Title: The New Economy: High-Tech Global Marketing and the Engineering Manager (Virtual Reality Exemplified)

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and the Engineering Manager

(Virtual Reality Exemplified)

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THE NEW TECHNOLOGY: HIGH-TECH GLOBAL MARKETING AND THE ENGINEEING MANAGER (VIRTUAL REALITY EXEMPLIFIED)

Abstract

Team 1 researches new technology marketing with a global flare. Seven essential marketing strategies are identified and compared with engineering management principles to raise awareness of the need for engineering and marketing integration. Strategies and principles are then applied to broad category of high technology products for geographic regions around the world to gain perspective of their effectiveness. Virtual reality products are used as a specific example to illustrate marketing techniques that apply to emerging new technology. Although there is considerable interest in virtual reality in itself, the Team opted to focus on international new technology marketing using virtual reality as a representative product line. The study is approached from the perspective that Team 1 is a virtual reality product supplier.

Included in this report is a comparison of the initial model of the steps needed to create an international marketing plan for a high technology product. A seven step outline is presented for creating a marketing plan, ten principles of market behavior are identified By intersecting marketing strategies and engineering management concepts, there are four critical areas that directly concern engineering managers. International considerations add other dimensions. Culture, government, environment, and economics play key roles in determining effectiveness of marketing efforts.

It is the engineering manager's responsibility to know the technology, its purpose, and its direction. That manager also must clearly understand global influences to ensure that design and after-market support considerations account for diverse international conditions. Innovation, rather than invention, is key, and the focus is on marketing, not sales.

Introduction

This is a wake-up call for new technology company engineering managers. Knowledge of global marketing is no longer optional. Soothsayers foretell visions of the future and the economic impact of technology on it. Whether their forecasts are right or believable, new technology is reshaping worldwide economy. Worn out clichés describe a shrinking planet. Communication satellites, Toyota plants in Georgetown, Kentucky, McDonald's in Bejing and Moscow, and microchips everywhere atest to the notion that globalization is rapidly replacing local, regional, and even national interests.

Virtual reality (VR) has numerous uses - and limitations - typical of a new technology product. Original applications were designed for military pilot training. Since then, VR has surfaced in a variety of design disciplines, entertainment, medical research, advertising, etc. But, VR is not without its flaws: It requires substantial computing power and is expensive. Products are designed for specific applications and are not versitile or readily transportable. And, there are known side effects for helmet wearers: crude graphics cause nausea and vertigo.

In their book, **Strategic Management**, Authur Thompson and A.J. Strickland frame steps to a marketing plan:

1. Identify the industry's dominant economic characteristics.
2. Identify and assess "driving forces"
3. Evaluate strengths of competitors.
4. Assess competitive positions of companies in the industry.
5. Predict who will make what moves.
6. Pinpoint key success factors.
7. Draw conclusions about overall industry attractiveness.

Hans Thamhain devotes an entire chapter in his text, **Engineering Management,** to requirements for integrating marketing and engineering management. His principles include market and technology forecasting, technology development, product and service development, technical product selling, and field engineering/servicing.

By intersecting marketing strategies and engineering management concepts, there are four critical areas that directly concern engineering managers:

1. Market needs and opportunities must be recognized and acknowledged. Technology cannot exist for itself.
2. Organization, skills, and resources must be in adequate supply and managed.
3. Rapid product development is required for entry into high technology

markets. 7. Time is a luxury.

4. After-market product support is essential to generating repeat and new business.

International considerations add other dimensions. Culture, government, environment, and economics play key roles in determining effectiveness of marketing efforts. Interactive TV has no meaning to Sahara dessert tribesmen while U. S. medical researchers clamor for VR interpretation of magnetic resonance imaging (MRI) output. The Japanese government throws up numerous trade barriers to protect their vested interests. The European Common Market favors member nations and imposes a litany of safety regulations for electronics. Currencies play havoc with financial statements and planning. One key factor in the term "user friendly" is the capability for a product and its support functions to communicate in native languages. The list goes on, and on....

Engineering managers in emerging technology cannot hide in the R & D lab and be creative [13]. There must be a purpose for what goes into the test tube, and the test tube must produce marketable results that hit the street when needed. It is the engineering manager's responsibility to know the technology, its purpose, and its direction. That manager also must clearly understand global influences [27] to ensure that design and after-market support considerations account for diverse international conditions.

Project Presentation

> *"The nation that thrives on high technology is going to have a superior material standard of living... a larger say in the conduct of world affairs. Adeptness depends not only on the collective ability of a nation's scientists to make headway in the laboratory, but also on the prowess of its business people in developing and marketing incipient technologies..."*
>
> William L. Shanklin, John K. Ryans, Jr.
> **Essentials of Marketing High Technology**

Shanklin's and Ryans' statement is profound. But, what bears out their assertion? In a February 1993 article in the *IEEE Transactions on Engineering Management*, presents a table of 39 microelectronic technologies ranging from advanced composite materials to VCRs. Original R&D efforts, first product introduction, and current market leaders are given by geographic area for each technology. Here is a summary of the 39 items.

Presentation Bar Graph Figure really revealed importance of Market

Geographic Area	Original R&D	First Products	Current Market Leader
U. S.	30	30	13
Europe	9	6	2
Japan		2	22
Other		1	2

The U.S. led R&D efforts and first product introductions on 77% of the items. While Japan did not contribute to any of the original development, the country now leads the market with 56% of the products. Why the shift? Edosomwan's case study of Xerox's attempts to enter the microcomputer arena is a classic example. Xerox invested $150 million on the Palo Alto Research Center and untold man years on the "Alto" computer system only to watch the technology disperse to competitors. Businesses across the U. S. and Europe have seen the story repeated again, and again... electronics, automobiles, heavy equipment, machine tools, etc. Some of the shift can be attributed to lower labor costs outside the U. S., but the Xerox story is more indicative of the issue. The U. S. is very good at inventing and innovating; problems begin after R&D. Products

are introduced, but market development is lacking.

Project Structure

Team 1 is a collage of international interests; members represent six countries. Given the team's global makeup, international aspects of technology appealed as a topic of study. Team 1 set out to research and recommend strategies to successfully market virtual reality internationally, from a technology management perspective. The intent was to research how virtual reality currently is being used and marketed, to separate successes from failures, and to develop recommendations from winning scenarios. As research began, interest peaked more in virtual reality technology rather than getting the product to market. Dozens of articles and books providing valuable background on virtual reality's uses were collected. But, research and the Team's focus had to be redirected to marketing issues. At that point, the Team realized that virtual reality was only emblematic of a far more significant issue: successful international marketing of new technology. The remainder of this discussion is directed at the broader topic.

Assumptions

The following assumptions were set to establish some logical boundaries for the project:

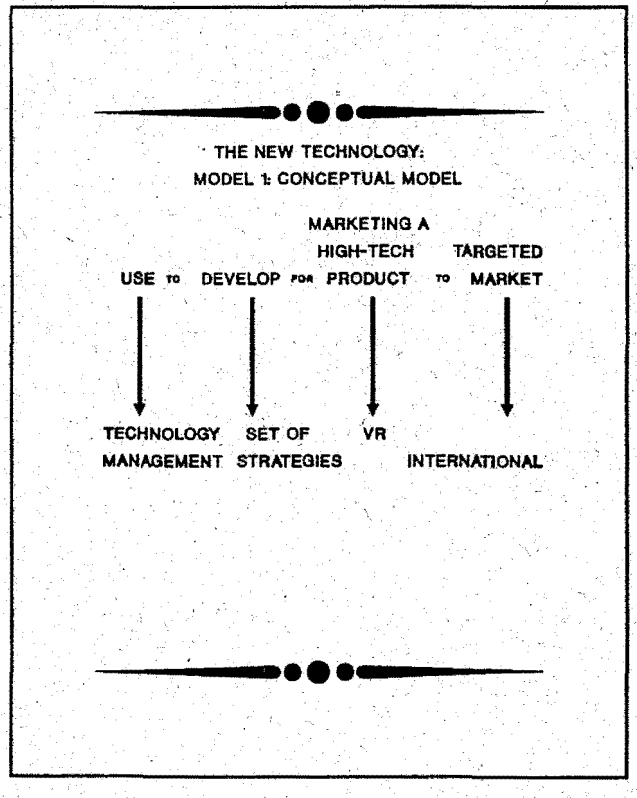
1) The problem is approached as though the Team is a supplier of a virtual reality product.

2) The product is in existence, but innovation is a key factor.

3) Marketing is clearly differentiated from sales. For a new technology product, identifying and building a market comes well ahead of closing sales.

Project's Conceptual Model

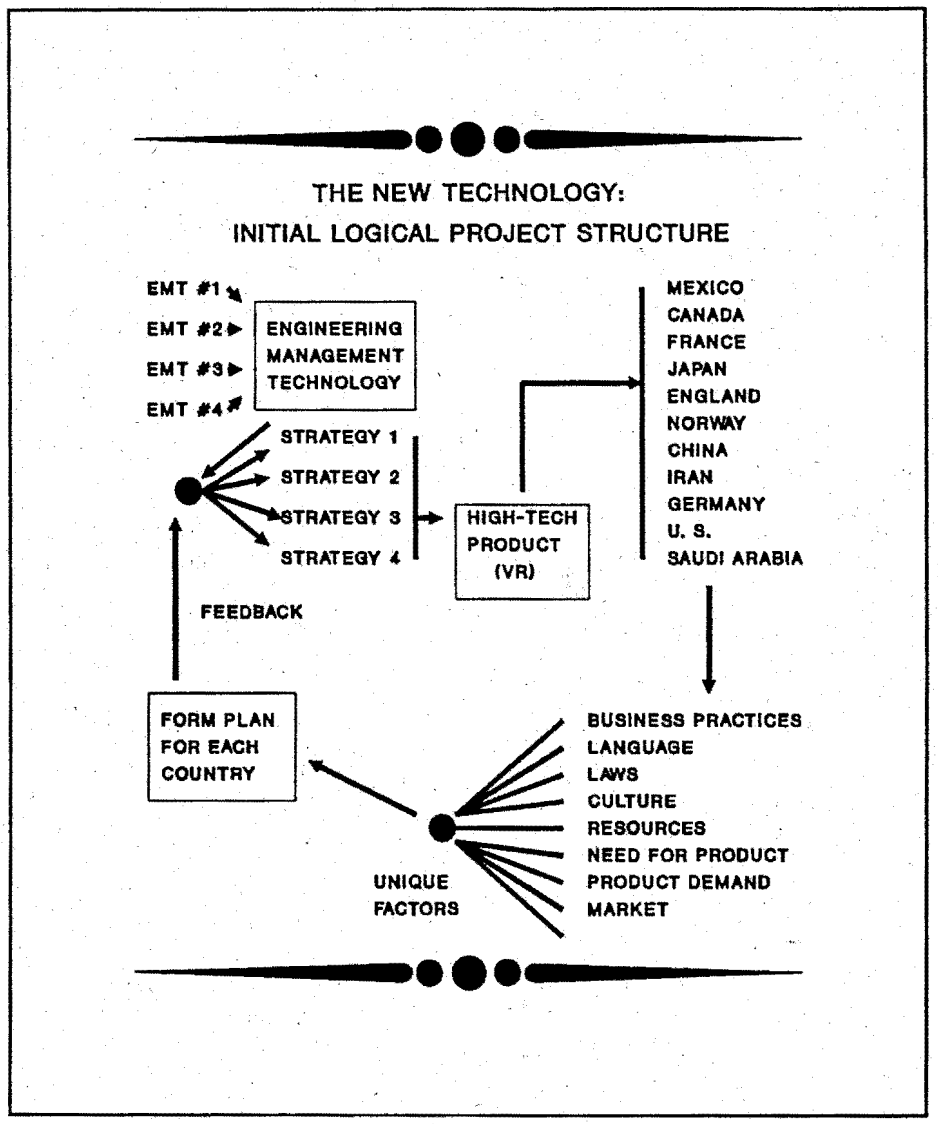
Model 1 is the initial logic which the Team assumed to be true and is presented below.



These Models (pages 6+7) should be discussed in the report when they are presented.

The model from the previous page allowed us to develop Flowchart 1.

Flowchart 1. - Initial logical structure of the project



Literature Search

Team members devoted the majority of their research efforts toward resources available at Portland State University and Multnomah County libraries. However, some

important material was found at Powell's Book Store, Technical branch. Recent periodicals provided much of the technical data, but several recently published text books discuss high technology marketing in detail. The text books concentrated on marketing strategies in general with only cursory looks at specific international issues. Periodicals focused on narrower topics including marketing in specific countries.

Supporting Data

In their book on strategic management, Arthur Thompson and A. J. Strickland define an outline for a marketing plan.

7 Marketing Steps

1. Identify the industry's dominant economic characteristics, including the following:

- Market size
- Scope of local, regional national, and global competitive rivalries
- Market growth rate and the industry's position in the growth cycle
- Number of rivals and their relative size
- Number of buyers and their relative size
- Prevalence of forward and backward integration
- Ease of entry and exit
- Pace of technological change in both production processes and new product introductions
- Whether there are economies of scale in manufacturing, transportation, or mass marketing
- Whether high rates of capacity utilization are critical to achieving low cost production efficiency.
- Whether the industry has a strong learning and experience curve
- Capital requirements
- Whether industry profitability is above or below par

2. Identify and assess driving forces which are...

   - Changes to long term industry growth rates
   - Changes in who buys the product and/or how the product is used
   - Product innovation
   - Technology change
   - Market innovation
   - Entry or exit of major firms
   - Diffusion of technical know-how
   - Increased globalization
   - Changes in cost and efficiency
   - Emerging buyer preference for differentiated instead of a commodity products
   - Regulatory influences and government policy changes
   - Changes in societal concerns, attitudes, and lifestyles
   - Reduction in uncertainty and business risk

3. Evaluate strength of competitors and their competitive forces which are...

   - Substitute products
   - Power of suppliers
   - Power of buyers
   - Potential new entrants
   - Rivalry among competitors

4. Assess competitive positions of companies in the industry.

5. Predict who will make what moves next.

6. Pinpoint key success factors
   - Technology-related
     - Scientific research expertise
     - Production process innovation capabilities
     - Product innovation capabilities
     - Expertise in a given technology
   - Manufacturing-related
     - Low cost production efficiencies
     - Quality of manufacture
     - High utilization of fixed assets
     - Low cost plant locations
     - Access to adequate skilled labor
     - Low cost product design and engineering
     - Flexibility in manufacturing
   - Distribution-related
     - Strong network of distributors
     - Low cost distribution
     - Fast delivery
   - Marketing-related
     - Effective sales force
     - Available, dependable service and technical assistance
     - Accurate order filling
     - Breadth of product line
     - Merchandising skills
     - Attractive styling and packaging
     - Guarantees, warranties
   - Skills-related

- Superior talent
- Quality control know-how
- Design expertise
- Expertise in a particular technology
- Ability to get products out of R&D and into the market

- Organization-related
  - Superior information systems
  - Ability to respond to shifting markets
  - Experience and managerial know-how
- Others
  - Favorable image or reputation with buyers
  - Overall low cost producer
  - Convenient locations
  - Pleasant, courteous employees
  - Access to financial capital
  - Patent protection

7. Draw conclusions about overall industry attractiveness
   - Industry growth
   - Whether the industry will be favorably or unfavorably impacted by prevailing driving forces.
   - Potential for entry and exit of major firms
   - Stability and/or dependability of demand
   - Whether competitive forces will become stronger or weaker
   - Severity of problems or issues confronting the industry as a whole
   - Degree of risk and uncertainty in the industry's future
   - Whether the industry's overall profitability is above or below par

As can be observed from the marketing strategies presented thus far, consideration for international influence [4], [14] is marginally addressed. There are four major categories [18] which must be included in any international marketing plan surrounding high technology products.

1. Cultural

   - Is the targeted market ready for the product?
   - If so, will the targeted market intuitively accept the product, or is product concept education required?
   - Is product documentation available in the country's native language?
   - Is advertising and packaging in keeping with the country's mores?
   - Are those performing services and technical support versed in the country's language, business ethics, and culture?

2. Governmental

   - Will the government permit deployment of the technology to the targeted customers?
   - Are licenses required to market and sell the product?
   - Does the product need to be certified?

3. Environmental

   - For electronic products, is the country's power source compatible with the product's requirements?
   - Are there safety requirements, such as radiation emission levels, that must be satisfied which were not included in product design parameters?

4. Economic

- Is the new technology affordable by the targeted market?
- What trade barriers exist?
- Is the country a member of the IF? Can currency be moved in and out of the country, or are intermediaries needed?
- Are letters of credit required?
- Are there customs or value-added taxes that must be paid by the supplier?

Where does virtual reality fit into the discussion? (For the interested reader, a discussion of virtual reality's history and some actual marketing experiences are given in Appendix A.) As noted earlier, the product is representative of emerging new technology. Initially developed for the military as a pilot training tool, the product has evolved into numerous other areas. It is now commonly used for architectural and mechanical design, medical research, entertainment, and advertising. These are but a few examples:

National Information Display Laboratories in Princeton New Jersey, in cooperation with the National Institute of Health is using virtual reality to detect breast cancer [15].

Using high-speed data links, doctors at Oregon Health Sciences University can share 3-D diagnostic information over the Internet. The 3-D images allow the doctors to move about the diagnostic area... a virtual lab.

ViaTech recently announce a "virtual exercise" machine which is a stationary bicycle with controls that allow the user to cycle through the English countryside. Scenes change as the bicycle is steered. Physical exertion is governed by road surface and inclines. Price: $3,800.

Ford Motor Corporation is planning to build the "virtual showroom" in which a car buyer can select a particular model and test drive the car in the confines of virtual reality.

When planning the new test and training center for the 777 airplane, Boeing's

architects completely designed and constructed the building in virtual reality, then allowed Boeing management to tour the building using joy sticks to guide their path. The graphics included, pictures on the walls, other people in the building, plants, furniture, etc.

Even though virtual reality offers a powerful tool, it is important to note its limitations. First, the technology is relatively new to the commercial market. It is expensive. Second, much of the hardware is standard computing equipment with exception of the human-computer interface. Some implementations require a helmet and glove to control visual effects and motion. Others can use standard computer screens, joy sticks, etc. Where the helmet is used, some graphics are still relatively crude, and users have experienced vertigo and nausea from the jerky motion and depth perception displayed [20]. Virtual reality primarily appeals to sight and marginally to the touch senses. Development of interfaces to the other human senses is still in its infancy. Third, all of the implementations cited are application-specific. That is, equipment and software are paired to accomplish one task. Although buyers may be willing to use the technology, justification is difficult given its expense and specific task orientation.

In spite of the product's limitations, it is easy to see expanding possibilities for its use. The majority of applications are implemented in technically advanced countries. Given the limitations, can the product be successfully marketed elsewhere? In his book on accelerating innovation, Marvin Patterson cites Asian success in the computer industry as a "me too, but better" strategy[19]. The way Japan tackled the electronics industry could be just as easily applied to any other technology, such as virtual reality[27]. If virtual reality's cost and applications limitations are overcome, prohibited markets become available.

Thompson's and Strickland's outline is a comprehensive (and exhaustive) list of considerations for building a strategic marketing plan[26], but it does not address specific new technology or international marketing considerations. As illustrated at the beginning of the paper, Japan has taken significant market away from the rest of the world. They have learned the difference between marketing that is profit-driven and marketing that is new technology-driven.

10 Principles of High-Technology Market Behavior

Our research concerning the marketing of high technology brought to our attention a series of observations. We sensed that there were marketing-related differences between high- tech companies and markets and those of basic industries. The more that we studied the inner workings of high-tech markets, the more apparent those differences became.

Through our research, we identified 10 high technology marketing principles. They represent significant common traits among markets such as robotics, computers, biotechnology, fine ceramics, and other advanced technology industries. They define the uniqueness of those markets relative to more established fields. To incorporate the engineering management fundamental of planning, before a marketing manager can fully grasp the complexities of a specific high tech industry, he or she must recognize the broader characteristics of marketing high technology described by these 10 principles.

Table 1.0

10 Principles of High-Technology Market Behavior

1. Turbulence and change characterize high technology markets.
2. Corporate bigness is not necessarily competitively advantageous.
3. Supply side marketing dominates early market stages.
4. Opportunity priorization is the high technology company's critical initial step.
5. Major corporate entrants and industry shakeouts signal an evolution to demand-driven markets.
6. Buyer insecurity significantly influences demand.
7. High technology triggers public reactions of hope and fear.
8. High technology attracts inordinate government attention and regulation.
9. High technology has nationalistic overtones.
10. High technology publicity overstates short run market potential.

Table 2.0

How Top Managers in Biotechnology Companies See the Importance of Strategic and Operational Factors to Their Companies' Market Success

(from most important to least important)

Having state-of-the-art technology.

Product image (reputation).

Price competitiveness.

Reputation of the company's distributors.

Having a strong service organization.

Completeness of product line.

Personal selling efforts.

Having strong patent protection.

Use of marketing research.

Creativity of advertising message.

Advertising media employed.

Employing a competent advertising agency.

Source: William L. Shanklin and John K. Ryans, Jr., "Biotechnology in Transition: From Supply-Side to Demand-Side Marketing," *Genetic Engineering News*, June 1985, pg 12.

1. Turbulence and change characterize high technology marketing

The concept of a product life cycle, whereby a new product is introduced commercially and thereafter proceeds through predictable life cycle stages until it dies or is terminated, can be grossly misleading for high technology products. Frequently, it isn't apparent where such products are in their life cycles at any given time. For instance, while most observers would agree that biotechnology is currently in the introductory market phase, they disagree about semiconductors. That market has both growth and maturity characteristics.

Perhaps that kind of uncertainty gives a reason why a CEO or president of a typical high-tech firm often is intimately involved in all major aspects of product development, from the ground up. In successful companies, the CEO or president is a key member of the product development team. This could be more reflective of small company size, but examples such as Steve Jobs and Bill Gates do indicate that top management involvement is a high tech industry characteristic.

Additionally, market turbulence makes the idea of an orderly and forecastable life cycle unlikely at best and counterproductive at worst. Many unexpected technological and product deaths occur, and today's industry leader sometimes is tomorrow's also-ran or departed. A competitive laboratory breakthrough can render a product or process obsolete almost overnight as a new contender, even a start up firm, leaps ahead to industry prominence.

Life cycle is crucial in high technology marketing[1], [7]. A company must continually monitor and evaluate objectively how the technology that it uses is performing in the marketplace, and how it will perform against unwise substitute technologies. The profit motivated market does not show loyalty to a company's past glories and investment in R&D. As vacuum tube manufacturers learned when transistors came along, an investment in technology can be destroyed quickly, an event that sometimes can't be avoided by pouring more R&D money into the fading technology.

Therefore, the successful long-term competitor in high-tech markets[19] understands and lives by the philosophy of 'creative destruction.' The company continually seeks to destroy its own profitable existing technologies by obsolescence, in order to replace them with something superior in technology and market appeal. The high tech firm really has no other choice. If it does not create superior products, someone else will. Change is the only constant.

2. *Corporate bigness is not necessarily competitively advantageous.*

3. *Supply side marketing dominates early market stages*[24].

The question of how does supply side marketing compare with demand side marketing must be addressed. So we will start with some history. About 175 years ago, the classical

economist Jean Baptiste Say (1767-1832) proposed an idea that gave birth to a leading and remarkably resilient school of economic thought: supply of a product can create its own demand. Until John Maynard Keynes came along in the 20th Century, 'Says Law' was widely accepted. Say's proposition is contrary to the conventional marketing wisdom of identifying buyer and preferences, then devising offerings to fulfill them at a profit. And although demand should precede supply in the great majority of cases, there are notable exceptions to the rule[1]. They are seen most often in high technology markets[22], [17].

In high tech, Say's law frequently appears to be right on target. Examples of products, services and processes that have created market demand where none existed before would include fire, the wheel, the light bulb, and the airplane. In addition, consider the impact of these three:

Microcomputer technological progress enabled Apple, Commodore, IBM, and others to stimulate and exploit a demand for in-home personal computers.

In biotechnology, or gene-splicing, many possible marketplace applications confront companies with the problem of deciding which commercial opportunities they should pursue aggressively[25]. At the moment, many biotech companies focus on diagnostic tests for cancer and a diversity of human infections, with a long-term eye on treating them. Even so, potential gene-splicing applications are so diverse that a bio-technology company might choose to create and exploit markets unrelated to human medicine.

Technological advances in robotics are so rapid that new market applications and opportunities are forming at an unexpected pace.

The infancy of every high-technology market has been characterized by supply-side conditions in which the marketer's job is to stimulate primary or basic demand for the product, process, or service at hand. As with biotechnology, the initial task of selecting the market with long-run profit potential may be the marketer's toughest decision.

4. Opportunity priorization is the high technology company's critical initial step.

The critical first step is perhaps the ultimate frustration for many high tech companies

as each searches for where to begin the commercialization process. Which products, in fact, which industries, should be pursued first becomes a standard question for high tech firms when their products and processes have multiple applications.

5. Major corporate entrants and industry shakeouts signal an evolution to demand driven markets.

Does a high tech company always have to be the technology leader? A widely held misconception is that a high-technology company must time and again be the early product or market leader to be successful in the long term. Not so[21]. By reasonable standards, if a high-tech company, even a giant, can be the initial market entrant about a third of the time it can be judged eminently successful.

Being first is not synonymous with being successful. Often, the pioneers end up as the ones with debt collectors on their backs. For example, Xerox has had all kinds of well publicized setbacks commercializing its computers, and they brought out the very first commercialized personal computer.

Eventually, supply side market conditions begin to yield to demand side conditions. High tech markets in early development are R&D driven; the major focus is on technological breakthroughs and stimulating primary demand for the industry's offerings. Then competitors seeking new markets and healthy profit margins inevitably challenge the pioneers. Subsequently, those markets evolve commercially and marketing prowess determines who wins and who loses.

Weaker firms wither under competitive pressure. For example, IBM's entry into the microcomputer market, although belated, helped trigger the present shakeup in that field. The companies that do founder, are generally unable or unwilling to adapt as their markets mature. In the early stages, R&D discoveries or a single technological breakthrough carries them, but when marketing skills and a marketing mentality become essential to continued success, many of them are simply not up to the task. For example, Texas Instruments' withdrawal from the home computer business was not for lack of technological skills. It was deficient consumer marketing know-how that did them in.

6. Buyer insecurity significantly influences demand.

Buyer insecurity creates a volatility within high technology markets and takes its toll on the demand side as well. Unlike other business/industrial markets where technically wise exert influence because they properly evaluate a product for both current version and most probable future version. The high technology purchaser may feel uncomfortable about "what and when" to buy. There are many examples of major companies that have delayed purchasing products such as microcomputers because they were not certain whether today's state-of-the-art market leader would be tomorrow's follower, or would be made totally obsolete by a "breakthrough."

Enough potential buyers have the "what and when" fear to affect high technology market growth. For instance, Satellite Business Systems has a superior product for transmitting data, phone calls, and pictures. But to date, it hasn't shown a profit, possibly because potential customers are more comfortable with less sophisticated technology.

High technology marketers must reduce the potential buyer's technological skepticism, or fear. The chore inevitably requires jargon-free explanations of high-tech products to low-tech minded audiences. In the home computer field, for example, technology has intimidated would-be buyers, especially in households without school age children. As John Sculley, former president of Apple Computer and a former Pepsi-Cola marketing executive said, companies like Apple must de-mystify the personal computer to get the public to think of it as just another household appliance.

7. High technology triggers public reactions of hope and fear.

Public reactions plays a role. The great promise of any era characterized by major technological change is always balanced by public uneasiness and at times protest. Today, while there is great hope that high-tech ventures will generate enough new jobs to mitigate 'smokestack' industry unemployment, many people fear real and perceived socioeconomic side effects such as structural unemployment. That thorn in the high-tech rose envisions a host of blue color workers who can never be retrained for the skilled jobs required by robotics and computers. In addition, there is debate over computerized information access and privacy.

8. High technology attracts inordinate government attention and regulation.

Government attention and regulation follow areas of business. Greater governmental control occurs because of both practical (national security and economic growth) and nationalistic (giving up our state-of-the-art lead) reasons, the government and the public have conflicting feelings about spreading advanced technologies.

Domestically, industries such as biotechnology face barriers to initial approvals and patents and subsequent commercialization.

On the international trade front, all U. S. high technology industries receive even closer scrutiny when attempting to export or license their technologies and products. The U.S. Export Administration stands guard at the exit with prohibitions to sales to a lengthy list of countries.

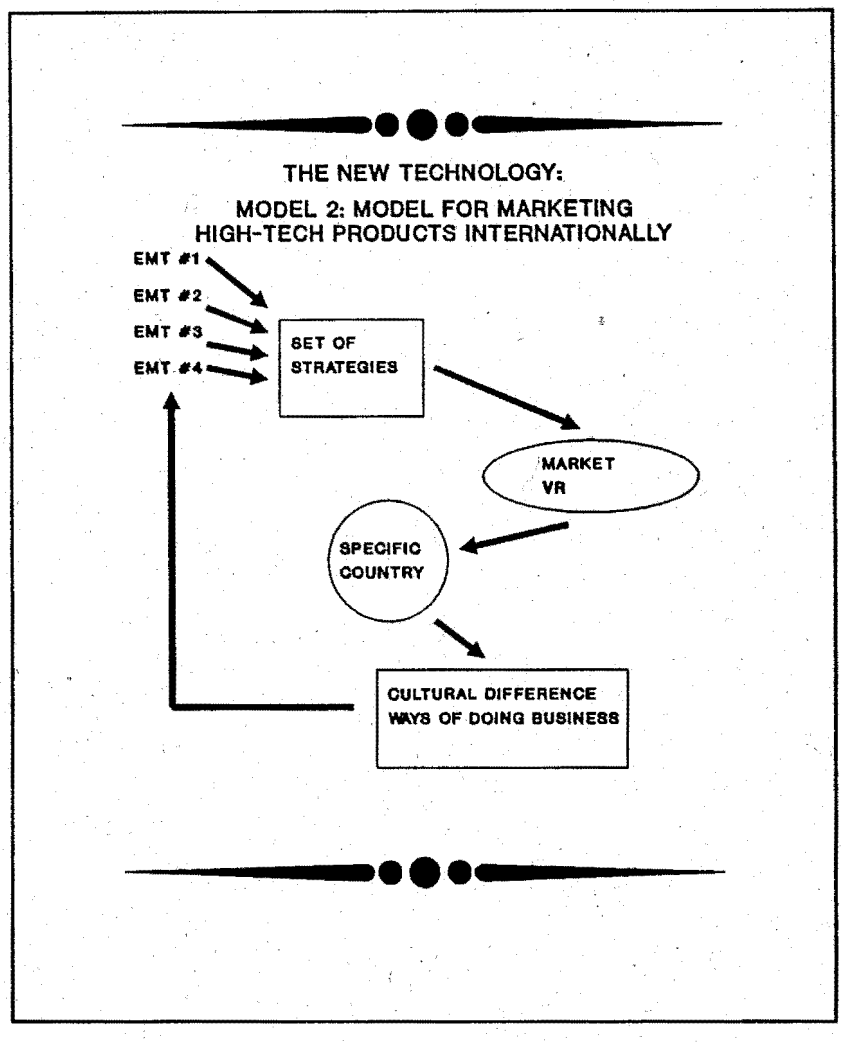
More recently, their concern has been transshipping, the high-tech seller must be careful that an overseas buyer is not going to resell sensitive products and processes to prohibited markets. Events such as the recent Swedish "last second" blocking of a Russia-bound high-speed computer, sold via a South Africa-based buyer, further encourage tough regulations. The free trade argument that "if they don't buy it from us, they will get it somewhere else" has become ineffective since the Soviet pipeline deal. A new convincing argument is yet to be found. History is on the side of regulators, and the trend will continue for high-tech marketers.

9. High technology has nationalistic overtones.

The "we or they" battle for high-tech supremacy has become an industrial version of the Olympics. Each nation in the game waves their country's flag and stirs emotions of being faithful to nationalistic fervor.

International cooperation, such as a robotics agreement General Motors recently signed with a Japanese manufacturer, does occur often[22]. But nationalism seems to reign. The European Economic Commission, beset with high-tech rivalry among its own members, cites the United States and Japan as the rivals to beat. France plans to unilaterally spend $20 billion over the next five years on its electronics industries.

Model 2 - Model for marketing high technology products internationally.



Results

A consistent message was communicated by all marketing strategy authors: Regardless of the product, there is considerable information required to develop a successful marketing strategy. The Thompson, Strickland is clear indication of the breadth of analysis. The marketing plan must be a living document that includes a feedback loop. This is particularly true of new technology ventures. Rapid development and technology deployment does not permit much of a window for marketing error.

Consequently, the high in high technology depends on the times. To early humans, the discovery of the wheel and its possibilities was advanced applied science. And such incremental gains in applied science, meager though they may later seem to be, are enormously important to us: Technology brings freedom to our lives from laborious tasks, facilitates our education through improved worldwide communications, and mitigates our worries over disease [2]. Inarguably, technological progress also carries with it great

responsibility, especially with regard to controlling technology's potential for destructive use. Advances in weaponry systems, exporting computer capabilities to totalitarian regimes for possible use in surveillance, and genetic engineering have all raised moral and ethical issues in our day. There are essential economic ramifications from high technology as well.

The nation that thrives in high technology is going to have a superior material standard of living vis-a-vis its sister nations and a larger say in the conduct of world affairs. Power and influence inevitably flow to the countries most adept at fostering the discovery and advancement of technology [17]. The same can be said for the individual states within the United States. And adeptness depends not only on the collective ability of a nation's scientists to make headway in the laboratory, but also on the prowess of its business people in developing and marketing incipient technologies in a commercially successful way. Indeed, the development of high technology that fulfills a significant human need or desire, present or future, is the critical marketing task. Keen and perceptive need discernment and fulfillment do not make the actual selling job superfluous, but they certainly make it easier.

Technological innovation in the United States and elsewhere in the free world has often been the product of individual free-lance inventors who saw their ideas through to ultimate success, frequently in the face of many trials and tribulations and with great odds against the inventor. Thomas Edison's advocacy and use of the industrial research laboratory in the nineteenth century began to change this pattern and to shift technological innovation to corporate sponsorship--although one-person entrepreneurs did and still do occasionally succeed.

With increased corporate sponsorship of technological innovation came an important dichotomy between those people who conceptualized and invented technology and those individuals who developed, financed, and marketed it [19]. Risk of failure was also spread over more individuals, primarily the corporate shareholders or sometimes the venture capitalists. This distinctive and critical division of labor between the technological and business sides of innovation has largely been glossed over in the ongoing debate in the United States about the causes of and remedies for the nation's eroding technological leadership.

As the United States has watched its technological edge slip in various fields, one suggested solution is that the United States needs more scientists, mathematicians, and engineers, as well as improved education in the sciences. This could be part of the solution but it is not the complete answer. Even if the United States now could miraculously produce enough capable scientists, mathematicians, and engineers overnight,

our technological concerns as a nation would not be resolved. The most brilliant scientist or engineer might be a poor discoverer of market trends and needs--the very place where every technological breakthrough must ultimately prove its worth. Scientists and engineers are just as susceptible as the rest of us in being wrapped up in their own work and consequently making errors of judgement about how others will perceive and accept it. Technologically oriented corporate employees need solid direction from the marketplace of today or tomorrow if their efforts in the laboratory are to coincide with corporate goals and strategies. The role of marketing is to provide this direction. As Dr. Edward W. Ungar of Battelle Memorial Institute says, "In corporate R&D, most ideas for new products need to be evaluated against the test of whether or not the product will be accepted in the competitive marketplace."

We began the project which resulted in the initial version of our logic diagram for this project by testing our intuition that the same marketing concepts and techniques that are so largely responsible for the high standard of living enjoyed by mass distribution societies need adaptation and sometimes refinement to fit the specialized and often singular needs of companies engaged in high technology. Our belief was based on our literature search of interviews of key industry executives that represent high technology companies. "Rarely do engineers and scientists run a company without the counsel of personnel with first rate marketing knowledge and savvy." [John Sculley of Apple Computer Company, 1987] Something far more fundamental was a factor. The observation exists that conventional marketing concepts and methods work best once a technology has matured and established itself in the marketplace. But in the initial stages of market acceptance, or what can be compared to supply side stages, the same marketing concepts and techniques are sometimes not applicable. The volatility of high technology industries calls for creative approaches to product management and to human resource staffing requirements (entrepreneurial managers versus maintenance managers) over the product and technology life cycles. Similarly, the intrinsic complexity of high technology has interesting and meaningful implications for the communications functions as presented by advertising and personal selling.

As we turned to collecting data, we initially searched for existing marketing literature that pertained precisely to marketing Virtual Reality high technology. But we found that we had to expand the scope of supply side marketing and that using a general concept of a high technology product was too difficult because it resulted in isolating the unique product features of Virtual Reality rather than the fundamentals strengths of a strong marketing strategy that was partnered to high technology and that also used engineering management principles to improve results. Expanding the singular area of Virtual Reality (VR) to include a wide and representative cross section of high tech industries (from ventures as diverse as robotics and on toward biotechnology) allowed our

team to discover high technology marketing strategies rather than to discover how to write a sales brochure that described the features and reasons for a perspective buyer to purchase a VR product.

Our data was selected from the proven winners in the high tech industry. While much can be learned from the mistakes of companies that failed, we wanted to produce a list that takes a winning product and partners it with a winning marketing plan. This list should provide a basis for action for the future. It also is amendable from the standpoint of a feedback loop of real information observation and will serve as an amendable plan that becomes more flexible as each unique customer group is identified.

We, again, want to emphasize that neither a single very narrowly focused and single product specific nor a broad based whole industry marketing technique will assure a success. While these may be insightful and provide useful illustrations, they often claim to have direct relevance beyond their limited bounds. For example, the marketing program of a computer software or PC company hardly provides the necessary framework for a company seeking to establish a supercomputer presence, much less a presence in biotechnology, lasers, or fine ceramics. We have tried to examine patterns of similarities in evolving high technology industries and to find the similarities that help to explain transitions and to offer guidance when a firm is operating at various stages of development. There are some advantages of learning from the history of previously emerging high technology industry like biotechnology, for example, in order to form a do's and don'ts list.

Additionally, we found that linking Research and Development and marketing and including international high tech competitiveness [27] to be very difficult due to the diversity of organization from one corporate structure to another. We found it quite common, for example, for companies to have sharp delineations between the activities of their research people on the one hand and marketing on the other. This division prevented the kind of synergistic strength that could be used at critical points in the research-to-development-to-market process.

Conclusion

In conclusion, this paper does not intend to be an all-inclusive guide on how-to-market all high technology products in all international markets. It is a resource on what factors to consider when planning to market a high technology product in order to increase

the chances of success. Ultimately, the marketing concepts, techniques, and activities to use (or not to use) along with the uniqueness of the country being targeted as a market is compounded with the varying skill levels of the team formed from engineering, planning, manufacture, R&D, marketing, sales and others. Management of all resources still remains the challenge for technological innovation.

Recommendation for Future Study

Concurrent engineering principle have compressed concept-to-market lead times but have done little to improve overall marketing cycle times. Research should continue toward applying principles similar to concurrent engineering to strategic marketing in an effort to reduce time and labor requirements needed to assimilate marketing data. Knowledgebase systems should be developed to build learn-as-you-go information that is accessible organization-wide. That implies continuous feedback loops to affected areas, particularly engineering, so that new technology life cycles are accurately identified, and new product planning can be effective.

APPENDIX A

VIRTUAL REALITY- A PERSPECTIVE

Introduction

> *"The human being is an intensely visual animal. Most of our information comes from visual images that are interpreted by an extremely efficient image-processing computer - the human brain. On the other hand, computers have typically responded only to implements such as keyboards and mice.*
>
> *Now with virtual reality, computers and the human mind are entering a realm where communication between the two can proceed at a much more intimate level. This quantitatively new capability holds the promise of extending the range of computer-assisted human experience in completely new directions."*
>
> - Gordon E. Moore, Chairman, Intel Corporation (Pimentel. p xii)

The promise that Gordon Moore refers to is seamless integration of the computer into daily lives of everyday people. New power enabled by the proliferation of virtual reality is akin to mass use of electricity, the telephone, or the automobile. Electricity made workers more productive. The telephone negated distance, and the automobile enabled a level of mobility never before achieved. Each technology brought great social change as people learned to effectively use the tools of the technology. Virtual reality offers no less change. In the short time since its advent, the computer has altered the way people work, the way people communicate, and the way nations relate to each other. Although considerable progress has been made in human-computer interfaces, impact of the computer is severely limited by its ease of use. Virtual reality holds the potential to obliterate the need for any effort in the human-computer interface. The computer will

become an extension of a person's hands and will effortlessly collect and process information the way a telephone is used to communicate over long distances.

Virtual reality already has begun to emerge and bring about the social change it promises. "Virtual reality has spawned a new interaction between musicians, artists, entertainers, and electronic tinkerers. A rare excitement is in the air, an excitement that comes from breaking through to something new. Computers are about to take the next big step out of the lab and into the street - and the street can't wait." (Pimentel. p 7)

The promise of virtual reality has not been missed by business. Hundreds of companies trying to sell their version of virtual reality have come forth over the past twelve years. Companies and organizations like NASA, Tokyo University, the Human-Interface Lab in Seattle, Washington, Boeing, IBM, NEC, DEC, Intel, Fujitsu, Sun Microsystems, and Autodesk are all working on virtual reality. However, "the real innovation is happening at the grass-roots level" (Pimentel. p xii) with companies like VPL Research, Sense 8, Fake Space Labs, Greenleaf Medical Systems, Virtual Research, and more. Indeed, there is a rising interest in virtual reality. "Dozens of virtual reality conferences and hundreds of articles have seemingly appeared overnight in England, Germany, France, the U.S., and Japan." (Pimentel. p xiii)

Given that virtual reality holds such immense potential to improve the efficiency and capability of people, it is not surprising that companies are trying to profit by bringing the technology to fruition. However, if these companies are to succeed, they must not only develop the necessary technologies, but produce products with desired characteristics, at the right price, and targeted towards the right market.

This section of the paper briefly explores virtual reality's history and looks at some of the marketing efforts currently under way. A list of organizations that are actively involved in product development is given at the end of this section.

A Brief History of Virtual Reality

Virtual reality technology began in government funded labs and universities. As the technology was improved upon, commercial applications began to become plausible,

and research centers for virtual reality shifted from non-profit organizations to companies trying to exploit virtual reality for profit.

"The early pioneers in [virtual reality] were looking for the ultimate display technology, one in which the computer would disappear and allow users to navigate naturally with their eyes, ears, feet, and hands. Over the last thirty years, development at NASA and elsewhere finally led to the emergence of a commercial virtual reality industry." (Pimentel. p xv) The first company to make use of the virtual reality technology developed by NASA and others was VPL Research. VPL Research, founded in 1985, produced the first commercial wire glove - a device capable of sensing the user's hand's position and transferring that information to a computer for display on a screen. By 1988, VPL Research was selling a complete virtual reality suite with wire glove, sound, graphics hardware, and a head mounted display capable of sensing the user's head position and displaying the virtual environment for the user on embedded liquid crystal display (LCD) screens. (Pimentel. p 53) Soon after VPL Research, other companies began to emerge to exploit the new virtual reality market. In 1989, Autodesk, released the first personal computer-based virtual reality system at a substantially reduced cost from VPL Research's original system - $25,000 down from VPL Research's $250,000 system. In 1991, Sense 8 released its WorldToolKit - a C language software library designed to make virtual reality software easier and cheaper to develop. The virtual reality industry is still very young, but it is growing so fast that public perception of virtual reality is far behind the actual level of the technology. "The most common image people have of virtual reality is somebody sitting in a chair with what looks like a scuba mask strapped to his face, with a metal box over his eyes. Virtual reality technology, however, has already gone a long way beyond this." (Pimentel. p xvi)

Virtual Reality Marketing Case Studies

In order to understand how to market virtual reality, it is instructive to study the efforts of existing companies. The following introduces each company and its approach to marketing virtual reality.

VPL Research, first commercial virtual reality company, provides a good introduction to the virtual reality industry as a whole. VPL Research, made use of the public domain knowledge developed by NASA and other research centers to produce the first commercial wired glove. In 1988, VPL Research began selling a complete solution to virtual reality. Their package, Reality Built for Two (RB2) was priced at $225,000 for one user, $450,000 for two users. It consisted of a head-mounted display, a wired glove,

a 3-D sound processor, an Apple Macintosh computer, and two Silicon Graphic's workstations. With the RB2 system, "VPL began a booming business in selling [wired gloves] and [head mounted displays] to researchers cobbling together their own systems. By 1990, VPL claimed 500 customers worldwide." (Pimentel. p 54) Shortly thereafter, VPL Research began developing software solutions for virtual reality. One product, Swivel-3D, is still one of the most popular 3-D rendering tools for the Macintosh and provides "a continuous stream of revenue for VPL [Research]." (Pimentel. p 54)

"As VPL enters its seventh year of operation, it has grown to about 25 people and is still enjoying a comfortable lead over the rest of the nascent [virtual reality] industry. However, after years of being the sole supplier of virtual-reality hardware and systems, it has had to adjust to new competition from start-ups offering similar wares." (Pimentel. p 55) With new competition, VPL realized it had to develop lower priced products to remain competitive. The company's Microcosm system is based on a "Macintosh Quadra and two Division i860 microprocessor-based graphics boards. ... Microcosm is a low-cost system intended for the architectural market. Attempting to re-establish a technological edge, VPL also brought forth new gloves and new head-mounted designs." (Pimentel. p 55)

VPL Research is still a technology leader in the virtual reality market. Originally, the company had the luxury of having the market all to itself. However, it had to cut prices due to increased competition from other small firms that are selling imitator devices. VPL Research, probably figuring that it could not compete on equal price-footing with the new small start-up imitators, created a new line of products in order to maintain its technological edge and its market leadership. VPL Research additionally developed the Microcosm system in order to try to find a new, lower-priced market.

Autodesk is another early pioneer of commercial virtual reality. Autodesk originally got its start making inexpensive computer aided design (CAD) software. However, after watching VPL Research's success with virtual reality, Autodesk saw the potential to use their expertise in CAD software to design a low priced virtual reality system. "For under $25,000 [Autodesk] replicated VPL's quarter-million-dollar system." (Pimentel. p 56) Autodesk succeeded in doing so by porting virtual reality to the desktop computer. With its relatively inexpensive virtual reality product, Autodesk succeeded in blending technology with market savvy in order to produce a successful product.

Sense 8 was formed from disgruntled Autodesk employees. Their vision was to

develop an inexpensive virtual world C language tool. The result was WorldToolKit - a C language tool kit that allowed users to develop their own virtual worlds relatively easily and inexpensively. The impetus behind creating a generic tool kit was the knowledge that they could not predict which industries would present the largest market for virtual reality. Sense 8 collaborated with Intel, Sun Microsystems, and others to port their product to several hardware platforms. WorldToolKit was essential in bringing about the lower cost of a virtual reality system - "by the end of 1991, the cost was down to $20,000 and dropping fast." (Pimentel. p 61) Sense 8, like Autodesk utilized a strategy of supplying a little new technology and a new product idea to launch a successful business.

VPL Research, Autodesk, and Sense 8 are among the more profitable virtual reality companies. The discussions above were necessarily broad because there is little information available on each company's in-depth marketing strategy. Key components of all of the above strategies are an emphasis on reduced price to allow for higher volume sales and hence higher profits, leveraging each company's strengths to produce a superior virtual reality project, and maintaining a market leadership presence.

Organizations Working on Virtual Reality (Source: Pimentel.)

Advanced Robotics Research Centre
Advanced Technology Systems
Advanced Gravis
AICOM Corp.
Artificial Reality Corp.
Ascension Technology Corp.
Autodesk Inc.
Battletech Centers Inc.
BioControl Systems
CAE-Electronics Ltd.
CIS Graphics Inc.
CM Research
Covox Inc.
Crystal River Engineering
CyberEdge Journal
Dimension International
Division Ltd.
Dragon Systems Inc.
DTM Corp.
Evans & Sutherland
EXOS Inc.
Fake Space Labs
Flogiston Corp.
Focal Point 3D Audio

GEC Ferranti
General Electric
Gyration Inc.
Human Interface Technology Lab
Institute for Simulation and Training
International Telepresence Corp.
Kaiser Aerospace & Electronics Corp.
LEEP Systems Inc.
Logitech Inc.
MULTIPOINT Technology Corp.
NASA Ames Research Center
Polhemus Labs
Polhemus Inc.
Reflection Technology
SARCOS
Sense8 Corp.
Shooting Star Technology
SimGraphics Engineering Corp.
Software Systems
Spaceball Technologies, Inc.
Spatial Positioning Systems, Inc.
StereoGraphics Corp.
StrayLight
Telepresence Research
Textronix
The Computer Museum
The Vivid Group
University of North Carolina
Virtual Technologies (Virtex)
Virtual Research
Virtual Reality Group
Visual Synthesis, Inc.
Voice Connexion
VPL Research Inc.
VR News
VREAM
W Industries Ltd.
Xtensory

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