Changes in North American PWB Materials Infrastructure

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Abstract
This paper will compare the current capabilities of raw material suppliers to the PWB industry to those same capabilities 10 and 20 years ago. Key raw materials such as resin, glass fabric, copper foil, laminates and prepregs will be discussed. Supplier profitability, consolidation and globalization have all had some influence on these changes. Globalization of the supply base and changes in telecommunications has also driven the trend

Market segments especially affected by the migration of intellectual investment to Asia are computers, telecommunications and consumer electronics. More recently automotive electronics, internet infrastructure, test equipment and even some military electronics have found the need to search outside of the US for advanced raw materials. High Speed materials and RF products have traditionally been the most innovative and performance driven materials. Current trends have pushed even those materials into the realm of cost control and reduction.

The paper will also discuss how these changes affect the long-term viability of the PWB industry in North America. What markets can prosper under these conditions and what markets have suffered. Current and future business plans and investments of these key suppliers have shifted the US from a leader to follower in all but the most specialized raw materials. The shift from innovation driven business models to efficiency driven models in the supply base is also a major reason for the shift to lower cost manufacturing.

Is this trend going to continue unabated is it irreversible or is there a place for companies with manufacturing in North America to survive? This paper will also describe how some suppliers are restructuring to deal with these changes while continuing operations in North America.

A Brief History of Laminate Time

In 1975 there were over 30 factories producing FR-4 in North America. By 2008 that number had been reduced to 9, 4 of which are owned by one company. In any successful industry a cycle exists that is immutable. In the laminate industry we have passed through the introduction, expansion, maturity and are in the decline phase in North America. As with the textile, steel, consumer electronics and other notable examples, this decline does not necessarily mean extinction. What it does mean is that survival depends on prudent use of resources to find a niche and support the customer and product base that will survive.

I will compare the current capabilities of raw material suppliers to the PWB industry to those same capabilities 10 and 20 years ago. We will review key raw materials such as resin, glass fabric, copper foil, laminates and prepregs. Supplier profitability, consolidation and globalization have all had some influence on these changes. Globalization of the supply base and changes in telecommunications has also driven the trend

Manufacturing Capabilities

Laminate Base Materials

In the last 20 years, the number of raw material suppliers with manufacturing capabilities in North America has been drastically reduced. There were few suppliers to start with, but several had more than one plant. If considered as a whole, the suppliers of resin, copper and glass had over 20 plants in North America in 1988 and less than 6 in 2008. The volume of product made in those plants increased from 1988 to 1998, but has been reduced by over 50% between 1998 and 2008.

Epoxy Resin US producers

1988 – Dow, Shell, Reichold, HiTek Polymers, Ciba
1998 – Dow, Shell, Ciba

2008 – Dow, Huntsman

During the 1980's it was not unusual for a laminator to have multiple sources for base difunctional resin and the most common hardener used (dicyandiamide). By 1998 this was still possible, but most laminators had contracts with one or the other to try to keep costs down. Today there is only one domestic source for base resins. Development and marketing for the copper clad laminate segment has all but stopped at the resin suppliers. We benefit from the application of older technologies, (phenolic curing) and new designs or regulations forcing the use of them.

Copper Foil US producers

1988 – Yates, Gould, Oak
1998 – Circuit Foils, Gould, Oak-Mitsui
2008 – Oak Mitsui

Copper foil production has always been driven by volume. It is so expensive to run these continuous plating lines that often during slack times plants would be taken off line to match demand. Since 2000 all domestic production of copper foil has ceased save for one plant. Capacity in that plant does not supply even 50% of the domestic market let alone export. A plant that was 50% complete in 2000 in Canada was never finished due to the rapid fall in demand in 2001. Specialty copper foils such as resistive foils continue to exist, but at very small volumes.

Glass Fabric US producers

1988 – JP Stevens, BGF, Uniglass, Clark-Schwebel, Hexcel
1998 – JPS, BGF, Hexcel-Schwebel
2008 – JPS, BGF

The production of e-glass fabric in the US has mirrored the decline of two markets in the last 10 years. The textile business in general has moved off shore and as the bulk of commercial electronics moved, the glass weavers have consolidated and focused on other business segments. The use of glass fabrics in industrial, recreational and construction has remained steady during this time. Those businesses are less sensitive to the cost per square inch of the fabric and more driven by the success of the end product. (snow boards, ski's, PTFE domed stadiums etc.) The mainstay of the PCB industry, 7628 fabric is produced only in very small volume domestically. Factories built in China, by Taiwanese suppliers dominate the commercial market with the vertically integrated producers having a clear advantage over everyone.

Laminate and Prepreg Manufacturing

When considered as a group, Laminators have reduced domestic manufacturing plants and output by about 75% since the year 2000. Only 5 domestic producers of commercial FR-4 remain. Some of this has come through consolidation, but over half of all the plants that existed in 1998 have been shut down.

Laminators US Producers

1988 – (15) GE, Westinghouse, NVF, Nelco, Polyclad, ADI, Keene, Norplex-Oak, Synthane-Taylor, Electroply, Glasteel, Fortin, Mica, Lamco, Precision
1998 – (8) GE, Norplex, Nelco, Polyclad, ADI-Isola, Electroply, Herco, Arlon
2008 – (5) Isola, Nelco, Taconic, Electroply, Arlon

Laminators R&D Personnel

Personnel dedicated to developing new materials and applications have also been proportionately reduced. These technologists as a group are responsible for virtually all development of substrates from 1960 to the current day. No major innovation, from paper based phenolic laminates, through today's advanced materials was developed without the contributions of the North American laminators, OEM's and fabricators and suppliers.

As any good materials scientist knows, these products were the result of millions of hours of work starting in the lab and moving to the factory and commercialization. For every successful product introduction, hundreds of iterations were set aside.

R&D, Applications Engineering and Product Development personnel

1988 = 103 1998 = 48 2008 = 12

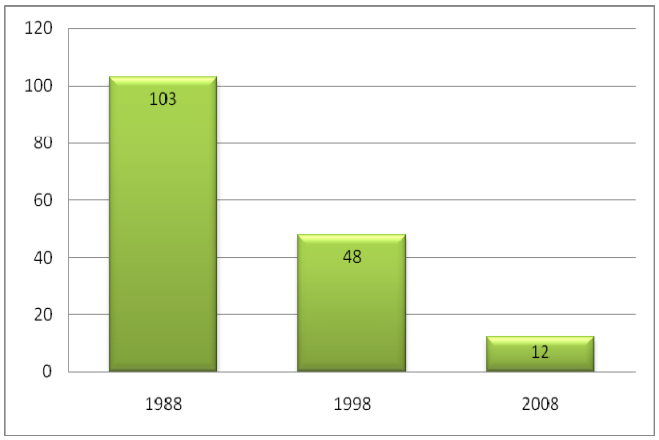

Figure 1

SOME of the products developed by laminators since 1988

PPO /Epoxy, PPE, CE-Epoxy, HC Ceramic, Phenolic FR-4, Polyester Glass Matte, Unidirectional Composite, Polysiloxane Glass, CE Quartz, Epoxy-S-Glass, 170 Tg epoxies, HF Epoxy (non brominated FR), Resin Coated Foil, Laser-friendly prepregs, Regal Flex, RT copper foil, Solventless Epoxies, Unidirectional reinforcements, Fluorescing base resins, Resistive Foil, Polyimides, BT/Epoxies

SOME of the processes developed by laminators since 1988

Vacuum Lamination, Black Oxide Replacements, Foil Laminated Multilayers, Mass Lamination, Single Ply prepregs, Clean Room Layup, Pinless multilayer lamination, Post Lamination tooling.

These developments have helped move the interconnect industry forward over the last 20 years and many have become the basic fabric of the Printed Circuit Industry. Innovation and creativity fueled the success and expansion of the base materials business. That has changed over the last 5 years. The driving force of change in the domestic market has been cost reduction and capacity elimination. As the base market for materials has shifted to Asia, the resources for pure R&D and process development have evaporated.

Who will pick up the pieces?

Does the reduction in capacity and personnel mean that we will stagnate? Certainly the number of projects that the supply base can sustain has been reduced. It is simple math to understand that, if 100 engineers are working on 1 project each, it is unlikely that 10 engineers can work on those same 100 projects. A sort of technological Darwinism has evolved in the Laminate industry over the last few years. Many projects have just disappeared with the companies that invented them. (Unidirectional multilayer cores – Compositech) Some projects have merged as companies consolidate bringing the best of competing technologies forward while eliminating the weaker products. The time it takes a supplier to recognize the winners and the losers has also decreased radically. In 1980, a small New England Laminator made a bold move by introducing "tetrafunctional" FR-4. This product took over 10 years to become commercially successful despite all of the technical reasons that almost everyone acknowledged. Today if a new product does not have legs within 18 to 24 months from introduction, it is likely to be replaced or discarded.

What this means for the laminators is that the paradigm has shifted from broad based global standardization to targeted high value development. Projects now target specific applications and OEM's with immediate design demands and specific project timelines. The products that are developed are often variations on a theme or a subset of larger product lines, tailored to the need of one or two designers. In the RF business this has been the rule for over 30 years. Low volume, custom products that often can only be produced in one facility, by one group of workers. The price of these products is often secondary to performance. That being said, cost control is a fact of life in all base material markets today. High Speed materials and RF products have traditionally been the most innovative and performance driven materials. Current trends have pushed even those materials into the realm of cost control and reduction.

One example of a previous paradigm shift in materials follows.

In 1988, Controlled Impedance PWB's were a new phenomenon. The idea that all FR-4's were not created equal electrically was a new concept. Laminators regularly sold products ranging from 35% resin to 65% resin, and fabricators did not know how that. Several laminators leveraged their knowledge of this to market specific constructions for certain impedance models. This allowed those companies and their customers to capture this emerging market. In the last 20 years the industry has learned the minutiae of Dielectric constant and materials construction. Every CAM guy knows if he is going to build a controlled impedance design, he has to make sure he uses certain constructions. As the speed of circuits increases, this becomes more and more critical. Other factors come in to play, and the laminators that understand how to develop and sell products to meet these design needs will have an advantage.

OEM Marketing

This strategy has become more and more important to the survival of materials companies. Listening only to PWB fabricators about the current and future needs of the industry is no longer an option. In the old model, laminators provided new materials based on the request of a few large captive fabricators like IBM, or Digital Equipment. In the 1980's most of those captive shops closed. As OEM's have shifted focus away from all issues related to PWB manufacture and even assembly, the knowledge base at those companies has diminished. Lead by the High Frequency Materials suppliers, the laminators have aggressively started to work with designers years ahead of product introduction. Some products are technically driven and some are driven by things like the WEEE and RoHS regulations in Europe. The OEM's can and do specify products by vendor in this case. This allows suppliers to invest R&D time and money with some expectation of future sales related to the performance of the product, not the price alone.

Partnerships

Again, drawing from the model that exists in the specialty markets, laminators will have close relationships with key fabricators as they begin to test and commercialize new products. Those fabricators will benefit by being the first to see many new products and the first to sell to the OEMs. If new processes need to develop to optimize the material properties, these shops will be capable of marketing that skill to their customers as well. Again, price is secondary. The speed and flexibility of this partnership is critical to its success.

Global Specification Synchronicity

Through the work of organizations like the IPC, IEEE and others, forward looking suppliers have started to expose the differences in grades of materials by developing new categories of materials almost at their introduction. This helps to eliminate some of the mysticism surrounding new products. Designers and fabricators can compare these new materials with less guesswork. Participation and leadership in these efforts can help even small players remain competitive. One good example of this is the addition of Low Halogen and novel curing FR-4 materials slash sheets to IPC-4101 before those products are widely available.

Executive Generalization

The new supplier paradigm requires the owners and managers to have knowledge across the range of disciplines. Engineers are doing sales, salesmen are designing products and Accountants are driving quality programs. With fewer players and a smaller market, the labor force at all levels of the organization must perform more than one function. This puts a much higher value on building a group within these companies with complimentary skill sets. Smaller companies have always needed to practice this paradigm, but the survivors in this market will all find value in this strategy. We have all heard the anecdotes about the value of cross-training our work force, but have we ever applied it to top management? In a shrinking market less is always more.

Conclusion

Over the last 20 years the capabilities of raw material suppliers in North America have evolved from a technology to a cost driven industry. Key raw materials such as resin, glass fabric, copper foil, laminates and prepregs have become less sustainable in North America. The number of facilities, technical personnel, and product innovations has reached an all-time low. This has removed key resources from the North American stage and forced downstream businesses to rely less and less on the suppliers for support and innovation. Globalization of the supply base has not replaced these resources as the model in the rest of the world is cost driven rather than technology driven. 20 years ago OEM's played a key role in directing and developing critical processes and materials for the interconnect industry. That is not the case today. Innovation is now being done on a much smaller scale by much smaller players for very specific markets.

The future of the domestic interconnect industry will rely on smaller, faster and less ambitious business models than at any other time in the history of electronics. Those businesses will have personnel that can perform many functions rather than being highly specialized. Whether the firm is private or public, the entrepreneurial talents of its workers will decide the success or failure of each enterprise.

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IPC/APEX March 30-April 3, 2008

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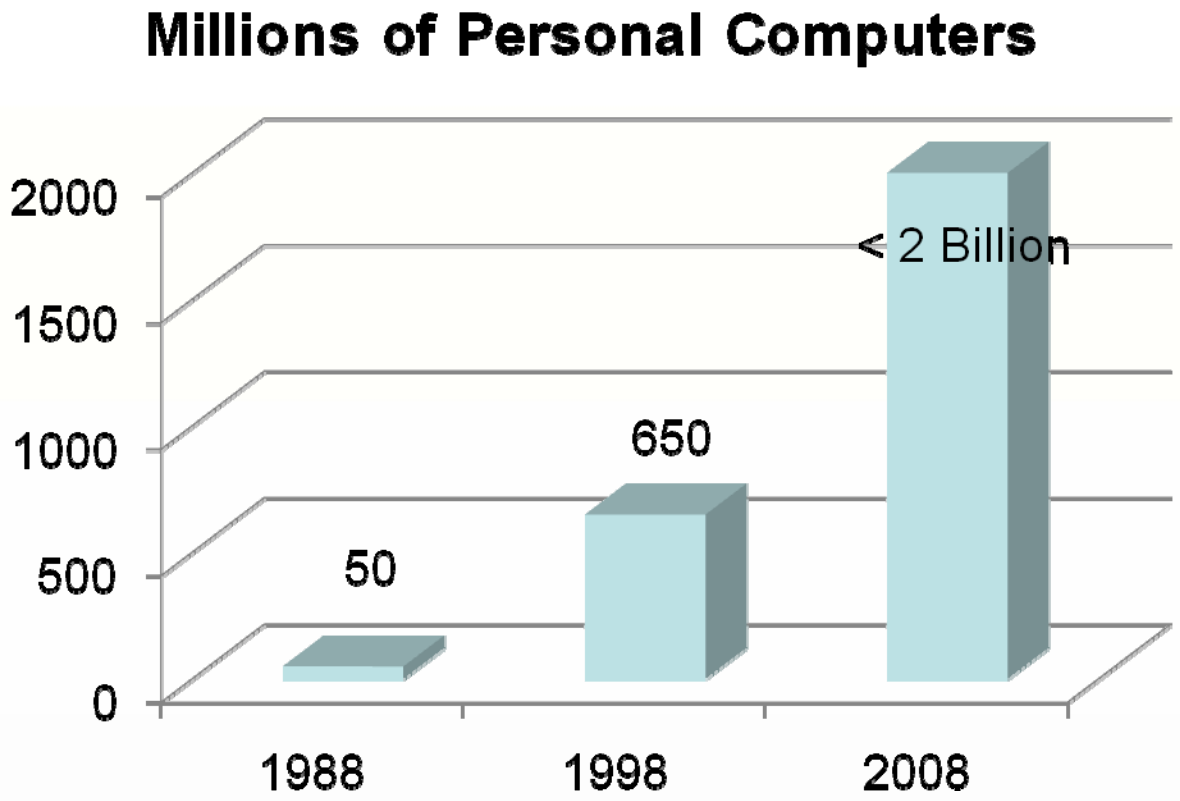
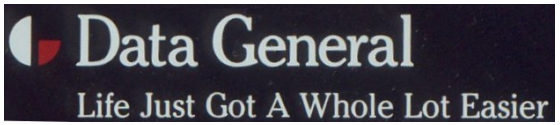
1988-2008 Product Research and Development



Some PC makers of yesteryear

Gone, but not forgotten……



1,200,000,000
cell phones (hand sets)
were sold in 2007

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were sold in 2007

Almost none were made in the US

BusinessWeek

HOME INVESTING COMPANIES TECHNOLOGY INNOVATION MANAGING SMALL BIZ B-SCHOOLS ASIA

Tech Home CEO Tech Guide Computers Electronics Entertainment Internet Reviews Software Investing Tech

NEWS ANALYSIS February 1, 2008, 12:01AM EST

Motorola: The End of an Error

The Razr maker will likely sell or spin off its cell-phone division. Possible acquirers include Asian rivals and private equity players

by Roger O. Crockett

The MotoROKR U9 mobile phone and music player on display at the 2008 Consumer Electronics Show in Las Vegas. Robyn Beck/AFP/Getty Images

TECHNOLOGY

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Google Disappoints the Street

Motorola: The End of an Error

FCC Auction Opens Door to Open Access

Reframing Digital Entertainment

1988-2008 Laminators

TACONIC
Advanced Dielectric Division

nelco
Subsidiary of Park Electrochemical Corp.

synthane·taylor

POLYCLAD

QLP

We bring good things to life.

OAK

ARLON

NVF

ROGERS CORPORATION

IBM

Westinghouse

Fortin Laminating

AlliedSignal Laminate Systems

Electroply, Inc.

GIL Technologies

MEM

THE Mica CORPORATION

1988-2008 Laminators

TACONIC
Synthane-Taylor Laminates

isola
Isola Laminate Systems

ROGERS CORPORATION

ARLON

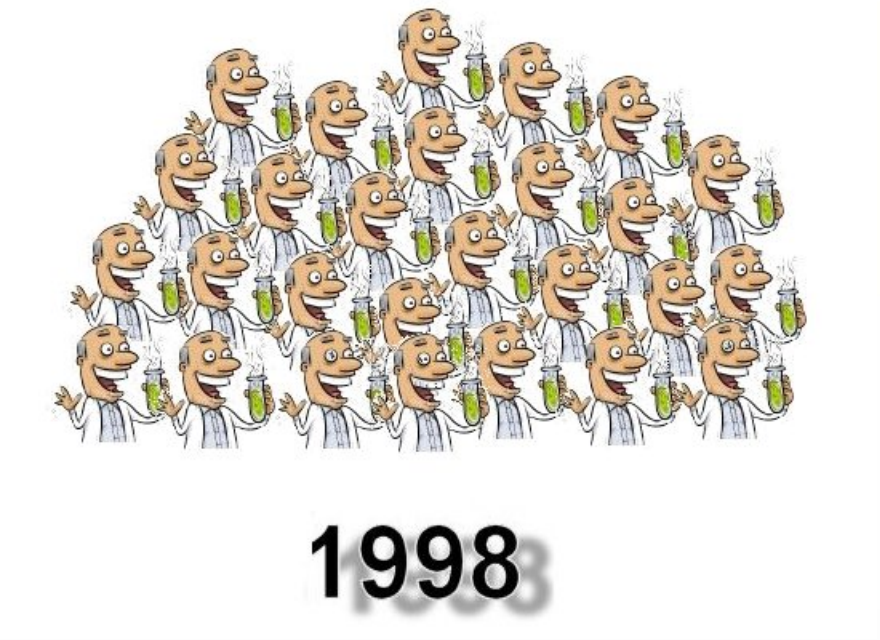
PARK nelco®

Electroply, Inc.

TACONIC
Advanced Dielectric Division

1988-2008 Product Research and Development

1988-2008 Product Research and Development



1988-2008 Product Research and Development

So What's Next????


2008
MGM
EFX
THE CITY OF ENTERTAINMENT
TROPICANA
EXCALIBUR


2018??

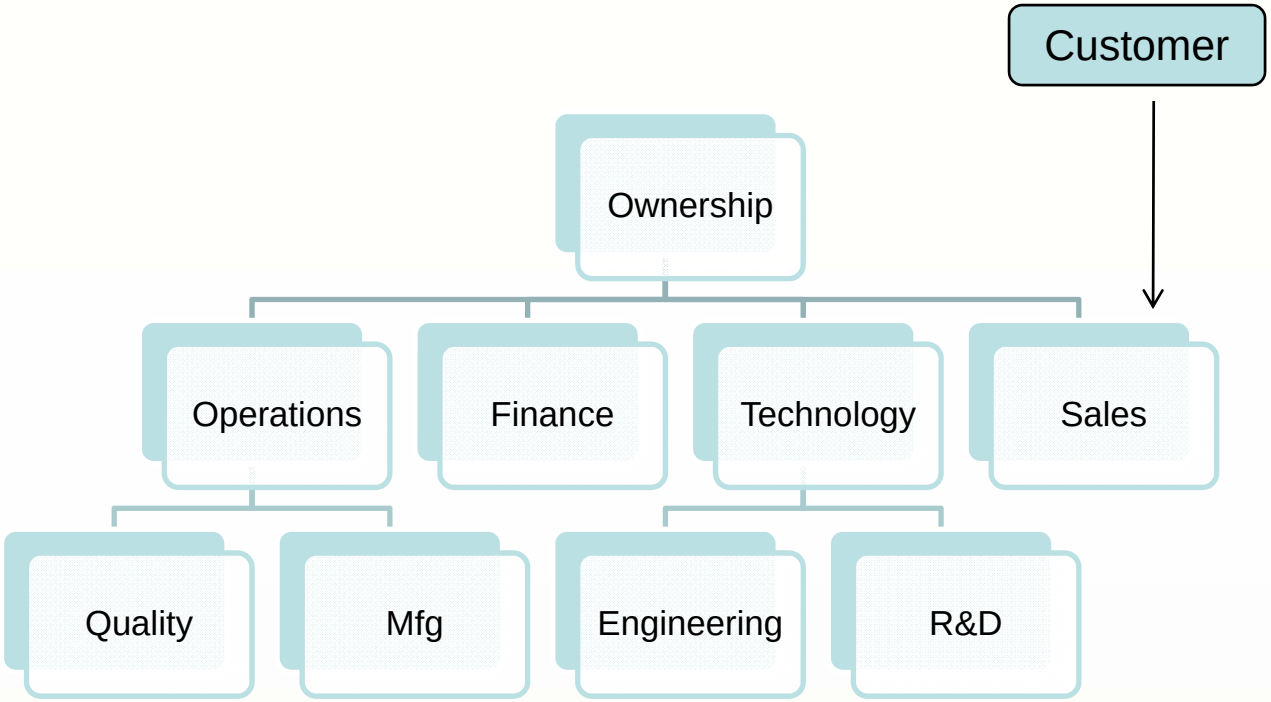

HEAD FOR THE HILLS
SINCE 1879
CONTENTS 12 FL OZ

Organizational Focus

Functions will merge

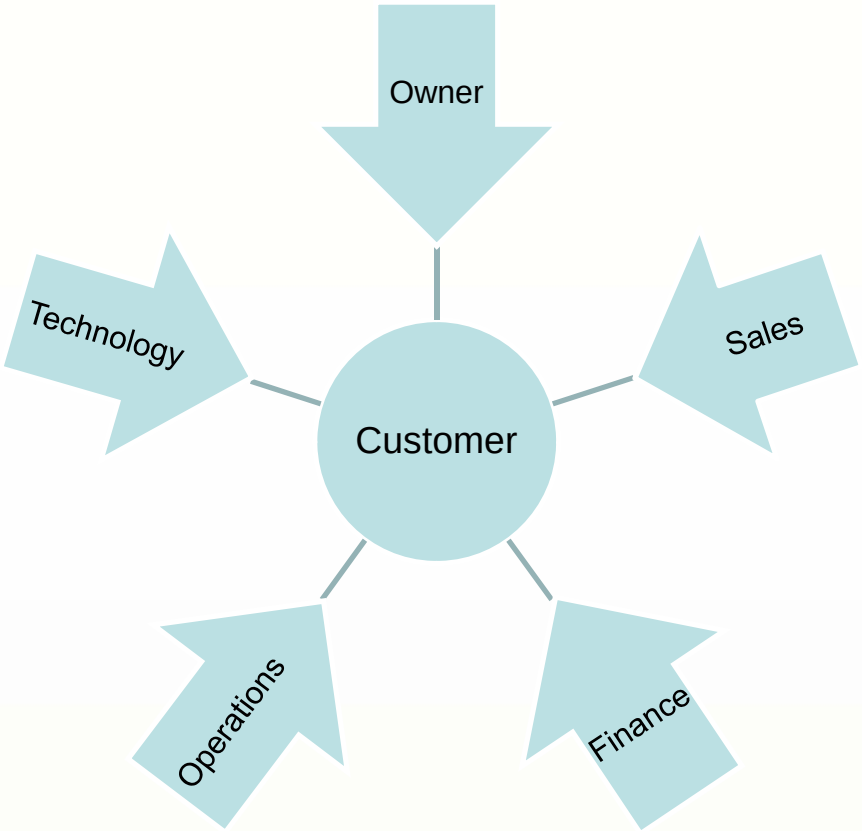
Organizational Focus

Normal Hierarchy



Organizational Focus

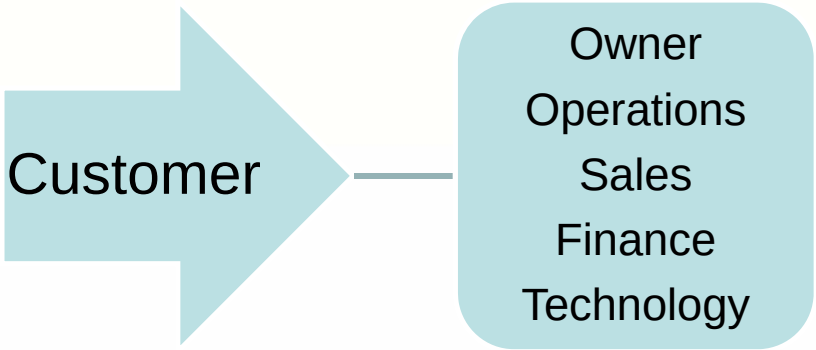
No Hierarchy



Organizational Focus

No Hierarchy

No Managers



Direct electronic communication facilitates this structure speeding up the entire cycle.

Old vs New

- Cost Driven
- Standardization
- HUGE Inventories
- 80:20 drives product line
- Centralized decisions
- Revolving-Door-Management
- Driven by Largest customers
- System is key to success
- > $100,000,000 sales needed to survive

- Profit/Survival Driven
- Specialty Products
- Made-to-Order
- Short Lead time
- No inventory
- Little “organization”
- Driven by small customers
- Instantaneous answers
- Knowledge/Information is key
- $10,000,000 business units


Thanks!
TACONIC
1400 ARROW HIGHWAY