low price may be extremely important to raw materials buyers in the furniture industry, but if all available materials are priced at essentially the same low level, then price would not be a "determining" factor in what materials are purchased.

Determinant attributes are those that are important, yet also discriminate well among competing products and materials. This type of analysis is also useful in discovering unfilled needs in the market. If those needs are important enough and can be fulfilled by designing the new product in a certain way, then the new product can enjoy a differential advantage in the market and stands a much better chance of becoming a commercial success (Webster 1969).

While the determinant attributes of a product-type are useful in and of themselves, they are also very useful within the marketing discipline as inputs to further analysis. Schaninger and Buss (1986) described techniques for incorporating determinant attributes into cluster analyses. Multiple discriminant analysis and other market segmentation techniques are capable of using such attributes as inputs in many cases (Anderson, Cox, and Fulcher 1976; Lumpkin, Greenberg, and Goldstucker 1985). More directly

related to the current research, Wilson, and Ghingold (1987) utilized determinant attributes as the basis of multiple regression analysis concerning product introductions. Another use for determinant attributes, inputs into decision models, was used for this study.

### **Decision Matrices**

Decision models in the form of matrices have been used for many years in the marketing discipline. Their purpose is to not only guide strategic planning and decision-making, but to provide a graphic representation of a product or business situation. One of the most prevalent uses is constructing and evaluating business portfolios for large firms; the best known examples are the Boston Consulting Group's (BCG) growth/share matrix, the business profile matrix, and the directional policy matrix (Wind and Mahajan 1981). Each model addresses different problems with relatively unique combinations of factors affecting the decision-making process. Wind, Mahajan, and Swire (1983) note further that for a given situation, different matrices may lead to dramatically different results. Obviously, the appropriateness of a particular model is a critical factor to consider when making strategic decisions.

The majority of existing models are designed to evaluate product mixes or business portfolios. The product performance matrix is used to evaluate an existing product

on specific dimensions, such as profitability. Other models consider the attractiveness of proposed business projects. The level of management at which these different matrices should be employed varies; however, one common feature is that these models provide information valuable to resource allocation decisions. The innate flexibility of matrix-type models allows managers and researchers to tailor the design and criteria of a matrix to nearly any strategic problem and to communicate the situation to others involved in the decision process. Wind and Mahajan (1981) provide an excellent discussion of portfolio models and their usefulness in decision-making.

The dimensions employed in decision models vary widely, and are truly limited only by the designer's imagination. Selection of dimensions is a critical step in model construction and ideally must directly or indirectly reflect the needs of the decision maker. Simple generic models such as the Boston Consulting Group's model may use one criterion per axis, while complex composite dimensions may be formed by combining several factors as in the case of the directional policy matrix (Wind and Mahajan 1981). Numerous authors have investigated the factors affecting product introductions and market attractiveness (e.g. Day 1986, and Porter 1985). While these factors are too extensive to consider individually, Table 1 provides a summary of many of



the factors or dimensions which are believed to be relevant to the attractiveness of a given market.

### **Summary**

The following chapters outline the research methodology and results obtained in the development of a marketing oriented approach to new product development in the wood products industry. To illustrate this approach, a new wood-based panel being developed by the U.S. Forest Service Forest Products Laboratory - FPL Spaceboard II - was used as an example, with the office furniture substrate market as the target for introduction.

Determinant attribute analysis was used to identify the physical characteristics of substrates which are most critical to successful introduction and substitution by Spaceboard into the target market. Building on the results of that analysis, a matrix-type model was developed which not only highlights those critical characteristics, but allows comparison of a wide variety of potential markets based on relative competitive advantage of the product and attractiveness of the market.

The methods illustrated in this study should facilitate a more market-oriented approach to new product introduction in the wood products industry, a critical concept for the long-term survival of the industry as a whole.

### ***Literature Cited***

- Ackerman, J.C. 1987. Markets for Solid and Composite Wood Products for Furniture and Cabinets. Forest Products Journal 37(10):11-15.
- Anderson, W.T. Jr., E.P. Cox, and D.G. Fulcher. 1976. Bank Selection Decisions and Market Segmentation. Journal of Marketing 40(1):40-45.
- Arkush, D., and H. Kuhl. 1989. Technology Remains at Basic Level. Wood & Wood Products 94(2):58-59.
- Bennion, M.L. 1987. Segmentation and Positioning in a Basic Industry. Industrial Marketing Management 16(1):19-28.
- Christianson, R., E. Kaufman, and J. Yates. 1987. The Changing Workplace Spurs Contract Furniture Growth. Wood & Wood Products 92(1):46-57.
- Cooper, R.G. 1979. Introducing Successful New Industrial Products. European Insights in Industrial Marketing. Ed. by Malcolm McDonald. MCB Publications Ltd. Bradford, England. pp. 195-225.
- Cooper, R.G. 1988. Predevelopment Activities Determine New Product Successes. Industrial Marketing Management 17(3):237-247.
- Cooper, R.G., and E.J. Kleinschmidt. 1987. Success Factors in Product Innovation. Industrial Marketing Management 16(3):215-223.
- Cooper, R.G., and E.J. Kleinschmidt. 1988. Resource Allocation in the New Product Process. Industrial Marketing Management 17(3):249-262.
- Day, G.S. 1986. Analysis for Strategic Market Decisions. West Publishing Co., St. Paul, MN. pp. 193-216.
- Easton, G., and B. Latham. 1980. Marketing to Associations That Specify or Approve Industrial Products. Industrial Marketing Management 9(3):223-229.
- Fishbein, M. 1967. A Behavior Theory Approach to the Relations Between Beliefs About an Object and the Attitude Toward the Object. Readings in Attitude Theory and Measurements. Wiley, New York, p. 389-399.

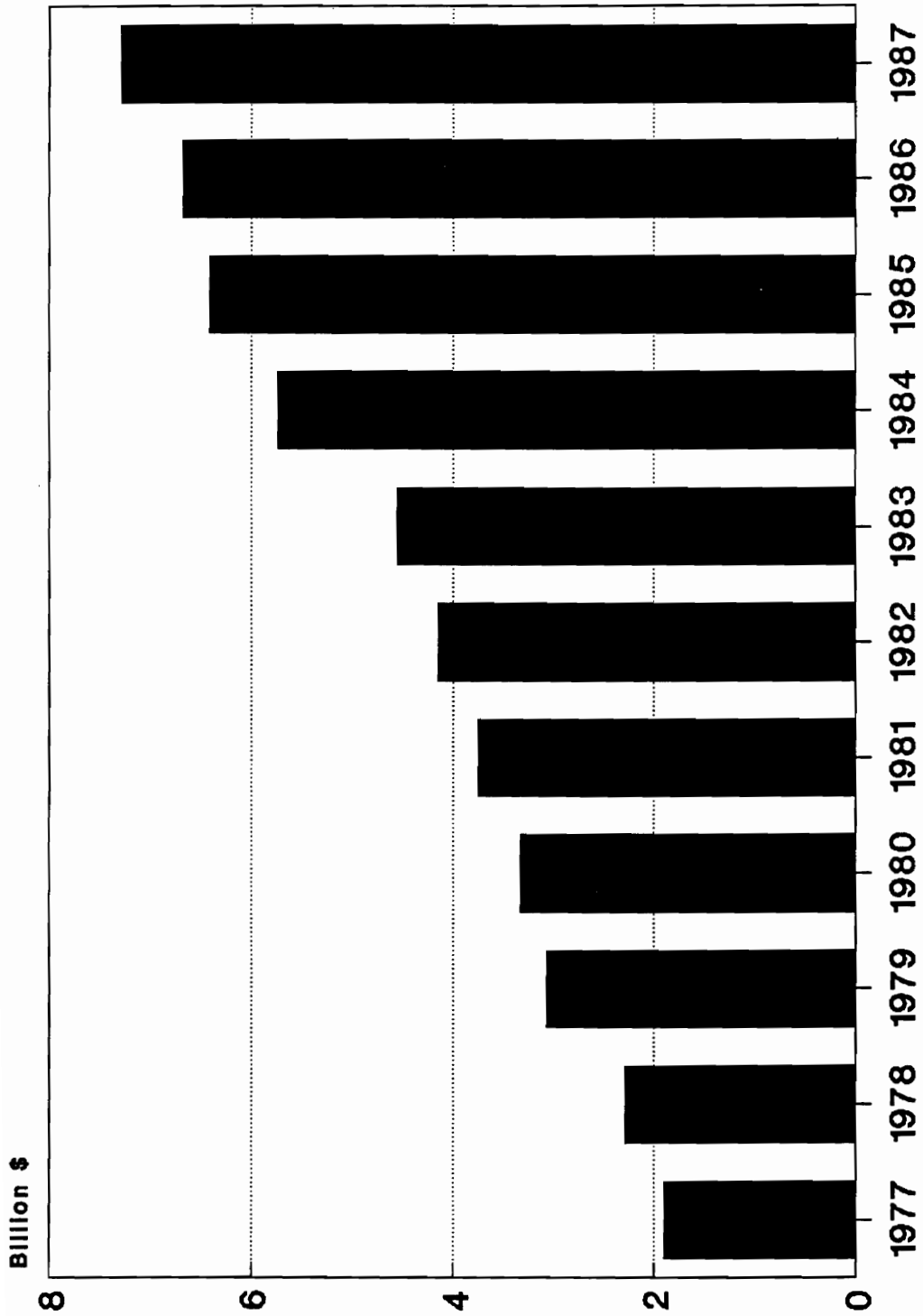
- Garet, B. 1988. Expect Office Furniture to Gain 5% in 1988. Wood & Wood Products 93(1):54-57.
- Garet, B., and E. Kaufman. 1988. Office Furniture Companies Strong and Self-Assured. Wood & Wood Products 93(1):50-54.
- Hopkins, D.S. 1980. New Products Winners and Losers, The Conference Board, report no. 773, New York.
- Kaiser, J. 1986. Office Furniture Manufacturers Sitting Pretty in Mid-80's. Wood & Wood Products 91(1):48-78.
- Karakaya, F. and M.J. Stahl. 1989. Barriers to Entry and Market Entry Decisions in Consumer and Industrial Goods Markets. Journal of Marketing 53(2):80-91.
- Kleeman, W.B., Jr. 1989. The Office Goes Home: Design Needs for a Growing Market. Wood & Wood Products 94(5):32-36.
- Kuhl, H. 1989. Particleboard and MDF On a Steady Path For 1989. Wood & Wood Products 94(5):85-89.
- Kuhl, H., and D. Arkush. 1989. America Goes to Work at Home. Wood & Wood Products 94(2):57-66.
- Link, P.L. 1987. Keys to New Product Success and Failure. Industrial Marketing Management 16(1):109-118.
- Lumpkin, J.R., B.A. Greenberg, and J.L. Goldstucker. 1985. Marketplace Needs of the Elderly: Determinant Attributes and Store Choice. Journal of Retailing 61(2):75-104.
- Luppold, W.G. 1988. Material-Use Trends in U.S. Furniture Manufacturing. Southern Journal of Applied Forestry 12(2):102-107.
- Myers, J.H., and M.I. Alpert. 1968. Determining Buying Attitudes: Meaning and Measurement. Journal of Marketing 32(4):18-20.
- National Particleboard Association. 1988. 1987 Particleboard and Medium-Density Fiberboard Annual Production and Shipments, Gaithersburg, MD.
- Porter, M.E. 1985. Competitive Advantage. The Free Press, New York.

- Resource Information Systems, Inc. 1987. unpublished report.
- Schaninger, C.M., and W.C. Buss. 1986. Removing Response-Style Effects in Attribute Determinance Ratings to Identify Market Segments. Journal of Business Research 14(3):237-252.
- Seward, K.E., and S.A. Sinclair. 1988. An Examination of the Changing Marketing and Product Policy Strategies of North American Structural Panel Producers. Forest Products Journal 38(3):5-12.
- Sinclair, S.A., and M.W. Trinka. 1989. Product-Market Opportunities for FPL Spaceboard II Molded Structural Products. unpublished report.
- Smith, E.M. Jr. 1985. The Table: An Office Staple of Tomorrow. The Office 101(3):88.
- U.S. Bureau of Census. 1982. Current Industrial Reports, Office Furniture - 1981. U.S. Department of Commerce.
- U.S. Bureau of Census. 1983. 1981 Annual Survey of Manufacturers. U.S. Department of Commerce.
- U.S. Bureau of Census. 1987. Current Industrial Reports, Office Furniture - 1986. U.S. Department of Commerce.
- U.S. Bureau of Census. 1988a. Current Industrial Reports, Office Furniture - 1987. U.S. Department of Commerce.
- U.S. Bureau of Census. 1988b. 1986 Annual Survey of Manufacturers. U.S. Department of Commerce.
- Wallis, J.S. 1987. Will a Specialty Business Become a Commodity Business? Industrial Marketing Management 16(1):19-24.
- Webster, F.E., Jr. 1969. New Product Adoption in Industrial Markets: A Framework for Analysis. Journal of Marketing 33(July):35-39.
- Wilkie, W.L., and E.A. Pessemier. 1973. Issues in Marketing's Use of Multi-Attribute Attitude Models. Journal of Marketing Research 10(4):428-441.
- Wilson, D.T., and M. Ghingold. 1987. Linking R&D to Market Needs. Industrial Marketing Management 16(3):207-214.

- Wind, Y., and V. Mahajan. 1981. Designing Product and Business Portfolios. Harvard Business Review 59(1):155-165.
- Wind, Y., V. Mahajan, and D.J. Swire. 1983. An Empirical Comparison of Standardized Portfolio Models. Journal of Marketing 47(2):89-99.
- Yates, J.M. 1986a. BIFMA Director Reports Business Furniture Industry Still On the Rise. Wood & Wood Products 91(1):62-74.
- Yates, J.M. 1986b. Plastic Honeycomb Replaces Traditional Substrate Materials. Wood & Wood Products 91(10):76-78.
- Yates, J.M. 1987. BIFMA Director Talks Business. Wood & Wood Products 92(1):58-59.
- Zoltners, A.A., and J.A. Dodson. 1983. A Market Selection Model for Multiple End-Use Products. Journal of Marketing 47(2):76-88.

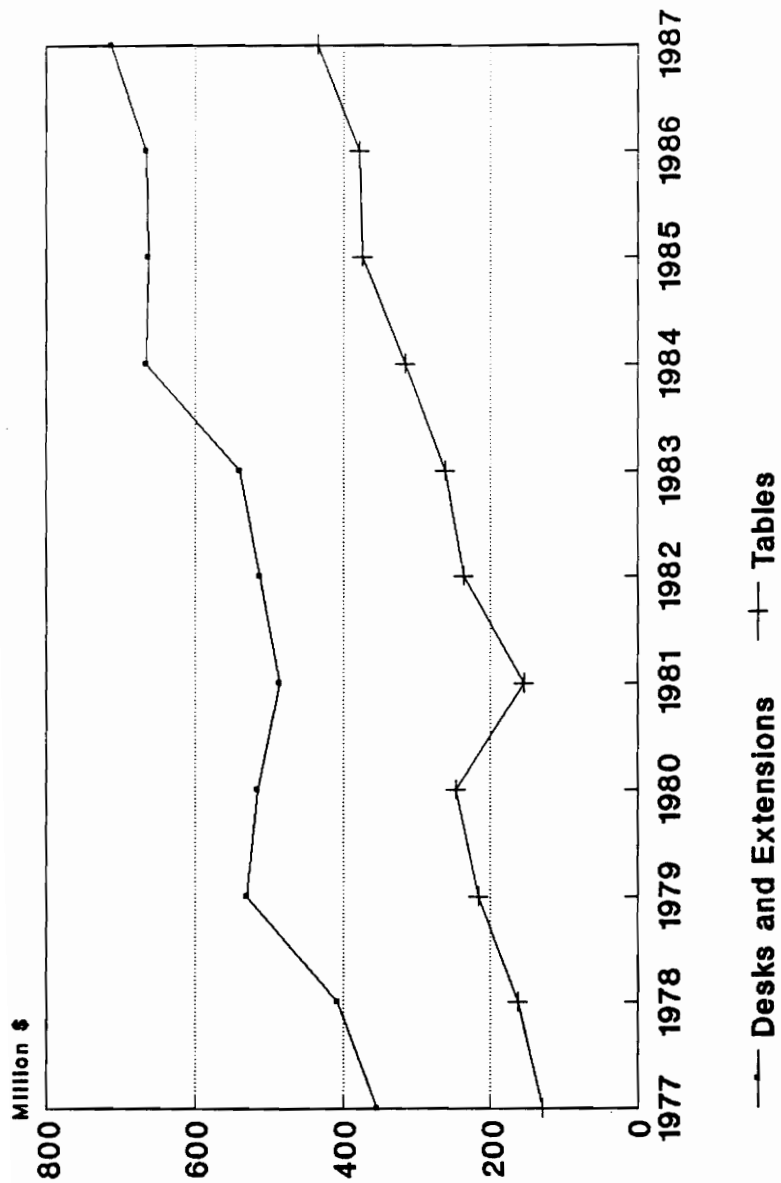
TABLE 1. Summary of Market Attractiveness Factors.

	G.E. Business Screen	Day (1986)	Shell Directional Policy Matrix	Zoltners and Dodson (1983)	Porter (1986)	Karakaya and Stahl (1989)	BCG Growth/ Share Matrix
Legal Environment	X	X	X	X	X		
Structure of Competition		X	X	X	X		
Market Growth Rate	X	X	X	X			
Market Size	X	X	X	X			
Market Profitability	X	X	X	X	X		
Barriers to Entry	X	X			X	X	
Market Cyclality	X	X		X			
Level of Technology			X	X			
Threat of Backward Integration		X			X		
Substitution Threat	X		X		X		
Potential for Differentiation		X					
Stage of Product Life Cycle							X



\*U.S. Bureau of Census 1988a, 1982.

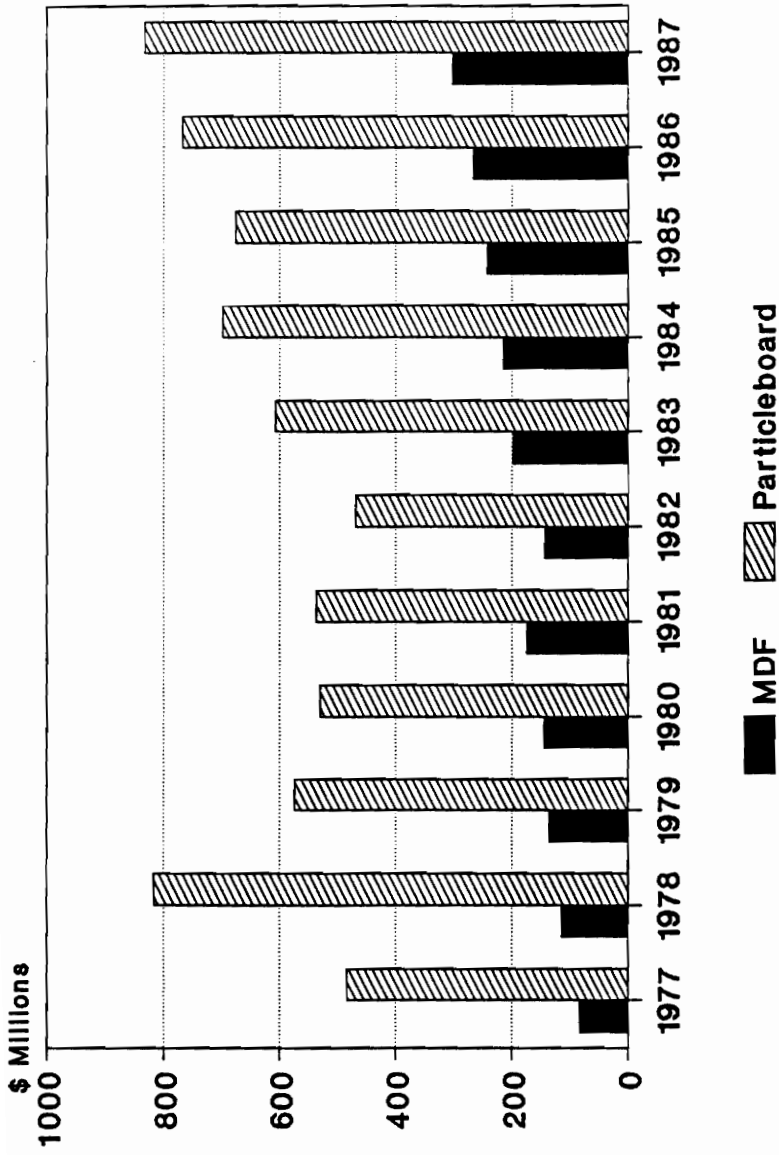
Figure 1. Sales volume for office furniture, 1977-1987.\*



\* U.S. Bureau of Census 1988a, 1982.

Figure 2. Sales trends in selected segments of the office furniture industry.\*





\* National Particleboard Association 1988

Figure 3. Value of medium-density fiberboard and industrial particleboard shipments (in \$ millions) from 1977-1987.\*

Determinant Attribute Analysis: A Tool  
for New Wood Product Development

(A manuscript prepared for submission to  
Wood & Fiber Science)

### ***Abstract***

Determinant attribute analysis was employed to identify the physical product characteristics most crucial in the purchase decision process for office furniture substrate materials. Fastener withdrawal strength, surface smoothness, flatness, stiffness (MOE), and edgebanding capability had the most affect on selection decisions. These results were then viewed in terms of the development of a new product for the market and opportunities that could arise from achieving a superior competitive advantage based on those characteristics. The importance of recognizing customer needs in the new product development process is central to the analysis, and the potential of determinant attribute analysis as a powerful tool for this process is demonstrated.

## ***Introduction***

The development of many new wood products has been driven by resource availability, resource cost and technology - not customer needs (Rosenberg, et al. 1990). This process, while perhaps a rational one for the wood products industry, is counter to the marketing concept where customer needs are the driving force (Levitt 1965). Resource and production factors drive innovation and most new wood product development while customer needs are reduced to a secondary concern.

However, in today's increasingly competitive marketplace, understanding the needs of customers and potential customers of a product is becoming more and more essential to success (Day, et al. 1979; Cooper 1988; Link 1987; Cooper and Kleinschmidt 1987; Porter 1980). Every product can be viewed as possessing a collection of characteristics or attributes which impact its commercial success. These characteristics may be physical and measurable such as modulus of elasticity, market-related as in the case of price, or more nebulous characteristics such as quality or value.

Our increasing ability to alter the physical characteristics of new products through adjustments in the manufacturing process offers the opportunity to put customer

needs back into the forefront of new product development in the wood products industry.

To guide product development more efficiently, efforts should be concentrated on characteristics which most influence purchase decisions. These characteristics have become known as "determinant attributes". Determinant attributes are those characteristics of a product (or product class) which are not only important to the purchasers of the product, but also vary enough between substitute products and/or suppliers to differentiate them from each other. In other words, if price is important but all substitutes are priced essentially the same, price is not a differentiating characteristic and is, therefore, not determinant. Service life on the other hand may not be quite as important as price, but may vary greatly between substitutes and consequently has a greater influence, or greater "determinance", on the purchase decision. In automobiles, steering wheels are very important features, but since most cars have steering wheels, that feature rarely drives purchase decisions. By understanding the determinant attributes for products in a given market, competitive advantage may be gained by capitalizing on these attributes when developing new products.

A relative newcomer in the long line of resource/technology driven forest products is FPL Spaceboard II. It is one of a new family of molded fiberboard panel

products whose development was driven by a U.S. Forest Service desire to better utilize wood fibers from low-value timber species. The basic product is adaptable to a wide variety of situations by varying the physical properties of the panels to meet users' needs. For the product developer, the question is, "Which properties most influence the purchase decisions of my potential customers?" These are the obvious focal points for development efforts.

The product developers' problem with Spaceboard II is used as an example of how determinant attribute analysis can aid in the development of new wood products.

### ***Methods***

#### **Selection of Target Market**

Since the critical properties (i.e. determinant attributes) of a product are dependant upon the end-use market, it was necessary to select an end-use market for Spaceboard II. A modification of the market attractiveness/competitive position matrix developed jointly by McKinsey and General Electric in the early 1970's was used as guideline to help structure the selection process (Day 1986). In selecting an end-use or target market, two objectives were kept in mind. First, the market itself should be attractive, not only to business ventures in general, but also as an outlet for new technologies and products. Second, the market should be one in which the new

product has, or could potentially have, a competitive advantage against existing products.

Seven potential product/markets<sup>1</sup> chosen in consultation with the developing scientists were qualitatively investigated along those guidelines. Interior doors, mobile home components, modular and prefabricated housing components, household furniture, office furniture, and movable office partitions were all considered as potential venues for the introduction of Spaceboard.

The stage of the Product Life Cycle, as proposed by Levitt (1965), was used as a surrogate for market attractiveness. In turn, market characteristics such as growth, product differentiation, and estimated technological innovativeness of the firms within the market were used to position each product/market in terms of attractiveness.

Competitive advantage was gauged in terms of Spaceboard's theoretical performance in comparison to materials or products currently used in a particular application. For each product/market, product performance needs were quite varied, so relative comparisons were necessary. In each case, Spaceboard's theoretical capabilities were estimated as anywhere from "strongly superior to" to "strongly inferior to" existing materials in the marketplace. Following this preliminary examination,

---

<sup>1</sup>Combination of target market and currently existing products in that market.

consultation with the product development scientists lead to the selection of the office furniture substrate market as the focus of further research.

### **Attribute Selection**

The selection of attributes for the analysis had three basic requirements. The attributes needed to be physical characteristics of substrate materials affected by design and processes, the number of characteristics had to be large enough to allow differentiation among themselves and the attributes needed to be stated in relatively familiar terms. Several sources were used to compile the list of characteristics. Wood technology textbooks, previous research into panel characteristics, and concerns by the product development scientists formed the basis of the list (Suchsland and Good 1968; Hunt and Gunderson 1988; Setterholm 1985; Bodig and Jayne 1982). Conversations with furniture and wood composite specialists, along with interviews with industry personnel, were used to develop the final list of 18 attributes as shown in Table 1.

### **Data Collection**

The sample frame in this study was large manufacturers of office and institutional furniture. The goal of the data collection effort was to reach the larger firms in the industry that have the most influence on the adoption of new products. Larger firms in the industry are more likely to use mass-production processes which typically involve



substrate/laminate-type construction central to the use of Spaceboard II. These larger firms would, therefore, be essential to the eventual adoption or rejection of a new substrate product.

The identification of office furniture manufacturers began with the FDM Top 300 list, and was supplemented with the Secondary Wood Products Manufacturers Directory (Furniture Design and Manufacturing 1990; Miller Freeman 1989). Each firm was personally contacted by telephone to confirm its potential as a user of a new wood-based furniture core material and to identify the person in the firm best qualified to answer a survey.

A total of 69 office furniture manufacturers were identified from the directories and subsequent telephone conversations as potential users of FPL Spaceboard II as a core material. The surveys were sent by facsimile to the identified person at each firm, to be returned in the same manner<sup>2</sup>. Follow-up telephone calls were made at one-week intervals after the initial distribution. Fifty-eight manufacturers completed and returned the questionnaire for a response rate of 84%.

#### **Determinant Attribute Analysis**

The direct dual-questioning approach was used in the survey to develop the determinant attributes. This technique (described by Myers and Alpert (1968), and Alpert

---

<sup>2</sup>All 69 firms had facsimile equipment.

(1971)) has been used in several studies including Bearden (1977); Lumpkin, Greenberg and Goldstucker (1985); and Moriarty and Reibstein (1986). For each attribute, the respondents were asked to rate that attribute in terms of its importance, and also to rate the variability among existing products (i.e. substrate materials) with respect to that attribute.

Ratings of the importance of the attributes were combined with ratings of perceived differences among existing products using a multiplicative model as shown in equation 1 (Alpert 1971; Anderson, Cox, and Fulcher 1976; Bearden 1977):

$$D_{ij} = I_{ij}Y_{ij} \quad [1]$$

Where:

$D_{ij}$  = determinance score for attribute  $i$  and respondent  $j$   
 $I_{ij}$  = importance rating for attribute  $i$  and respondent  $j$   
and  $Y_{ij}$  = variability rating for attribute  $i$  and respondent  $j$

The multiplicative model was suggested by Moriarty and Reibstein (1986) to be superior to an additive model for this purpose due to the implied relationship between the importances and variabilities of the attributes.

The determinance scores ( $D_{ij}$ ) resulting from this calculation may be biased since respondents may differ in the intrinsic attitude scales that they utilize (Moriarty and Reibstein 1986; Bass and Wilkie 1973). In other words, "strongly agree" may not imply the same absolute agreement

to a statement for different respondents. Furthermore, those intrinsic scales may not result in interval level responses; the difference between "agree" and "strongly agree" may be different for different respondents (Franke 1985). The same logic applies directly to the variability scores.

Assuming that an individual respondent would use both the importance and variability scales in the same manner, the resulting determinance scores should reflect the bias and may be dealt with accordingly. In order to compensate for this potential bias, the resulting determinance scores for each respondent were "row-centered" to a mean of zero using equation 2 (Schaninger and Buss 1986; Howell 1987):

$$DN_{ij} = (D_{ij} - \bar{X}_j) \quad [2]$$

Where:

$DN_{ij}$  = normalized determinance score for attribute  $i$   
and respondent  $j$   
 $\bar{X}_j$  = mean value of  $D_{ij}$  for all  $i$  of respondent  $j$ .

This transformation is preferred because response bias is reduced and the variability within individual respondents is preserved (Green and Carmone 1978).

## **Results**

### **Importance**

The office furniture manufacturers were asked to rate the importance of the 18 physical characteristics of core

materials on an interval scale from 1 ("Somewhat Important") to 7 ("Absolutely Critical"). The mean responses for each are shown in ranked order from highest importance to lowest in Table 1. Flatness, the capability of the material to be edgebanded, and surface smoothness were found to be the most important physical characteristics when selecting core materials for purchase.

### **Variability**

Office furniture manufacturers were also asked to rate the variability of available substrate materials on the same 18 characteristics. Ratings ranged from 1 ("All About the Same") to 5 ("Highly Variable"). Overall density, fastener withdrawal strength, and machinability were perceived to be the most variable of the product characteristics among currently available substrate materials (Table 2).

### **Determinance**

To develop determinance scores, the importance rating for each characteristic was weighted by the variability rating for that characteristic for each respondent. The determinance scores for each attribute and respondent were then "row-centered", or adjusted to a mean of zero (Schaninger and Buss 1986). Mean determinance scores were then calculated for the product characteristics across respondents (Table 3).

The Tukey HSD multiple comparison test (Howell 1987) was then employed to select the group of variables (at  $\alpha =$

0.05) most important to the material selection process. Attributes that were included in groups (based on the Tukey test) falling wholly or partly above the mean of all the attribute scores were considered to be the most determinant. Fastener withdrawal strength, surface smoothness, panel flatness, panel stiffness (MOE), and edgebanding capability emerged as the physical characteristics of substrate materials which most affect purchasing decisions.

### ***Discussion***

Determinant attribute analysis calls attention to product characteristics which can be manipulated by design and manufacturing processes to provide a competitive advantage and set the stage for commercial success by a new product in the marketplace. Product developers must be aware of not only the relative determinance of specific physical characteristics in affecting purchase decisions, but also the importance and variability which combine to achieve determinance.

In the Spaceboard/office furniture example, the physical characteristics of flatness, surface smoothness, edgebanding capability and fastener withdrawal strength were the most important. Any characteristic scoring high in importance is perceived as being critical to the performance of the product and must obviously be accounted for in the design process. Although flatness is not a characteristic

that readily differentiates existing products competing in the office furniture substrate market, any product that would enter the market as a substitute must be designed to meet the requirements of the market in terms of flatness at least to the level of existing products.

Interpretation of the variability of the product characteristics allows for even greater opportunities in new product development. A high variability rating may mean that currently available products may be easily differentiated and some products are clearly superior in terms of a given physical characteristic. Fastener withdrawal strength, for example, again ranks highly in terms of variability. In this case, a product with high design values for this characteristic/attribute would have a competitive advantage over most existing substrate materials.

Clearly, product characteristics that rank highly in terms of determinance offer the most obvious opportunities for new product developers. High determinance scores indicate that the characteristics are not only important in terms of purchase decisions, but also that enough variability exists between existing products that superiority on those characteristics will lead directly to a competitive advantage in the market place for a new product. In the case of office furniture substrates, a new product developed to have superior fastener withdrawal strength for

stronger and more durable construction, better edgebanding capability to meet changing design requirements, and a higher quality surface to meet the requirements of today's laminates should certainly have a competitive advantage in the marketplace.

Remembering that perceived characteristics are central to this analysis, further opportunities from a marketing standpoint exist for successful new product introduction. Consider the potential for a new substrate material that has superior and consistent machining characteristics. At this time, machinability has limited persuasive power in an office furniture substrate selection decision (ranked 8th in terms of determinance). The culprit is a relatively low perceived importance associated with that feature. If a producer of substrates was able to demonstrate to its customers that improved machinability would give them a competitive advantage, and that its product could consistently provide that improved machinability at a reasonable cost, the producer should enjoy a strong competitive advantage of its own in the marketplace.

New product design is only one of many applications of determinant attribute analysis that can be valuable to the wood products industry. Most importantly, it allows firms to look beyond resource-driven technology and put market needs into the forefront of new product development.

### ***Literature cited***

- Alpert, M.I. 1971. Identification of Determinant Attributes: A Comparison of Methods. Journal of Marketing Research 8(2):184-191.
- Anderson, W.T. Jr., E.P. Cox, and D.G. Fulcher. 1976. Bank Selection Decisions and Market Segmentation. Journal of Marketing 40(1):40-45.
- Bass, F.M., and W. Wilkie. 1973. A Comparative Analysis of Attitudinal Predictions of Brand Preference. Journal of Marketing Research 10(3):262-269.
- Bearden, W.O. 1977. Determinant Attributes of Store Patronage: Downtown Versus Outlying Shopping Centers. Journal of Retailing 53(2):15-22.
- Bodig, J., and B.A. Jayne. 1982. Mechanical Behavior of Wood and Wood Composites. Van Nostrand Reinhold Co., Inc, New York. pp. 712.
- Cooper, R.G. 1988. Predevelopment Activities Determine New Product Success. Industrial Marketing Management 17(3):237-247.
- Cooper, R.G., and E.J. Kleinschmidt. 1987. Success Factors in Product Innovation. Industrial Marketing Management 16(3):215-223.
- Day, G.S. 1986. Analysis for Strategic Market Decisions. West Publishing Co., St. Paul.
- Day, G.S., A.D. Shocker, and R.A. Srivastava. 1979. Customer Oriented Approaches to Identifying Product Markets. Journal of Marketing 43(4):8-19.
- Franke, G.R. 1985. Evaluating Measures Through Data Quantification: Applying Dual Scaling to an Advertising Copytest. Journal of Business Research 13(1):61-69.
- Furniture Design and Manufacturing. 1990. The FDM 300. Furniture Design and Manufacturing. 62(2):21-158.
- Green, P.E., and F.J. Carmone. 1978. Some Methodological Alternatives in the Analysis of Life Style Data. Journal of Economics and Business 30(2):158-161.
- Howell, D.C. 1987. Statistical Methods for Psychology, 2nd edition. Duxbury Press, Boston, MA.



- Hunt, J.F., and D.E. Gunderson. 1988. FPL Spaceboard Development. TAPPI proceedings of the 1988 Corrugated Containers Conference; Oct. 24-27; Orlando, FL. Atlanta, GA: TAPPI Press:11-17.
- Levitt, T. 1965. Exploiting the Product Life Cycle. Harvard Business Review 43(6):81-91.
- Link, P.L. 1987. Keys to New Product Success and Failure. Industrial Marketing Management 16(1):109-118.
- Lumpkin, J.R., B.A. Greenberg, and J.L. Goldstucker. 1985. Marketplace Needs of the Elderly: Determinant Attributes and Store Choice. Journal of Retailing 61(2):75-104.
- Miller Freeman. 1989. Secondary Wood Products Manufacturers Directory. Miller Freeman Publishers, San Francisco, CA.
- Moriarty, R.T., and D.J. Reibstein. 1986. Benefit Segmentation in Industrial Markets. Journal of Business Research 14(6):463-486.
- Myers, J.H., and M.I. Alpert. 1968. Determining Buying Attitudes: Meaning and Measurement. Journal of Marketing 32(4):18-20.
- Porter, M.E. 1980. Competitive Strategy. Free Press, New York, NY, pp. 396.
- Resource Information Systems, Inc. 1987. unpublished report.
- Rosenberg, N., P. Ince, K. Skog, and A. Plantinga. 1990. Understanding the Adoption of New Technology in the Forest Products Industry. Forest Products Journal 40(10):15-22.
- Schaninger, C.M., and W.C. Buss. 1986. Removing Response-Style Effects in Attribute-Determinance Ratings to Identify Market Segments. Journal of Business Research 14(3):237-252.
- Setterholm, V.C. 1985. FPL Spaceboard - A New Structural Sandwich Concept. TAPPI Journal 68(6):40-42.
- Suchsland, O., and W.S. Good. 1968. The Selection of Panel Materials by Furniture and Cabinet Manufacturers. Michigan Agricultural Experiment Station Journal Article No. 4378. Dept. of Forest Products, Michigan State University, East Lansing, MI. pp. 11.

TABLE 1. - Importance of physical attributes of table and desktop substrates to office furniture manufacturers.

Attributes	Standard Deviation	Mean Importance <sup>1</sup>
Flatness	0.88	6.00
Surface Smoothness	1.19	5.91
Edgebanding capability	1.32	5.91
Fastener withdrawal strength	1.16	5.76
Gluability	1.36	5.74
Dimensional stability	1.22	5.64
Internal bond strength	1.22	5.45
Compatibility w/ mfg. system	1.62	5.38
Stress relaxation (creep)	1.22	5.24
Loss of smoothness w/ humidity	1.68	5.19
Stiffness (MOE)	1.48	5.17
Breaking strength (MOR)	1.40	5.12
Loss of strength w/ humidity	1.64	4.98
Loss of stiffness w/ humidity	1.58	4.97
Machinability	1.61	4.72
Overall density	1.57	4.62
Strength to Weight ratio	1.46	4.22
Fire resistance	1.96	3.69

<sup>1</sup> Scale of 1 to 7: 1 = Somewhat Important; 7 = Absolutely critical.

TABLE 2. - Variability ratings on physical attributes of substrate materials by office furniture manufacturers.

Attribute	Standard deviation	Mean variability <sup>1</sup>
Overall density	1.26	3.20
Fastener withdrawal strength	1.36	3.17
Machinability	1.26	3.04
Stiffness (MOE)	1.38	2.98
Breaking strength (MOR)	1.37	2.98
Surface smoothness	1.26	2.96
Internal bond strength	1.30	2.77
Flatness	1.24	2.76
Edgebanding capability	1.22	2.74
Strength to Weight ratio	1.25	2.68
Gluability	1.21	2.60
Stress relaxation (creep)	1.09	2.56
Fire resistance	1.32	2.49
Dimensional stability	1.19	2.46
Loss of smoothness with humidity	1.15	2.38
Loss of strength with humidity	1.11	2.32
Compatibility w/ mfg. system	1.17	2.30
Loss of stiffness with humidity	1.09	2.26

<sup>1</sup> Scale of 1 to 5: 1 = All products about the same; 5 = Highly variable.

TABLE 3. - Mean row-centered determinance scores for physical attributes of table and desktop substrate materials.

Attributes	Standard deviation	Mean determinance <sup>1</sup>
Fastener withdrawal strength	5.56	3.54
Surface smoothness	6.49	3.52
Flatness	6.07	2.27
Stiffness (MOE)	4.29	1.92
Edgebanding capability	5.61	1.35
Internal bond strength	6.35	0.95
Breaking strength (MOR)	5.74	0.94
Machinability	7.46	0.65
Gluability	6.69	0.52
Overall density	5.50	0.52
Dimensional stability	5.31	-0.20
Stress relaxation (creep)	4.61	-0.76
Loss of smoothness with humidity	4.67	-1.67
Compatibility w/ mfg. system	5.15	-1.80
Loss of strength with humidity	4.07	-2.20
Loss of stiffness with humidity	4.29	-2.52
Strength to Weight ratio	3.89	-2.73
Fire resistance	7.68	-4.31

<sup>1</sup> Mean overall score is 0. Scores above 0 have more impact on purchase decisions than scores below.

A Competitive Advantage Model for Guiding  
New Industrial Product Development

(A manuscript prepared for submission to  
Industrial Marketing Management)

### **Abstract**

A market-based model was developed as a tool to assist new industrial product development. The goal in developing this model was the selection of a target market for a product still in the early to middle stages of technical development, and to provide guidelines or target values for the physical attributes of the product essential for success in that market. Furthermore, the model needed to be readily interpretable by all affected parties in the product development process. Finally, the model had to be flexible enough to compare greatly varied product-market opportunities, and to fit a firm's individual needs. A new wood-based panel being developed by the U.S. Forest Service Forest Products Laboratory was used to demonstrate the model. Data was collected from manufacturers of office furniture regarding furniture substrate attributes, and from medium-density fiberboard/industrial particleboard manufacturers to investigate factors affecting market selection. The data was used to illustrate a market-based model for guiding market selection and subsequent technical development in the new product development process.

## ***Introduction***

Peter Drucker, widely recognized for his work in management science, recently put forth a strong statement on the current state of marketing research applied to technological innovations. He said, "...we have known for decades that one cannot conduct market research on something not in the market" (Drucker 1990). We should not, he proposed, attempt to investigate what the market is for a new product, but instead investigate the market potential for what the new product *does*.

A more dated industrial product example lends insight into Drucker's assertion. Research into the market potential during the 1960's of a then relatively new and unfamiliar wood-based panel led to the conclusion that the "... selection process indicates a less than intensive consideration of the potential of particleboard as a core material" in furniture (Suchsland and Good 1968). Today, particleboard is by far the dominant core material in furniture construction.

These statements reflect the need for a method by which researchers can not only develop an understanding of market needs, but also translate those needs into the technological innovation process - a process too often driven by resource and industry considerations at the expense of market potential (Rosenberg, et al. 1990). Numerous authors have

conducted research emphasizing the current imbalance of technological research over market research and the consequences of that imbalance to the success of new product development (Cooper 1979, 1988; Hopkins 1980; Cooper and Kleinschmidt 1987; Link 1987).

Decision models in the form of matrices have been used for many years. Their purpose is not only to guide strategic planning and decision-making, but to provide a graphic representation of a product or business situation. One of the most prevalent uses is constructing and evaluating business portfolios for large firms. The best known examples are the Boston Consulting Group's growth/share matrix, the business profile matrix, and the directional policy matrix (Wind and Mahajan 1981). Each model addresses different problems with relatively unique combinations of factors affecting the decision-making process. The growth/share matrix, for example, employs market share (cash generation) and market growth (cash use) to position strategic business units on the matrix. Expected cash-flows for each unit may then be used to plan optimal financial support for the entire portfolio (Wind and Mahajan 1981). Wind, Mahajan, and Swire (1983) note further that for a given situation, different matrices may lead to dramatically different results. Obviously, the appropriateness of a particular model is a critical factor to consider when making strategic decisions.



The majority of existing models are designed to evaluate product mixes or business portfolios. The product performance matrix is used to evaluate an existing product on specific dimensions, such as profitability and market share (Wind and Mahajan 1981). Other models consider the attractiveness of proposed business projects (Wind and Mahajan 1981). The innate flexibility of matrix-type models allows managers and researchers to tailor the design and criteria of a matrix to nearly any strategic problem and communicate the situation to others involved in the decision process. Wind and Mahajan (1981) provide an excellent discussion of portfolio models and their usefulness in decision making.

The dimensions employed in decision models vary widely, and are truly limited only by the imagination. Selection of dimensions is a critical step in model construction and ideally must directly or indirectly reflect the needs of the decision maker. Simple generic models such as the Boston Consulting Group's model may use one criterion per axis, while complex composite dimensions may be formed by combining several factors as in the case of the directional policy matrix (Wind and Mahajan 1981).

Decision matrices are a tool that have the potential to span the gap between resource needs and market desires, and to allow technological and market research to converge into a process by which new products may be successfully

introduced into the marketplace. This paper proposes a matrix designed to guide the development of a new industrial product based on attributes crucial to success in a given market and characteristics which make a given market desirable.

### ***Matrix Development***

Matrix design should be based on the level of decision-making and the needs of the users at that level. In other words, who is going to use the matrix, and what questions do they need answered?

For a new product in the mid-stages of technical development, a decision matrix would be most useful at an interface between marketing personnel and the designers. The matrix should then take a marketing approach to technical problems. For example, decisions regarding the design of the physical product should be based on market information (i.e. the needs of the customer), while not ignoring manufacturing capability. Likewise, the matrix should be easily understood by all of the involved parties; simplicity of design is a virtue for this type of model.

More than one potential market may be under consideration, so the matrix should be able to differentiate between them and make statements about the attractiveness of one market versus another. To accomplish this, a list of generic market attractiveness factors was developed from the literature (e.g. Wind and Mahajan 1981, Porter 1985, and Day

1986). The questions must then be answered: what impact does each factor have on perceived market attractiveness, and how do each of the potential markets compare in terms of those factors?

For a new product to succeed in a given market, it must have a differential advantage over competing products. When still in the developmental stage, physical attributes that could differentiate a product in the marketplace should be emphasized by the matrix. Each potential market is likely to have different requirements, so the matrix must necessarily provide an estimate of relative competitive advantage in terms of potential performance for the new product.

Finally the resulting analysis should propose a target market, and target levels for the product attributes in that market should be delineated to aid further development efforts.

The matrix proposed here consists of two axes - relative competitive advantage of the new product versus existing products and market attractiveness. The combination of the attractiveness of one market versus others and the ability of the product to compete with, and substitute for, existing products in one market relative to others should then drive the product development process.

### **An Example**

To illustrate this concept, research was conducted involving a new wood-based panel with potential as a core material<sup>1</sup> in the manufacture of office furniture. The new panel was developed by the U.S. Forest Service at the Forest Products Laboratory. Known as Spaceboard II, the panel is a molded wood-fiber product with potential for light structural applications (Hunt and Gunderson 1988). Spaceboard II will be the subject of examples in this study.

### **Data Collection**

Data for the analysis was collected through two separate surveys. One survey was directed to manufacturers of office furniture to investigate the physical attributes of core materials that are most important to the selection process. A total of sixty-nine office furniture manufacturers were identified from the FDM Top 300 list and the Secondary Wood Products Manufacturers Directory (Furniture Design and Manufacturing 1990; Miller Freeman 1989) and from subsequent telephone conversations as potential users of the new panel as a core material. Fifty-eight of these manufacturers completed and returned a questionnaire for a response rate of 84%.

---

<sup>1</sup>A substrate material serving a structural function in the piece of furniture to which laminates are applied in order to achieve the desired appearance and surface qualities.

The second survey was sent to manufacturers of industrial particleboard and medium-density fiberboard - the two most common furniture core materials - in order to determine what market characteristics were most important in choosing a target market for a product, and to estimate their perceptions of how the office furniture core material market fared on those characteristics. Manufacturers of industrial particleboard and medium-density fiberboard were identified in the Primary Wood Products Manufacturers Directory (Miller Freeman 1989). Thirty-eight manufacturers were surveyed and 17 usable responses were obtained for a response rate of 45%.

#### **Competitive Advantage Axis**

A modification of the "State of the Art" (SOA) analysis proposed by Gordon and Munson (1981) was employed to position the Spaceboard II panel along the competitive advantage axis. This analysis allowed the attributes (in this case, physical) of the product to be quantitatively compared in reference to other products performing the same functions. SOA analysis has been successfully applied to a wide variety of products and levels of technology (Edwards and Gordon 1983; Rosłanowska-Plichcińska 1988). The general form of the model is shown in equation 1 below:

$$SOA = K_1(P_1/P'_1) + K_2(P_2/P'_2) . . . + K_n(P_n/P'_n) \quad [1]$$

where:

SOA = the state of the art score for the product,  
 $P_n$  = the product's score on attribute  $n$ ,  
 $P'_n$  = the reference value for attribute  $n$ ,  
and  $K_n$  = the weight or importance of attribute  $n$  to  
the product's performance (Gordon and Munson  
1981).

The attributes ( $n$ ) used were those which are the most important factors resulting in the specification or purchase of a product for a particular use.

### **Attribute Selection**

The attributes were selected with three basic requirements in mind. The attributes needed to be physical attributes of substrate materials affected by design and processes, the number of attributes had to be large enough to allow differentiation among themselves and the attributes needed to be stated in relatively familiar terms. Several sources were used to compile the list of attributes. Wood technology texts, previous research into panel attributes, and concerns by the product development scientists formed the basis of the list (Suchsland and Good 1968, Hunt and Gunderson 1988, Setterholm 1985, Bodig and Jayne 1982). Conversations with furniture and wood composites specialists, along with interviews of industry personnel were used to develop a final list of eighteen attributes (Table 1).

Determinant attribute scores on the physical attributes were utilized to choose the attributes for this analysis.

Data for the determinant attributes were collected from the office furniture manufacturers using the direct dual-questioning technique described by Myers and Alpert (1968) and Alpert (1971) and Sinclair and Stalling (1990). By this technique, the perceived importance of each attribute is multiplied by the perceived variability of that attribute to arrive at a determinance score. These scores were then row-centered as described by Schaninger and Buss (1986) to remove response-style bias from the analysis. Determinant attribute analysis resulted in the ranking of eighteen furniture core material attributes in order of importance to the material selection decision (Table 1).

The Tukey HSD multiple comparison test was then employed to select the group of variables most important to the material selection decision (Howell 1987). Attributes that were in groups (based on the Tukey test) falling wholly or partly above the mean of all the attribute scores were chosen for further analysis. This method reduced the likelihood of arbitrary selection of one attribute whose score is very close to that of another which is not selected. The Tukey HSD test applied to the determinant attribute scores resulted in the selection of five physical attributes from the original list of eighteen (Table 1).

#### **Development of $P_n$ Values**

Ideally, the values of  $P_n$  would be obtained for a variety of substitute products. Respondent ratings could be

used for attributes for which objective measurement is not possible. Kalafatis, Cooper, and Smith (1989) used a similar method in a market analysis of a variety of wood-based panels with good results. In this Spaceboard II example, estimated values for industrial particleboard and the new panel were used.

#### **Development of $P'_n$ Reference Values**

Gordon and Munson (1981) suggest a variety of methods for selection of the reference values,  $P'_n$ . For the purposes of making statements about relative advantage, a mean value of  $P'_n$ 's for all products compared on each attribute could serve as the reference value. As such, the values of SOA would be distributed around a central mean, and statements about a particular product's position in such a distribution could be made.

#### **Development of $K_n$ Weights**

The weights ( $K_n$ ) for each attribute should, of course, reflect the relative importance of that attribute in performing the objectives of the product. Since perceptions of products often contribute greatly to the decision to purchase or specify a particular product or component, the determinance score can be used to calculate the weights (Fishbein 1967, Alpert 1971, Bass and Wilkie 1973, Bearden 1977). The weights are a relative term, and according to Gordon and Munson (1981) should sum to unity, so the weights



are calculated as the attribute's determinance score as a proportion of the sum of all the attributes' determinance scores as shown in equation 2:

$$K_n = \frac{\overline{DN}_n}{\sum_{i=1}^n \overline{DN}_i} \quad [2]$$

where:

$K_n$  = the weight factor for attribute  $n$ ,  
 $\overline{DN}_n$  = the determinance score for attribute  $n$ ,  
and  $\overline{DN}_i$  = the determinance score for each attribute  $i$ .

Once the weights for each attribute have been calculated, products which serve, or may potentially serve, as core materials in the individual market are assigned a value or score ( $P_n$ ) for each attribute.

### **Market Attractiveness Axis**

Special problems exist in characterizing a market in terms of generic attractiveness, since an individual firm's objectives and capabilities ultimately determine whether that firm can or should enter a given market (e.g. Wind and Claycamp 1976, Zoltners and Dodson 1983, Farquhar and Shapiro 1983, Porter 1985, Day 1986, Schill 1986). Nevertheless, many characteristics of a market for a

potential substitute product are not firm-specific, and are appropriate for consideration at the level of analysis for which the matrix is intended.

The positioning of each market on this axis of the matrix essentially follows the procedure used for the General Electric Business Screen (Wind, Mahajan, and Swire 1983). Each market attractiveness factor was assigned a rating as it applies to the market in question, and a weight to reflect the importance of the factor in affecting the decision to enter the market.

For this example, the marketing managers of firms producing wood-based substrate material were asked to estimate the importance of twelve market attractiveness factors in making a decision to enter any given market from 0 to 1 (with the total sum of the importances equal to 1) and to rate the office furniture substrate market on each factor from 1 to 5 (1="Very Unattractive" and 5="Very attractive") (Table 2).

The market attractiveness factors were chosen from an extensive array found in the marketing literature. Numerous authors have investigated the factors affecting product introductions and market attractiveness (e.g. Day 1986, Porter 1985), and several are summarized in Table 3.

A market attractiveness value was then calculated for the office furniture substrate market using equation 3:

$$V_a = R_1I_1 + R_2I_2 + \dots + R_nI_n \quad [3]$$

where:

$V_a$  = attractiveness rating of market  $a$ ,  
 $R_n$  = rating of market  $a$  on factor  $n$ ,  
and  $I_n$  = importance rating of factor  $n$ .

The importance ratings were based on a total sum of one, with each factor's importance being expressed as a percent of one. The ratings of the markets were based on a scale from 1 to 5 with a rating of 1 corresponding to a description of "Very Unattractive" and 5 being "Very Attractive". The resulting score (between 1 and 5, with 3 being the average) is a weighted average of a market's scores on each market attractiveness factor with the emphasis being placed on factors most important to decisions to enter a given market.

These procedures would be repeated for each potential product-market combination, each based on the importance of factors and attractiveness scores for the individual combination. Each new product-market combination would be plotted on a matrix similar to the one shown in Figure 1. Comparison of each product-market in terms of the relative attractiveness of the market and potential relative competitive advantage can now be made and is clearly visible on the matrix.

### **Results**

The Tukey HSD test conducted on the determinant attribute scores resulted in the selection (at  $\alpha = 0.05$ ) of

five attributes which offer the greatest potential for differential advantage in the market. These five physical attributes of the product (fastener withdrawal strength, surface smoothness, flatness, stiffness (in terms of Modulus of Elasticity - MOE), and edgbanding capability) are listed in Table 1 along with their respective determinance scores ( $DN_n$ ) and the weights ( $K_n$ ) for the SOA analysis are provided in Table 4.

For the reference values,  $P'_n$ , objective measurements were possible in only two cases. Fastener withdrawal strength data was available for a wide assortment of commercially available industrial particleboards. The mean value of these was 335 p.s.i. Panel stiffness (MOE) data was also available, and a mean value of 395,000 p.s.i. was determined to be a reasonable estimate for currently available industrial particleboards.

Unfortunately, widely accepted methods for objectively measuring the three remaining physical attributes are not currently available. However, given the nature of this analysis, subjective ratings may be applied without detracting from the purpose of the analysis. By using an arbitrary scale of 1 to 5 (with 1 being the lowest score), it naturally follows that normalized mean scores of existing products would be 3.

A new product may have no standard values for the product attributes in question. However, knowledgeable

estimation by the technical developers of the product regarding the potential properties can be used for comparative purposes. In the case of the Spaceboard II panel<sup>2</sup>, fastener withdrawal strength is expected to be approximately equal to that of industrial particleboard, the major product currently in use as a core material for office furniture. A score of 335 p.s.i., then, is reasonable for use in the analysis. Surface smoothness may be greater for the new product because of raw material attributes (wood fibers vs larger chips and shavings), so a value of 3.5 to 4 is an acceptable estimate. Flatness is determined by a wide variety of variables, so direct estimation of potential flatness is difficult; the developing scientists, however, believe that the new product should be equal to or better than industrial particleboard in this regard.

Panel stiffness (MOE) can be engineered in the new panel, so the developing scientists estimate that values should be at least equal to or better than those of industrial particleboard. Error to the conservative side is prudent, however, so the mean values of MOE for industrial particleboard were assigned to the new product.

Finally, values for edgbanding capability were estimated to be equal to those of industrial particleboard by the scientists who are developing the new Spaceboard II product.

---

<sup>2</sup>Actual product specifications not finalized.

All of these scores combined in this example for an SOA score for a new Spaceboard II panel in the office furniture substrate market of 1.09 (see Table 5), with a score of 1.00 being absolutely equal to existing materials and thus having no competitive advantage based on physical attributes.

The results of the analysis of the furniture market as a potential target for a new substrate material are provided in Table 2. The value of  $V_a$  (attractiveness rating) for the furniture substrate market is 3.20, indicating that producers of panel products feel that this market is more attractive than average.

### ***Interpretation and Discussion***

The process described would be repeated for all potential product-market scenarios, with the position of the new product in each situation displayed on the matrix. The result is an easily interpreted tool for guiding decisions regarding further product development.

The key issue in utilizing a matrix for decision-making, as with all models, lies in the interpretation of the results. For the example described here, a matrix has been developed with the new wood-based panel's status as a substitute in the office furniture substrate market relative to other potential markets.

Figure 2 is an example of how a completed matrix might look. Hypothetical alternate markets, 1 through 4, have been placed on the matrix for purposes of illustration.

Given the office furniture substrate market's score of 3.20 on market attractiveness, it has been positioned slightly above average on that axis (Figure 2).

Interpretation of the competitive advantage axis is slightly more complex. Each alternative market positioned on the matrix represents the new panel's relative competitive advantage versus existing products in that market. The new panel has an SOA score of 1.09, so it has been placed at a position indicating that it has a slightly greater competitive advantage than existing products in the office furniture substrate market. On the other hand, the same panel is approximately equal to other products that it might compete with in Alternate Market 3, and is inferior to existing products in Alternate Market 2.

In a full analysis, each existing product in a given market would be scored using the SOA procedure, and the SOA score of the new product would be compared to the distribution of SOA scores in that market. With scores centering around 1.00, one standard deviation above 1.00 might be considered "relatively superior to" existing products.

In addition to selecting a target market, this analysis may be used to guide further technical development. From

the example, screw-holding strength received the highest determinance score yet the new panel is estimated to have values for this attribute that are only equal to those of existing substrate materials. Development efforts, then, might be best directed at significantly increasing the new panel's screw-holding strength value above those of the existing materials. The combination of a higher value for that attribute and the high determinance score would have a much greater effect on the new panel's relative competitive advantage than would an increase for some other attribute such as edgbanding capability.

Ideally, a firm would choose the scenario which exhibited the greatest market potential (market attractiveness) and the greatest relative product advantage. Thus, the product-market combination positioned closest to the upper right corner of the matrix (office furniture substrates) would be selected, and targeted for further product development.

It should be noted that not all cases would be as clearly interpreted. This model will not make the ultimate decision regarding which market to enter, but does provide information which, when combined with other factors such as a firm's expertise or marketing capabilities, can help direct market selection and ultimately guide further product development.



This study has demonstrated a market-based approach to decision-making in the new industrial product development process. By employing an easy-to-interpret decision matrix for the selection of target markets and product attributes prior to final product development, market analysts can communicate to product development scientists/engineers not only the product attributes most determinant to the future purchase decisions of their customers, but also appropriate levels of these attributes. The product development scientists/engineers receive from the process clear and concrete goals to guide their efforts in the evolution of the new product. Firms gain a method by which they can systematically identify and concentrate on opportunities which afford the greatest competitive advantage, and ultimately provide greater opportunity for success in the marketplace.

### ***Literature Cited***

- Alpert, M.I. 1971. Identification of Determinant Attributes: A Comparison of Methods. Journal of Marketing Research 8(2):184-191.
- Bass, F.M., and W. Wilkie. 1973. A Comparative Analysis of Attitudinal Predictions of Brand Preference. Journal of Marketing Research 10(3):262-269.
- Bodig, J., and B.A. Jayne. 1982. Mechanical Behavior of Wood and Wood Composites. Van Nostrand Reinhold Co., Inc., New York. pp. 712.
- Bearden, W.O. 1977. Determinant Attributes of Store Patronage: Downtown Versus Outlying Shopping Centers. Journal of Retailing 53(2):15-22.
- Cooper, R.G. 1979. Introducing Successful New Industrial Products. European Insights in Industrial Marketing. Ed. by Malcolm McDonald. MCB Publications Limited, Bradford, England. p. 195-225.
- Cooper, R.G. 1988. Predevelopment Activities Determine New Product Successes. Industrial Marketing Management 17(3):237-247.
- Cooper, R.G., and E.J. Kleinschmidt. 1987. Success Factors in Product Innovation. Industrial Marketing Management 16(3):215-223.
- Day, G.S. 1986. Analysis for Strategic Market Decisions. West Publishing Co., St. Paul, MN. pp. 193-216.
- Drucker, P.F. 1990. Marketing 101 for a Fast-Changing Decade. Wall Street Journal Nov. 20, 1990.
- Edwards, K.L., and T.J. Gordon. 1983. Further Research into a Convention for Measuring the State-of-the-Art of Products or Processes. Technological Forecasting and Social Change 24(2):153-175.
- Farquhar, C.R., and S.J. Shapiro. 1983. Strategic Business Planning in Canada. Ottawa: The Conference Board of Canada. April.
- Fishbein, M. 1967. A Behavior Theory Approach to the Relations Between Beliefs About an Object and the Attitude Toward the Object. Readings in Attitude Theory and Measurements. Wiley, New York, p. 389-399.

- Furniture Design and Manufacturing. 1990. The FDM 300. Furniture Design and Manufacturing. 62(2):21-158.
- Gordon, T.J., and T.R. Munson. 1981. A Proposed Convention for Measuring State of the Art of Products or Processes. Technological Forecasting and Social Change 20(1):1-26.
- Hopkins, D.S. 1980. New Products Winners and Losers, The Conference Board, report no. 773, New York, NY.
- Howell, D.C. 1987. Statistical Methods for Psychology, 2nd edition. Duxbury Press, Boston, MA.
- Hunt, J.F., and D.E. Gunderson. 1988. FPL Spaceboard Development. TAPPI proceedings of the 1988 Corrugated Containers Conference; Oct. 24-27; Orlando, FL. Atlanta, GA: TAPPI Press:11-17.
- Kalafatis, S.P., R.J. Cooper, and C. Smith. 1989. The Promotion of a New Type of Particleboard to Architects - the Case of COMPAK. Journal of the Institute of Wood Science 11(5):186-192.
- Karakaya, F. and M.J. Stahl. Barriers to Entry and Market Entry Decisions in Consumer and Industrial Goods Markets. 1989. Journal of Marketing 53(2):80-91.
- Link, P.L. 1987. Keys to New Product Success and Failure. Industrial Marketing Management 16(1):109-118.
- Miller Freeman. 1989. Directory of the Forest Products Industry. Miller Freeman Publishers, San Francisco, CA.
- Miller Freeman. 1989. Secondary Wood Products Manufacturers Directory. Miller Freeman Publishers, San Francisco, CA.
- Myers, J.H., and M.I. Alpert. 1968. Determining Buying Attitudes: Meaning and Measurement. Journal of Marketing 32(4):18-20.
- Porter, M.E. 1985. Competitive Advantage. The Free Press, New York.
- Rosenberg, N., P. Ince, K. Skog, and A. Plantinga. 1990. Understanding the Adoption of New Technology in the Forest Products Industry. Forest Products Journal 40(10):15-22.

- Rosłanowska-Plichcińska, K. 1988. Measuring the Technical-Technological State of Products or Processes. Technological Forecasting and Social Change 33(2):63-74.
- Schaninger, C.M., and W.C. Buss. 1986. Removing Response-Style Effects in Attribute-Determinance Ratings to Identify Market Segments. Journal of Business Research 14(3):237-252.
- Schill, R.L. 1986. Managing Technology for Competitive Advantage in Interindustry Markets. R&D Management 16(2):103-116.
- Setterholm, V.C. 1985. FPL Spaceboard - A New Structural Sandwich Concept. TAPPI Journal 68(6):40-42.
- Sinclair, S.A., and E.C. Stalling. 1990. How to Identify Differences Between Market Segments with Attribute Analysis. Industrial Marketing Management 19(2):31-40.
- Suchsland, O., and W.S. Good. 1968. The Selection of Panel Materials by Furniture and Cabinet Manufacturers. Michigan Agricultural Experiment Station Journal Article No. 4378. Dept. of Forest Products, Michigan State University, East Lansing, MI. pp 11.
- Wind, Y., and H.J. Claycamp. 1976. Planning Product Line Strategy: A Matrix Approach. Journal of Marketing 40(1):2-9.
- \_\_\_\_\_, and V. Mahajan. 1981. Designing Product and Business Portfolios. Harvard Business Review 59(1):155-165.
- \_\_\_\_\_, \_\_\_\_\_, and D.J. Swire. 1983. An Empirical Comparison of Standardized Portfolio Models. Journal of Marketing 47(2):89-99.
- Zoltners, A.A., and J.A. Dodson. 1983. A Market Selection Model for Multiple End-Use Products. Journal of Marketing 47(2):76-88.

TABLE 1. - Mean importance, mean variability, and row-centered determinance scores for panel characteristics.

Attributes	<sup>1</sup> Importance	<sup>2</sup> Variability	<sup>3</sup> Determinance
Fastener withdrawal strength	5.76	3.17	*3.54
Surface smoothness	5.91	2.96	*3.52
Flatness	6.00	2.76	*2.27
Stiffness (MOE)	5.17	2.98	*1.92
Edgebanding capability	5.91	2.74	*1.35
Internal bond strength	5.45	2.77	0.95
Breaking strength	5.12	2.98	0.94
Machinability	4.72	3.04	0.65
Gluability	5.74	2.60	0.52
Overall density	4.62	3.20	0.52
Dimensional stability	5.64	2.46	-0.20
Stress relaxation (creep)	5.24	2.56	-0.76
Loss of smoothness w/ humidity	5.19	2.38	-1.67
Compatibility w/ mfg. system	5.38	2.30	-1.80
Loss of strength w/ humidity	4.98	2.32	-2.20
Loss of stiffness w/ humidity	4.97	2.26	-2.52
Strength to weight ratio	4.22	2.68	-2.73
Fire resistance	3.69	2.49	-4.31

<sup>1</sup>Scale of 1 to 7: 1 = Somewhat Important; 7 = Absolutely Critical

<sup>2</sup>Scale of 1 to 5: 1 = All about the same; 5 = Highly variable

<sup>3</sup>Mean overall score is 0. Scores above 0 have more impact on purchase decisions than scores below 0.

\*Selected by Tukey HSD multiple comparison test for further analysis.

TABLE 2. - Summary of market attractiveness factors.

Market Attractiveness Factor	${}^1R_n$	x	${}^2I_n$	=	$R_n I_n$
Market profitability	3.31		.2736		0.90
Overall market size	3.69		.1321		0.49
Market growth rate	3.31		.1221		0.40
Structure of the competition	3.31		.1107		0.37
Potential for differentiating your product	2.92		.0921		0.27
Market cyclicity	3.08		.0571		0.18
Rate of technological change in the market	3.23		.0471		0.15
Threat of substitution to your product	2.77		.0414		0.11
Barriers to entry	2.67		.0393		0.10
Legal environment	2.83		.0294		0.08
Stage of the market's "Life Cycle"	2.85		.0293		0.08
Threat of backward integration of the buyers of the product	2.77		.0258		0.07
			1.0000		${}^33.20$

${}^1$ Ratings of the market on  $n$ . Scale of 1 to 5; 1 = Very Unattractive; 5 = Very Attractive.

${}^2$ Mean relative importance of factor.

${}^3V_a$  or Market Attractiveness Rating.

TABLE 3. Summary of attractiveness factors.

	G.E. Business Screen	Day (1986)	Shell Directional Policy Matrix	Zoltner and Dodson (1983)	Porter (1986)	Karakaya and Stahl (1989)	BCG Growth/ Share Matrix
Legal Environment	X	X	X	X	X		
Structure of Competition		X	X	X	X		
Market Growth Rate	X	X	X	X			
Market Size	X	X	X	X			
Market Profitability	X	X	X	X	X		
Barriers to Entry	X	X			X	X	
Market Cyclality	X	X		X			
Level of Technology			X	X			
Threat of Backward Integration		X			X		
Substitution Threat	X		X		X		
Potential for Differentiation		X					
Stage of Product Life Cycle							X

TABLE 4. - Calculation of SOA weight factors ( $K_n$ ).

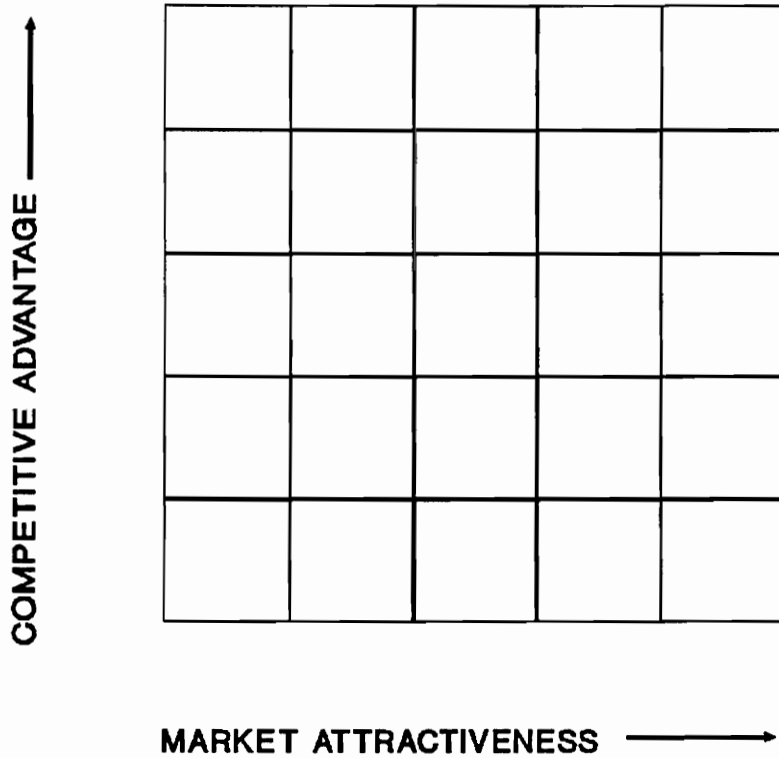
$\sum_{j=1}^2 D\bar{N}_j$	=	1.35 + 1.92 + 2.27 + 3.52 + 3.54	=	12.60
$K_{FASTEN}$	=	3.54/12.6	=	0.28
$K_{SURFACE}$	=	3.52/12.6	=	0.28
$K_{FLATNESS}$	=	2.27/12.6	=	0.18
$K_{MOE}$	=	1.92/12.6	=	0.15
$K_{EDGE BAND}$	=	1.35/12.6	=	<u>0.11</u>
				1.00



TABLE 5. Calculation of the State-of-the-Art (SOA) score for a new wood-based panel.

$$SOA = K_1(P_1/P_1) + K_2(P_2/P_2) + \dots + K_n(P_n/P_n)$$

Fastener withdrawal	0.28 (335 psi/335 psi)	=	0.28 (1.00)	=	0.28
Surface smoothness	0.28 (3.75/3.00)	=	0.28 (1.25)	=	0.35
Flatness	0.18 (3.30/3.00)	=	0.18 (1.10)	=	0.20
Stiffness	0.15 (395,000 psi/395,000 psi)	=	0.15 (1.00)	=	0.15
Edgebanding cap.	0.11 (3.00/3.00)	=	0.11 (1.00)	=	<u>0.11</u>
					1.09



**Figure 1. Market attractiveness matrix.**

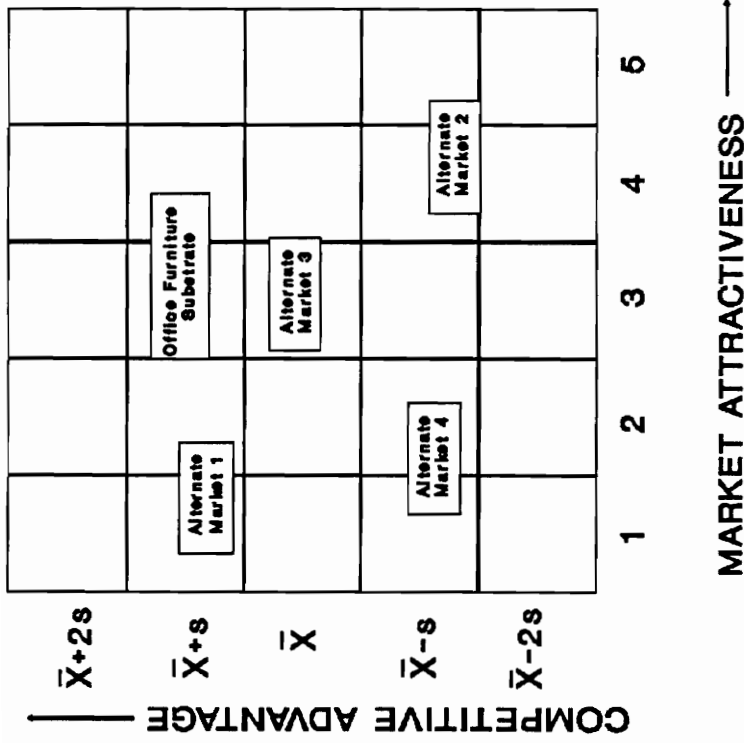


Figure 2. Market attractiveness matrix with hypothetical results.

## ***Conclusions***

This study sought to achieve two basic objectives, both intended to enhance the ability of the wood products industry to survive in the marketplace by bringing a marketing orientation to the new product development process.

The first objective was to demonstrate the use of determinant attribute analysis in identifying the key physical product attributes necessary for successful competition by a new wood-based product (in this case FPL Spaceboard II) in the office furniture substrate market. In addition, this analysis provides information which can lead product developers to design a product which can not only compete, but achieve a competitive advantage in the market and foster a greater chance of success in introduction and commercialization of the product. In the Spaceboard/office furniture example, fastener withdrawal strength, surface smoothness, flatness, stiffness, and edgbanding capability were identified by determinant attribute analysis as the physical product characteristics around which a competitive advantage for the product could be built, as well as target levels to be achieved or surpassed. The potential for reapplication of this method to any new wood product is obvious.

The second objective was to develop and illustrate a broader model by which target markets could be selected for new products and performance levels necessary for successful

introduction could be identified. The model was built around the concepts of market attractiveness and relative competitive advantage of the product versus existing materials in each potential market examined. The resulting model is an easily interpreted model which would be very useful in integrating marketing with technological research during the design stages of new product development.

The simplicity and intuitiveness of these methods lend support to their potential role in guiding the development of new value-added products to achieve competitive advantage for the wood products industry in the marketplace.

### ***Opportunities for Further Research***

Several opportunities exist for building on this study in future research projects, based both on the findings of the study and the methodology derived in it.

To better develop an understanding of the implications of the determinant attributes and their impact on the successful introduction of FPL Spaceboard II in the marketplace, conjoint analysis should be applied. Conjoint analysis can provide some measure of the value of trade-offs, which are often necessary in designing a product which not only meets the functional needs of the users but also is affordable to them. This analysis essentially can yield an estimate of how much the potential purchasers of the product are willing to pay for the design features.

The decision matrix also provides an opportunity for a more in-depth study in the application of the methods demonstrated here. Full implementation of the analysis involving several unrelated potential markets should result in measurable guidelines by which the actual introduction of Spaceboard II can be compared.

Finally, the methodology could be further validated by application to another new product. The methods used here are believed to be widely applicable to any new product scenario, and would certainly assist the wood products industry in

developing a market-oriented approach to new product introduction.

## ***Vitae***

Mark Trinka enrolled at Oklahoma State University in 1983, where he earned a B.S. in Agriculture (Forestry - Products option), and a minor degree in Marketing. Upon completion of his studies in 1988, he enrolled at Virginia Polytechnic Institute and State University in Blacksburg, Virginia to begin work towards the degree of Master of Science in Wood Science and Forest Products, specializing in Forest Products Marketing.

Prior to completion of the requirements of the degree, Mark took advantage of an employment opportunity with the Procter & Gamble Cellulose Company which matched his educational background of forestry, forest products, and marketing. His current position is international sales representative for undelignified cellulose-based structural products at the division headquarters in Memphis, TN. While employed with the company, he has continued work toward his degree, and will continue work with Procter & Gamble upon completion of the thesis.

  
\_\_\_\_\_  
MARK W. TRINKA



***Appendix 1: Survey Questionnaire***



SCHOOL OF FORESTRY AND WILDLIFE RESOURCES

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061-0503

DEPARTMENT OF WOOD SCIENCE & FOREST PRODUCTS

FAX: (703) 231-8868

Thomas M. Brooks Forest Products Center

FACSIMILE TRANSMISSION

DATE: ^D Page 1 of 3  
TO: ^F2^, ^F4^  
^F1^  
FAX: ^F11^  
PHONE: ^F10^  
FROM: Mark Trinkka - Research Assistant, Virginia Tech  
FAX: (703) 231-8868  
PHONE: (703) 231-5876  
SUBJECT: MDF / Industrial Particleboard Manufacturer Survey

^F3^:

Here is the survey concerning the market for MDF and industrial particleboard as core materials for business and institutional desk and tabletops that we discussed on the telephone. This survey is part of my work towards a Master's Thesis and I desperately need your input.

The short survey takes only a few minutes to fill out. Please use a dark pen to make the responses more legible. If the facsimile transmission is incomplete or unreadable, please notify me at (703) 231-5876 as soon as possible. When you have completed the survey, please FAX it back to me at (703) 231-8868.

Thank you very much for your time and consideration. Your response will be strictly confidential. The information that you provide will be invaluable in completing my research. **Thanks!**

Sincerely,

Mark Trinkka

## MDF / Particleboard Manufacturer Market Survey

This survey is designed to gather information on marketing decisions made by producers of MDF and industrial particleboard for core materials in the office furniture market. If your firm produces MDF and/or industrial particleboard at more than one location, please answer the questions with regard to your firm's total production. Thank you!

1. Please divide 100 points between the following factors based on their importance when making a decision to enter a market with your product. Please mark all factors; factors which are not important should be given "0".

- \_\_\_\_\_ Structure of the competition
  - \_\_\_\_\_ Market growth rate
  - \_\_\_\_\_ Legal environment
  - \_\_\_\_\_ Barriers to entry
  - \_\_\_\_\_ Overall market size
  - \_\_\_\_\_ Threat of substitution to your product
  - \_\_\_\_\_ Market profitability
  - \_\_\_\_\_ Potential for differentiating your product
  - \_\_\_\_\_ How cyclical the market is
  - \_\_\_\_\_ Rate of technological change in the market
  - \_\_\_\_\_ Threat of backward integration by the buyers of the product
  - \_\_\_\_\_ Stage of the market's "Life Cycle" (intro/growth/maturity/decline)
- 100%

2. Please rate the attractiveness of the table and desktop core material segment of the office furniture market regarding each of the above factors:

	<u>Very</u> <u>Unattractive</u>			<u>Very</u> <u>Attractive</u>	
	1	2	3	4	5
Structure of the competition	1	2	3	4	5
Market growth rate	1	2	3	4	5
Legal environment	1	2	3	4	5
Barriers to entry	1	2	3	4	5
Overall market size	1	2	3	4	5
Threat of substitution to your product	1	2	3	4	5
Market profitability	1	2	3	4	5
Potential for differentiating your product	1	2	3	4	5
How cyclical the market is	1	2	3	4	5
Rate of technological change in the market	1	2	3	4	5
Threat of backward integration by the buyers of the product	1	2	3	4	5
Stage of the market's "Life Cycle" (introduction/growth/maturity/decline)	1	2	3	4	5

3. Please indicate how important you feel the following physical characteristics of substrate materials are to the manufacturers of business and institutional furniture:

	<u>Somewhat</u> <u>Important</u>						<u>Absolutely</u> <u>Critical</u>
	1	2	3	4	5	6	7
Internal bond strength	1	2	3	4	5	6	7
Surface smoothness	1	2	3	4	5	6	7
Fastener withdrawal strength	1	2	3	4	5	6	7
Dimensional stability	1	2	3	4	5	6	7
Stress relaxation (creep)	1	2	3	4	5	6	7
Overall density	1	2	3	4	5	6	7
Edge-banding capability	1	2	3	4	5	6	7
Gluability	1	2	3	4	5	6	7
Breaking strength (MOR)	1	2	3	4	5	6	7
Stiffness (MOE)	1	2	3	4	5	6	7
Machining characteristics (abrasiveness)	1	2	3	4	5	6	7
Strength to Weight ratio	1	2	3	4	5	6	7
Compatibility w/ their current mfg. system	1	2	3	4	5	6	7
Loss of strength w/ humidity	1	2	3	4	5	6	7
Loss of stiffness w/ humidity	1	2	3	4	5	6	7
Loss of surface smoothness w/ humidity	1	2	3	4	5	6	7
Flatness	1	2	3	4	5	6	7
Fire resistance	1	2	3	4	5	6	7

4. Approximately how many square feet (3/4" basis) of your product did you sell in 1989 for table and desktop cores in the business and institutional furniture market?

\_\_\_\_\_ ft<sup>2</sup> (3/4")

5. Approximately what percentage of your annual production is sold into the table and desktop segment of the office and institutional furniture market?

\_\_\_\_\_ %

6. What physical characteristic of your product do your business and institutional furniture customers want to see improved most for core materials in table and desktops?

\_\_\_\_\_

Thank you for your help! It will go a long way toward helping me complete my master's thesis. Please FAX the completed survey back to me at (703) 231-8868 as soon as possible.

**FAX 703-231-8868**

**THANK YOU!**



VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061-0503

DEPARTMENT OF WOOD SCIENCE & FOREST PRODUCTS

FAX: (703) 231-8868

Thomas M. Brooks Forest Products Center

FACSIMILE TRANSMISSION

DATE: ^D Page 1 of 3  
TO: ^F2^, ^F4^  
^F1^  
FAX: ^F11^  
PHONE: ^F10^  
FROM: Mark Trinka - Research Assistant, Virginia Tech  
FAX: (703) 231-8868  
PHONE: (703) 231-5876  
SUBJECT: Office Furniture Manufacturer Survey

^F3^:

Here is the survey concerning business and institutional desk and tabletop core materials that we discussed on the telephone. This survey is part of my work towards a Master's Thesis and I desperately need your input.

The short survey takes only a few minutes to fill out. Please use a dark pen to make the responses more legible. If the facsimile transmission is incomplete or unreadable, please notify me at (703) 231-5876 as soon as possible. When you have completed the survey, please FAX it back to me at (703) 231-8868.

Thank you very much for your time and consideration. Your response will be strictly confidential. The information that you provide will be invaluable in completing my research. Thanks!

Sincerely,

Mark Trinka

## Office and Institutional Furniture Manufacturer Survey

This survey is designed to gather information on desk and tabletop core material decisions made by producers of office and institutional furniture. If your firm produces office or institutional furniture at more than one location, please answer the questions with regard to your firm's total production. Thank you!

1. Please rate the importance of the following physical characteristics in making materials decisions for table and desktop core materials:

	<u>Somewhat Important</u>					<u>Absolutely Critical</u>	
Internal bond strength	1	2	3	4	5	6	7
Surface smoothness	1	2	3	4	5	6	7
Fastener withdrawal strength	1	2	3	4	5	6	7
Dimensional stability	1	2	3	4	5	6	7
Stress relaxation (creep)	1	2	3	4	5	6	7
Overall density	1	2	3	4	5	6	7
Edge-banding capability	1	2	3	4	5	6	7
Gluability	1	2	3	4	5	6	7
Breaking strength (MOR)	1	2	3	4	5	6	7
Stiffness (MOE)	1	2	3	4	5	6	7
Machining characteristics (abrasiveness)	1	2	3	4	5	6	7
Strength to Weight ratio	1	2	3	4	5	6	7
Compatibility w/ your manufacturing system	1	2	3	4	5	6	7
Loss of strength w/ humidity	1	2	3	4	5	6	7
Loss of stiffness w/ humidity	1	2	3	4	5	6	7
Loss of surface smoothness w/ humidity	1	2	3	4	5	6	7
Flatness	1	2	3	4	5	6	7
Fire resistance	1	2	3	4	5	6	7

2. Please rate the range of variability between currently available table and desktop core materials (brands and types) on each of the following characteristics:

	<u>All About the Same</u>				<u>Highly Variable</u>
Internal bond strength	1	2	3	4	5
Surface smoothness	1	2	3	4	5
Fastener withdrawal strength	1	2	3	4	5
Dimensional stability	1	2	3	4	5
Stress relaxation (creep)	1	2	3	4	5
Overall density	1	2	3	4	5
Edge-banding capability	1	2	3	4	5
Gluability	1	2	3	4	5
Breaking strength (MOR)	1	2	3	4	5
Stiffness (MOE)	1	2	3	4	5
Machining characteristics (abrasiveness)	1	2	3	4	5
Strength to weight ratio	1	2	3	4	5
Compatibility with your current manufacturing system	1	2	3	4	5
Loss of strength w/ humidity	1	2	3	4	5
Loss of stiffness w/ humidity	1	2	3	4	5
Loss of surface smoothness w/ humidity	1	2	3	4	5
Flatness	1	2	3	4	5
Fire resistance	1	2	3	4	5

3. Is the core material for table and desktops that your firm purchases custom manufactured to your specifications?  
 Yes       No

4. Approximately how many square feet (3/4" basis) of desk and tabletop core material does your firm consume annually?  
\_\_\_\_\_ sq. ft. (3/4" basis)

5. Please indicate which type of surface material that your firm most often uses for business or institutional furniture desk and tabletops:

- a.  wood veneer      b.  high pressure laminates  
c.  low pressure laminates      d.  vinyl films (PVC)      e. other: \_\_\_\_\_

6a. What is the most common core material that your firm uses for table and desktops?  
\_\_\_\_\_

6b. Approximately what percentage of your total table and desktop core material consumption does that material account for?  
\_\_\_\_\_ %

6c. If your response to question 6a. was medium-density fiberboard or industrial particleboard, what grade and density does your firm most commonly use?

Grade: \_\_\_\_\_ lbs/ft<sup>3</sup>

7. Please indicate which of these types of business or institutional furniture that your firm manufactures. Check all that apply.

- a.  office desks      b.  bookshelves      c.  equipment support  
d.  credenzas      e.  laboratory tables      f.  work/conference tables

8. In your opinion, what physical characteristics of currently available core materials need to be improved most? Please rank from 1 to 3.

1. \_\_\_\_\_      2. \_\_\_\_\_      3. \_\_\_\_\_

9. Do you feel that your firm is under pressure to produce lighter-weight business and institutional furniture?  
 Yes       No

10. Approximately what percentage of your total materials cost does core material represent?  
\_\_\_\_\_ %

Thank you for your help! It will go a long way toward helping me complete my master's thesis. Please FAX it back to me at (703) 231-8868 as soon as possible.

FAX 703-231-8868

THANK YOU!