NEMI National Electronics Manufacturing Initiative, Inc.

# Technology Roadmap Overview


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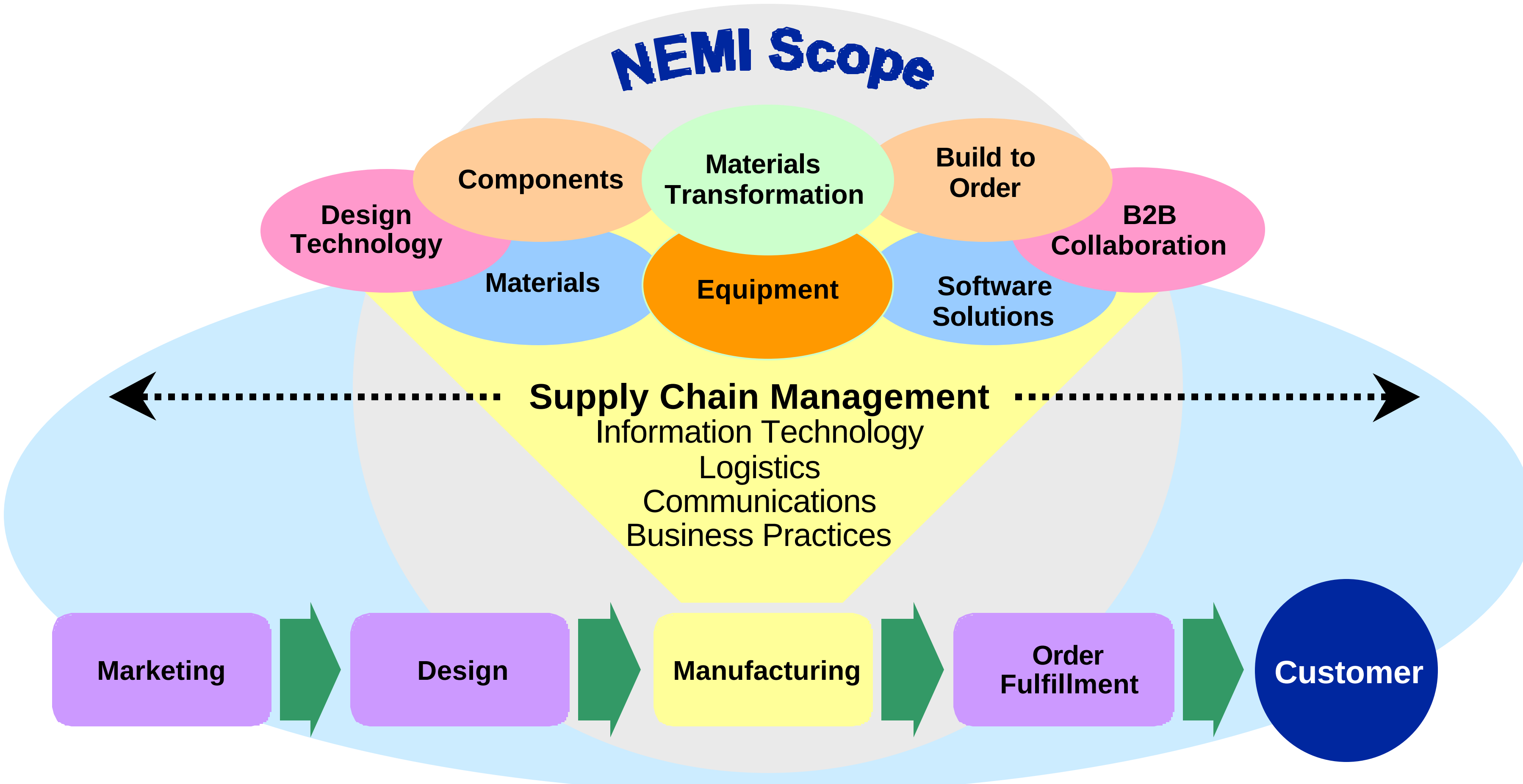
*September 19, 2002, SMTA Atlanta*

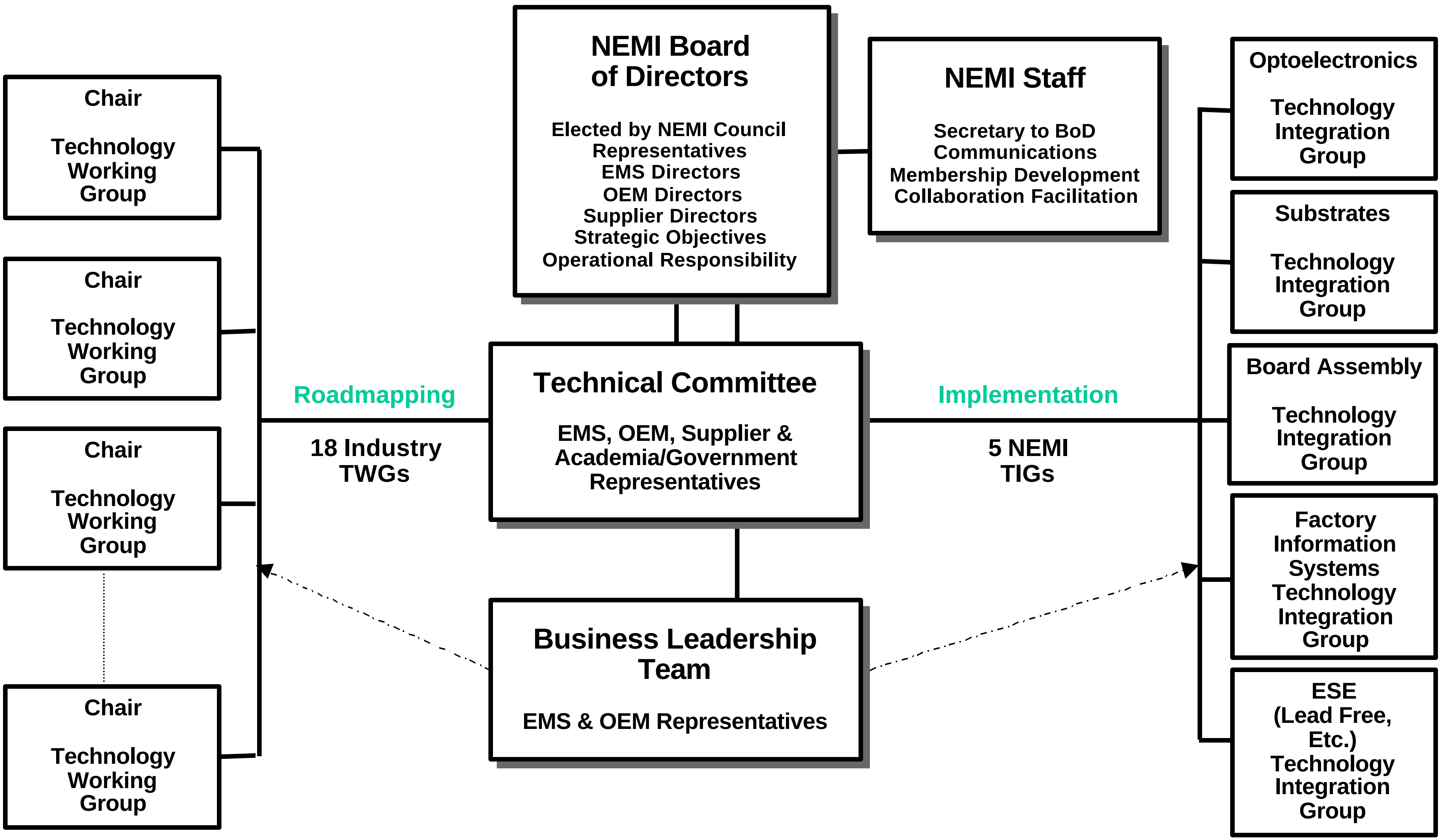
# NEMI Mission

*Assure the Global Leadership of the North American Electronics Manufacturing Supply Chain*



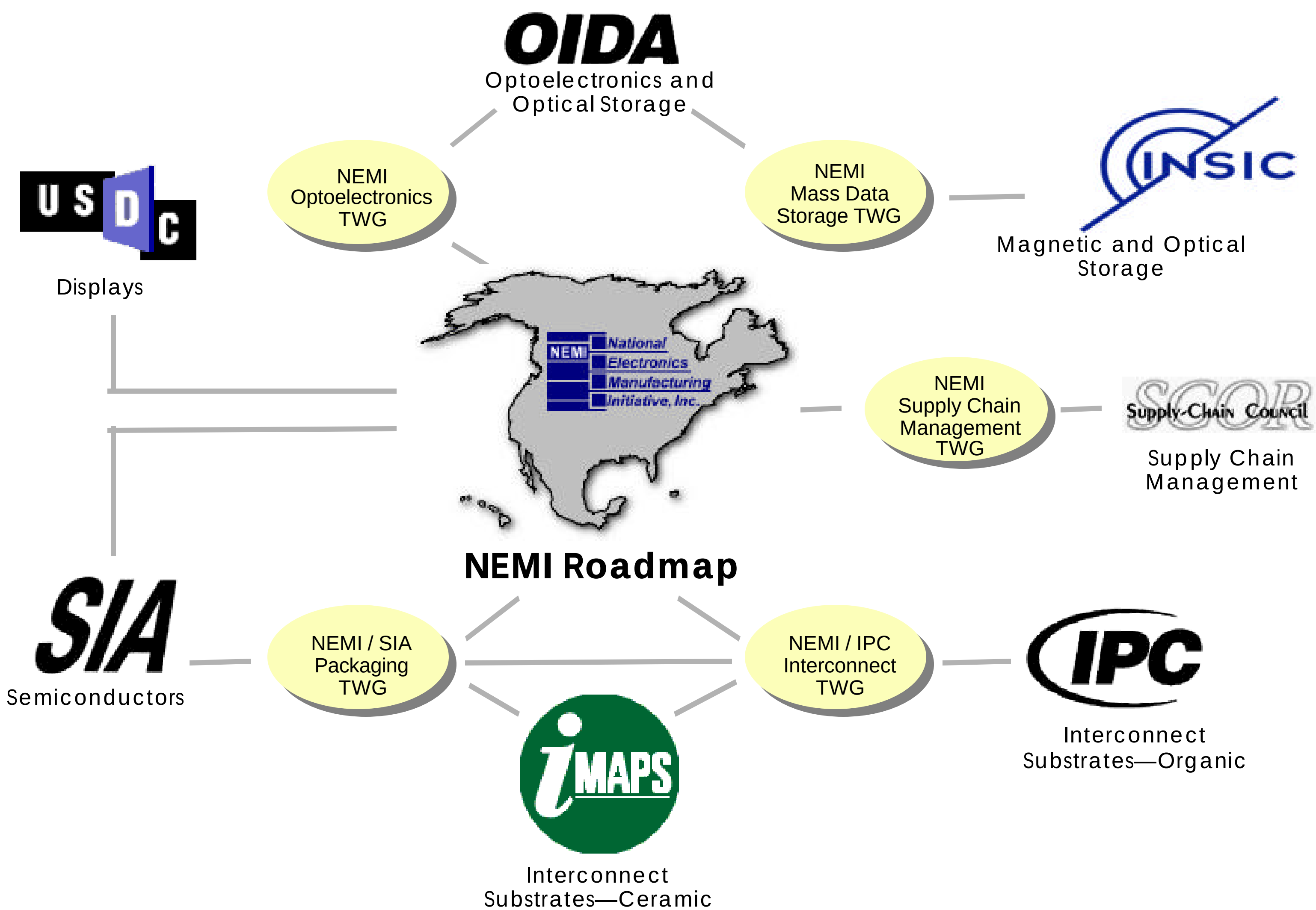

*Connect with and Strengthen Your Supply Chain*

# NEMI Organization




*Connect with and Strengthen Your Supply Chain*

# NEMI Affiliations




*Connect with and Strengthen Your Supply Chain*

# What Does NEMI Do?

## *Leverage the Combined Power of Member Companies to Provide Industry Leadership*

- **NEMI conducts Industry Forums on Emerging Topics**
- **NEMI Roadmaps the Needs of the North American Electronics Industry**
- **NEMI Identifies Gaps (both business & technical) in the North American Infrastructure**
- **NEMI Stimulates R&D Projects to fill these Gaps**
- **NEMI Establishes Implementation Projects to Eliminate these Gaps**
- **NEMI Stimulates Standards to speed the Introduction of New Technology & Business Practices**

# Perfect BOM Effort

- **Organized a One Day Workshop:**
  - **Hosted by Nortel Networks - RTP, NC**
  - **Held on June 27, 2001**
- **Premise: Focus on the Perfect BOM**
  - **What is it (Process, Content, Tools)?**
  - **What Gaps exist to get there?**
  - **How can Industry Close Those Gaps?**
- **Perspectives from Major Functional Users of BOM:**
  - **Engineering**
  - **Manufacturing**
  - **SCM/Purchasing**
- **Results:**
  - **Clearer Picture of "Ideal State"**
  - **Identification/Categorization of Issues/Challenges/Costs**
  - **Plan established for how to Address Opportunities**
  - **White paper available: www.nemi.org**

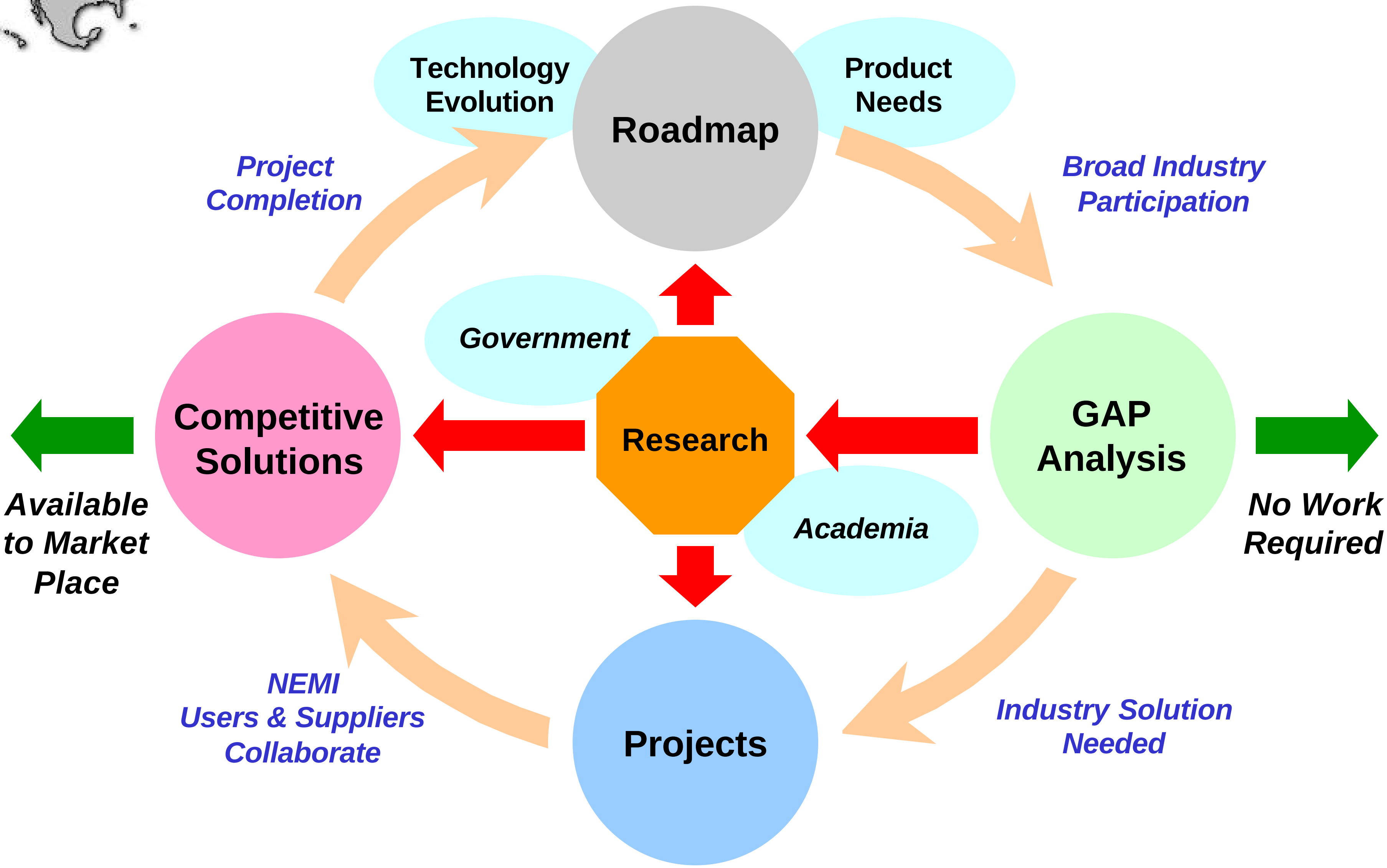
# Business Issues
# "Perfect" Bill of Materials

BOM Released → Neutralize & Validate BOM → Validate & Setup Components → Source Materials → Materials Pipeline Established

*ISSUES……..*

| Neutralize & Validate BOM | Validate & Setup Components | Source Materials |
|---|---|---|
| ◆ **Inconsistent Format**<br>◆ **Hard Copies**<br>◆ **Inconsistent with CAD File**<br>◆ **Foreign Language** | ◆ **Inconsistent Contents**<br>◆ **Invalid Supplier Info**<br>◆ **Incomplete Info**<br>◆ **Missing Info**<br>◆ **Customer Centric Info** | ◆ **Allocations**<br>◆ **Supplier Withhold Customer Info**<br>◆ **Obsolete Parts** |
| ***80% of BOMs Impacted*** | ***40% of BOMs Impacted*** | ***20% of BOMs Impacted*** |

# NEMI Roadmap Cycle




## NEMI Implementation Cycle

*Connect with and Strengthen Your Supply Chain*

# Cost-Effective Supply Chain Technology Deployment

- NEMI roadmaps/gap analyses help set the agenda for electronics industry.
- Leadership is provided to work emerging opportunities.
- Leverage R&D investments (academia & government) to address NEMI agenda.
- Improved deployment (faster, better, lower cost) created across manufacturing supply chain.
- Standards efforts (with IPC, EIA, IEEE, and RosettaNet) are encouraging broad utilization of emerging technologies/solutions.

# Attributes of NEMI Roadmap

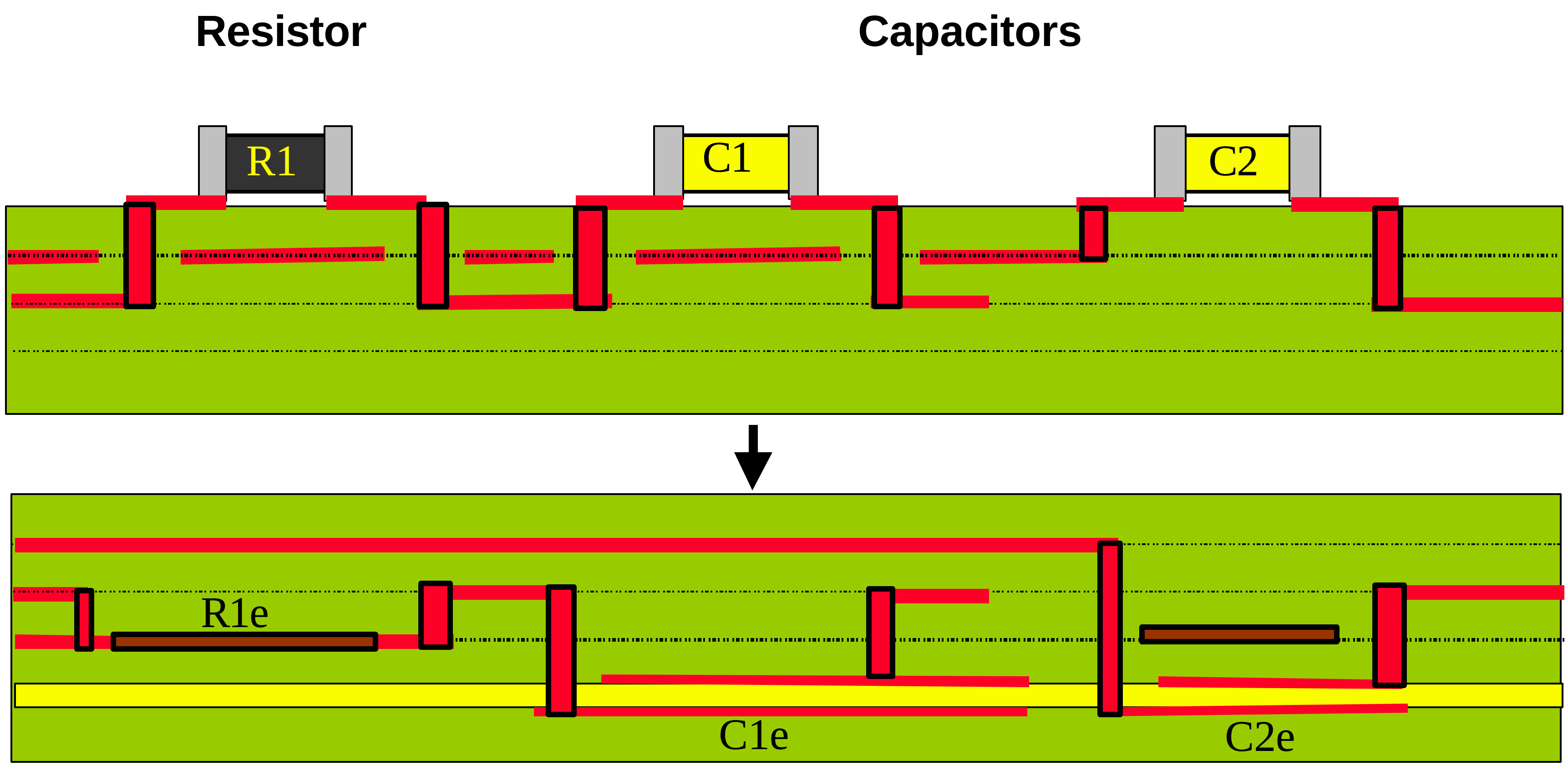
- The NEMI Roadmap is customer driven, not technology driven.
- The OEMs, through the Product Sector Champions, start the roadmapping process by presenting what they need to remain competitive in the world market.
- Focus of Roadmaps is on Manufacturing rather than End Products.
- The Technology Working Groups (TWGs) respond and identify gaps and showstoppers in the technology. They do not provide solutions.
- The Technical Committee discusses these gaps and forms Technology Integration Groups (TIGs) to address them.

# Gap Analysis – Integral Passives
# 2000 Roadmap –GAP Analysis

| | Area of Concern | 2000 | 2003 | 2005 | 2011 |
|---|---|---|---|---|---|
| EMBEDDED RESISTORS AND DISTRIBUTED PLANAR CAPACITANCE | Materials | Demonstrable | Meets Requirements | | |
| | Manufacturing | Low Yields | Acceptable Yields, Existant Infrastructure | Availible Cost-Effective Infrastructure | |
| | Design & Test | Demonstrable | | Widespread Common Practice | |
| | Cost | High | Competitive Price | Cost Savings | |
| | Availability | Few Suppliers No Standards | Available from a Few Sources | Standard Parts Available from Multiple Sources | |

Solutions Exist — Solutions Being Pursued — No Known Solutions

# Depiction of Embedded Passives



# Advanced Embedded Passives Technology Consortium Participants

NEMI's Embedded Passives Project is part of the Advanced Embedded Passives Technology Consortium which is managed by the National Center for Manufacturing Sciences (NCMS). Work performed by this group received funding from the U.S. Department of Commerce, National Institute of Standards and Technology (NIST), Advanced Technology Program (ATP), Cooperative Agreement Number 70NANB8H4025

# NEMI Projects List – Board Assembly TIG

- Test Strategy
- Optoelectronic Soldering Automation
- Optoelectronic Splicing
- DPMO (Defective Parts Per Million Opportunities)
- Flip Chip Reworkable Underfill

# NEMI Projects List – Environmental TIG

- **Lead-Free Hybrid Assembly and Rework**
- **Lead-Free Assembly**
- **Tin Whisker**
- **Tin Whisker Modeling**

# NEMI Project List – Factory Automation Systems TIG

- Data Exchange Convergence
- Virtual Factory Information Interchange
- Plug and Play Factory Project

# NEMI Project List – Optoelectronics TIG

- Fiber Optic Signal Performance
- Fiber Handling
- Optoelectronics for Substrates Study

# NEMI Project List – Substrates TIG

- High Frequency Material Effects on HDI Formation
- Advanced Embedded Passives Technology
- Integral Resistor and Capacitors Testing

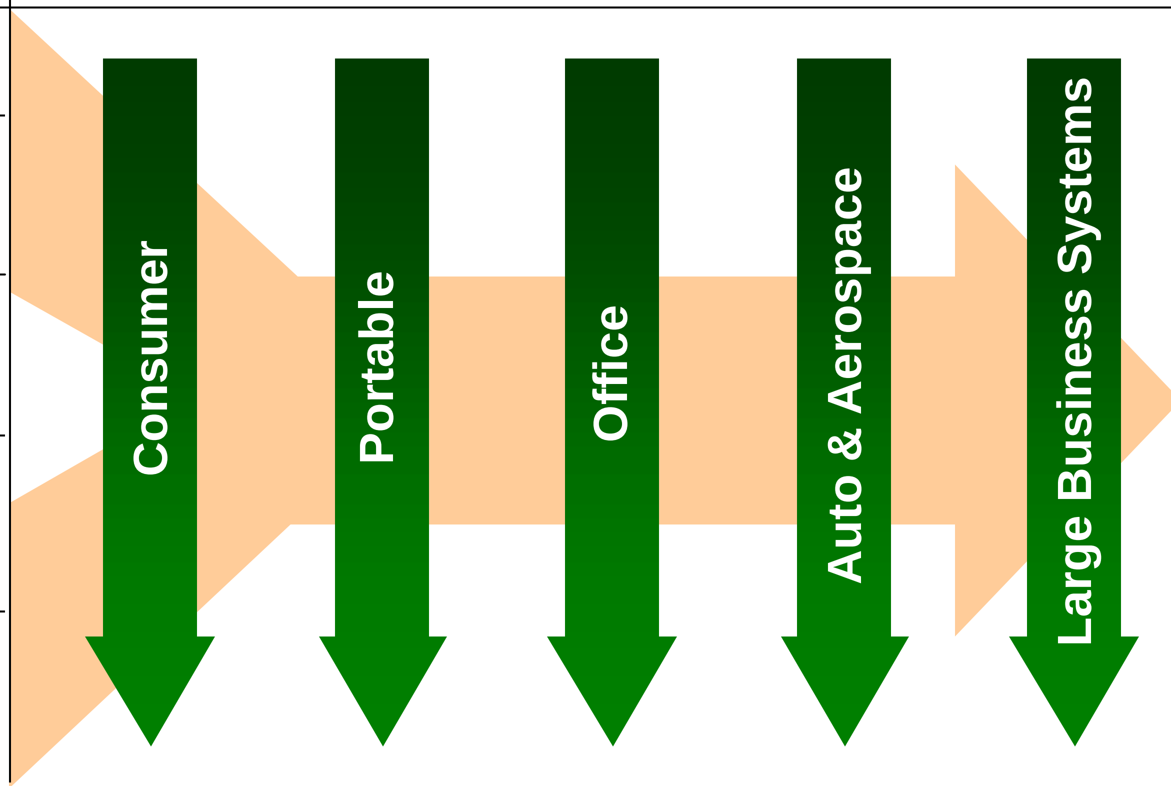
# The Drivers: Product Sector Profiles

| Product Sector | Characteristics |
|---|---|
| Consumer | High volume consumer products for which cost is the primary driver |
| Portable | Handheld, battery-powered products driven by size and weight reduction |
| Office | Products which seek maximum performance within a few thous and dollar cost limit |
| Large Business | High-end products for which performance is the primary driver |
| Automotive/ Military | Products which must operate in extreme environments |

# Roadmap Development

## *Product Sector Needs Vs. Technology Evolution*

| TWGs | Product Sectors |
| --- | --- |
| **Digital Silicon Technology** | |
| **Business Processes**<br>**Supply Chain, FIS, etc.** | |
| **Design Technologies**<br>Modeling, Thermal, etc. | |
| **Manufacturing Technologies**<br>Board Assy, Test, etc. | |
| **Comp./Subsyst. Technologies**<br>Packaging, Substrates, Displays, etc. | |

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# 2002 Product Sector Champions

| Product Sector | Chair | Co-Chair |
|---|---|---|
| Automotive Products<br><br>Aerospace/Military Products | D.H.R. Sarma, Delphi<br><br>William E. Murphy, Imco | Jim Spall, Delphi |
| Consumer Products | John Thome, Consultant | |
| Portable Products | John Thome | Kingshuk Banerji, Mot. |
| Office System Products | Terry Dishongh, Intel | Joshua Moody, HP |
| Large Business System Products | Evan Davidson, IBM | Scott Mitchell, Sun |

# Roadmap Structure - 18 TWGs

**Semiconductor Technology**
- Digital Silicon Technology

**Business Processes/Technologies**
- Product Lifecycle Information Management

**Design Technologies**
- Modeling, Simulation, and Design Tools
- Thermal Management
- Environmentally Conscious Electronics

**Manufacturing Technologies**
- Board Assembly
- Test, Inspection, and Measurement
- Final Assembly

**Component/Subsystem Technologies**
- Connectors
- Packaging
- Interconnection Substrates - Organic
- Interconnection Substrates - Ceramic
- Passive Components
- RF Components
- Optoelectronics
- Displays
- Mass Data Storage
- Energy Storage Systems

# 2002 TWG Structure

| Semiconductor Technology | Chair | Co-Chair |
|---|---|---|
| •Digital Silicon Technology | Paolo Gargini, Intel | Alan K. Allan, Intel |
| **Business Processes/Technologies** | | |
| | John Cartwright, Intel | |
| •Product Lifecycle Information Management | Barbara Goldstein, NIST | |
| | Ben Poole, Sanmina-SCI | |
| **Design Technologies** | | |
| •Modeling, simulation & design tools | Dr. Sanjeev Sathe, IBM | Dr. Koneru Ramakrishna, Mot. |
| •Thermal management | Richard C. Chu, IBM | Yogendra Joshi, GIT |
| •Environmentally conscious management | Robert C. Pfahl, Motorola | Mark Newton, Apple |

# 2002 TWG Structure (cont.)

| Manufacturing Technology | Chair | Co-Chair |
|---|---|---|
| • Board Assembly | Kirk VanDreel, Plexus; Alex Chen, Celestica | |
| • Test, inspection & measurement | Michael J. Smith, Teradyne | David Doyle, Orbotech |
| • Final assembly | Mike Reagin, Delphi Delco | Dr. Reijo Tuokko, Tampere U. |
| **Component/Subsystem Technologies** | | |
| • Packaging | Joseph Adam, Skyworks | Bill Bottoms, 3MT Solu. |
| • Connectors | John MacWilliams, Consultant | |
| • Interconnect subs – organic | John T. Fisher, NEMI | Dieter Bergman, IPC |
| • Energy Storage Systems | Dan Doughty, Sandia Labs | |
| • Interconnect subs – ceramic | Howard Imhoff, Midas Vision | Dr. Wayne Johnson, Auburn |
| • Passive components | Larry Marcanti, Nortel | Dr. Joseph Dougherty, PSU |
| • RF components | Dr. V.J. Nair, Motorola | J. Stevenson Kenney, GIT |
| • Optoelectronics | John Stafford, Consultant | Dr. Laura Turbini, CMAP |
| • Displays | M. Robert Pinnel, USDC | Dr. Norman Bardsley, USDC |
| • Mass data storage | Tom Coughlin, Consultant | Roger F. Hoyt, IBM |

# 2002 Roadmap Plan/Schedule

- 4Q01: Product Sector Champions Develop Emulators
- APEX Meeting in San Diego: January 24 Product Sector Emulator Review
- 2000 chapter & format mailed to each TWG chair (Word 6.0) Feb. 28
- Telecon TWG Chairs 3/5: What to expect at Kick-off, "lessons learned"
- Kick-off Meeting: March 21-22 With Technical Council Meeting in San Jose
- PS/TWG Conflict Resolution Meeting: April 24-25
- Product Sector Chapters Complete: May 30
- Workshop at NEMI HQ in Herndon, VA : June 20-21
- TC Review with TWG Chairs: August 22
- Final Roadmap Chapters Due: September 30
- Edit, Prepare Executive Summary: November 30
- Go To "Press": December

# What's New for 2002 Roadmap?

- New TWGs/Chapters created
  - Connectors
  - Product Lifecycle Information Management (encompassing FIS, SCM and IT chapters)
- MEMS/MOEMS technology addressed in relevant chapters
- Super Component, SoP, SoC, SiP, MCM, etc. addressed
- In addition to predictions, each TWG addresses:
  - Business issues/climate impacting their area
  - Specific R&D challenges needing attention
  - Validation of '00 predictions
- Continued support/participation of industry
  - Several hundred content experts involved
  - Representing >150 companies/organizations

# 2002 Roadmap

- The 2002 Roadmap is a “Work in Progress”
- 1st Review of chapters done Aug. 22, 2002
- Scheduled final chapter input 9/30
- Publication December, 2002

- Will discuss issues being addressed

# Evolution of Electronics Industry

| How it was: | How it is: |
|---|---|
| OEMs were Focused on N.A. Market (with some presence in other regions). | OEMs moving rapidly to serve all major market regions. |
| Vertically Integrated OEMs. | Distributed Mfg. Supply Chain. |
| OEM Mfg. Focus on Materials Transformation. | Broader Focus includes SCM & Business Practices. |
| OEM Focus on Performance of Technology. | OEM Focus on Integration of Technology. |
| OEM Emphasis on Best Solutions. | OEM Emphasis on Industry Standard Solutions. |
| High Margins – Long Product Life Cycles. | Shrinking Margins and Shorter Life Cycles. |

# Evolution of Electronics Industry (Cont.)

| How it is: | Future Projection: |
| --- | --- |
| OEMs moving rapidly to serve all major market regions. | No "regional frontiers" left – All population centers served. |
| Distributed Mfg. Supply Chain. | Distributed Competency Model. |
| Broader Focus includes SCM & Business Practices. | OEM only focuses on SC orchestration to provision the Customer. |
| OEM Focus on Integration of Technology. | OEM Focus on Integration of Solutions. |
| Emphasis on Industry Standard Solutions. | Emphasis on Industry Standard Subsystems. |
| Shrinking Margins and Shorter Life Cycles. | Electronics hardware mostly commodity. |

# Changing Roles & Responsibilities

| Attribute | OEM: | CM: | EMS: | ODM/Supplier: |
|---|---|---|---|---|
| R&D Focus: | End Product & Market | N/A | Mfg. Process Integration | “Widget” Technology |
| Design Focus: | Architecture of Product | N/A | Growing Design Content | “Widget” Design |
| Execution Focus: | Life cycle Supply/Demand | Board/System Manufacturing | Board/System Manufacturing | “Widget” Manufacturing |
| Key Value: | Customer Knowledge | Low cost | Integration of Manufacturing | Knowledge of Technology |
| Popular Business Strategy: | Virtual Company | Mean and Lean | Supply Chain Facilitator | Create Global Footprint |
| Key Issue: | Margin loss | Sustainability of Model | Margin growth | Competition from Abroad |

# Implications of ODM Model

- ODM = Original Device Manufacturer
- OEM provides top level specification, ODM does the rest (detailed design, sourcing, manufacturing).
- Strongly exploited at commodity end of computer segment
- Emerging for low end of cell phone market
- Will this model proliferate to other areas?
- Characteristics of current ODM segments
  - Cost driven
  - Mature and/or “contained” IP
  - High volume

# Implications of ODM Model (Cont.)

- **Taiwan is very strong in ODM segment**
  - **Strong electronics mfg. infrastructure (incl. PWB)**
  - **60% of world wide notebook computer production**
  - **40-50% of cell phone components can be sourced locally**
  - **Likely next target: Portable internet access devices**
  - **Expanding to mainland China (forecast $90B by 2006)**
- **Key ODM players in Taiwan**
  - **Acer**
  - **GVC**
  - **Arima**
  - **Compal**
  - **Quanta**

# Issues Being Addressed

- **Increasingly distributed manufacturing causes business issues to dominate quest for efficiency.**
- **Cost pressures are relentless (e.g. cell phone market bifurcation: low cost & high function)**
- **Explosive growth of top tier of EMS segment**
  - **Beginning to see consolidation in EMS ranks**
  - **Major movement to China for volume assembly**

# 1st Pass at Cost Changes

| FIRST YEAR OF SIGNIFICANT PRODUCTION | | | 2001 | 2003 | 2005 | 2007 | 2011 | 2013 |
|---|---|---|---|---|---|---|---|---|
| **Roadmap Year** | Parameter | **Metric** | | | | | | |
| Cost | | | | | | | | |
| **2000** | Board Assembly (Conversion) Cost | ¢ per I/O | 0.32 | 0.29 | 0.26 | | 0.19 | |
| **2002** | | | 0.31 | 0.28 | 0.25 | .23 | 0.19 | 0.19 |
| **2000** | PWB Cost (4 layer Conventional) | $/cm^2$ | 0.014 | 0.014 | 0.014 | | 0.014 | |
| **2002** | | | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 |
| **Design Packaging Density** | | | | | | | | |
| **2000** | Average I/O Density | I/O per cm^2 | 10 | 14 | 16 | | 20 | |
| **2002** | | | 10 | 14 | 16 | 18 | 20 | 20 |
| **2000** | Maximum I/O Density | I/O per cm^2 | 160 | 240 | 400 | | 630 | |
| **2002** | | | 160 | 240 | 400 | 630 | 630 | 630 |
| **2000** | PWB Size | cm^2 | 600 | 400 | 300 | | 200 | |
| **2002** | | | 600 | 400 | 300 | 300 | 200 | 200 |
| **2000** | Average Component Density | parts/ cm^2 | 1.7 | 2.1 | 2.4 | | 2.8 | |
| **2002** | | | 1.7 | 2.1 | 2.4 | 2.4 | 2.8 | 2.8 |

# 2002 Issues Being Addressed

- Moore's law rules but the landscape is changing:
  - Packaging role expanding (e.g. SOP)
  - Optoelectronics has hit selective growth trend
  - Estimated capital equipment growth negative > 2005
  - Metro market growth (20% / year 2001 - 2006)
  - Home market ripe for growth, 80% use dial up modems
  - 5M homes with high speed connections are 66% cable, 31% DSL and 3% other
  - Enterprise market forecast to grow to $6.5B by 2006
- New applications of MEMS on a number of fronts
  - Displays
  - Servo control for mass data storage
  - Optical switches
  - Laser tuning

# Business Pressures

- **Business forces**
  - **Shrinking life cycles**
  - **Greater competition**
  - **More sophisticated customers**
  - **Global markets**
- **Manufacturing focus is shifting to supply chain**
- **Strong "end to end" supply chains needed in all market regions**
- **Attributes of this strategy:**
  - **More responsive to local & long term requirements**
  - **Politically acceptable**
  - **Short/simple/fast logistics**

# Silicon Trends

- Silicon will continue to follow Moore's Law
  - New geometry introduction will move to three year cycle
    - Chip size growth will slow
  - Some signs silicon may slow
    - Design constraints
    - Lithography past 2005
- Packaging will continue to migrate into silicon - 10 layers of metal by 2010
- Silicon manufacturers wish packaging costs would scale like silicon

# Silicon Trends

- Key Silicon drivers on packaging
  - Chip size and I/O count
    - Area array package solutions to handle I/O
    - Trend toward flip chip for interconnect
  - High frequency making flip chip more attractive
    - Performance (low inductance)
    - Multi-chip solutions
  - Thermal Challenge
    - High heat flux at chip & module level

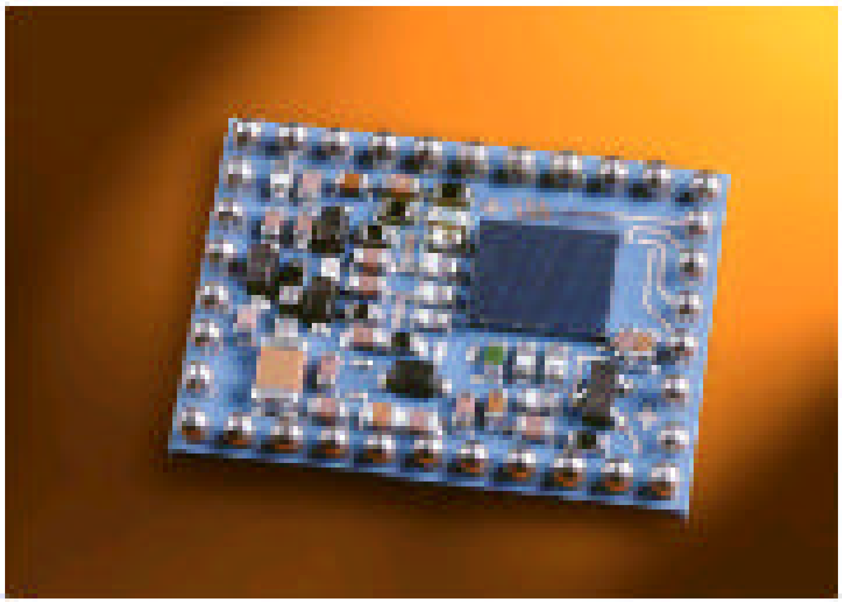
# The New Volume Drivers

- **Communications products replacing computers as key driver of volume manufacturing**
- **New products, enabled by new technologies, are creating a pronounced shift in the industry:**
  - **Blurring of the lines: computers & communications**
  - **Cell phone market growth**
  - **Emergence of wireless products (Bluetooth, 802.11)**
  - **Automotive electronics (adding functionality of home & office to your car).**

# The Changing Landscape

- New Volume Drivers
  - Cellphones
  - Bluetooth
  - PDAs
  - Automotive consumer electronics
- 1 billion cell phones by 2005/6
  - overtake PC for web access by 2004/5
- 2 billion Bluetooth by 2006/7
- 10 X Auto electronics by 2005
- Optoelectronics growth down through 2003
- PC growth stalled, market share shifting

# Bluetooth Module



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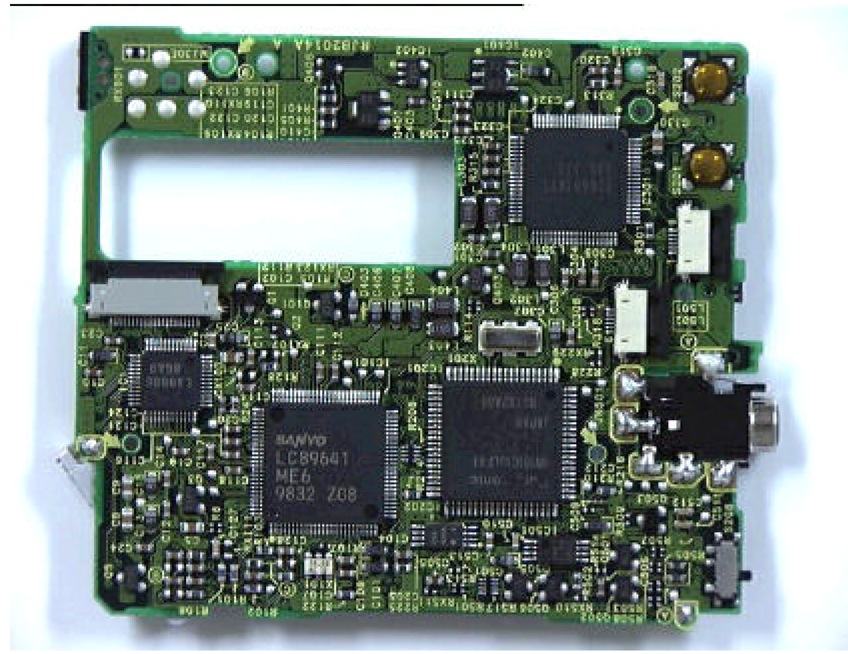
# Environmental Focus

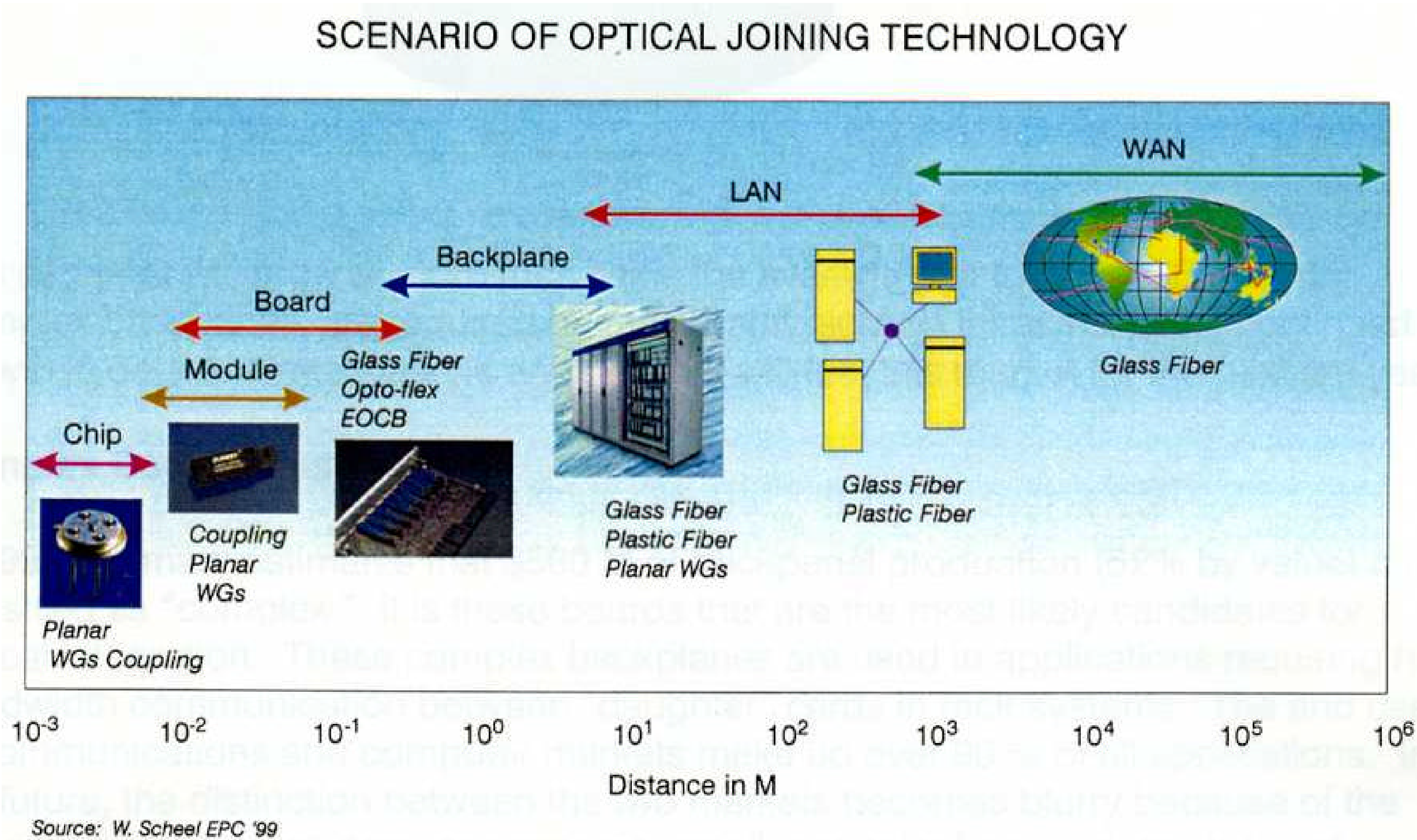
- Complex issue that is shaped by many forces
  - Marketing advantage
  - Regulation
  - Product differentiation
- Regional differences are dramatic
  - Europe driving regulatory agenda
  - Japan, a world leader in consumer electronics, appeals to "GO GREEN" desires of customers
  - North America prepares to compete on all fronts.
- Areas of focus
  - Materials of concern
  - Design for recycling

# Panasonic Mini-Disk Player

**“Pb-Free” solder**

# Optical Joining Technology



# Optoelectronics Issues

1998-2000: Growth approaching 100% per year
2001-2: Collapse of demand and subsequent revenue

- **Public and private investment created many speculative start-ups at carrier, equipment and component levels.**
- **Carrier stock values were driven by miles of fiber installed and technology advancement instead of cash/profit.**
- **Equipment and component companies driven by market share and revenue growth.**
- **Supply shortages led to aggressive purchasing and inventory behavior.**
- **Carriers derailed when debt payments came due.**

# High Level Optical Communications 2000 Roadmap

| Services / Networks | 1995 | 2000 | 2005 | 2011 |
|---|---|---|---|---|
| Services | POTS<br>Data<br>Fax<br>Internet<br>CATV | High-speed Internet<br>Tele-working, tele-learning<br>Tele-medicine<br>Video On Demand<br>Interactive entertainment<br>PWB interconnects | Next-Generation Internet (1Gb/s to the desktop)<br>Distributed Virtual Environments (joint working, learning, and play)<br>CMOS VLSI interconnects | |
| Core | 2.5Gb/s point to point<br>8 wavelength WDM pt. to pt. | 10 Gb/s 40Gb/s<br>OADM, OXC<br>~128 wavelength DWDM | 100/160Gb/s<br>Fully reconfigurable OXC.<br>>800 wavelengths DWDM | 400Gb/s |
| Access | POTS, Modem, ISDN, HFC, Cellular, Broadcast Satellite<br>56kb/s, 144kb/s | ATM/PON (155/622Mb/s)<br>Cable Modems | 2.5Gb/s-10Gb/s<br>2.5 - 10Gb/s DWDM | |
| Premises | 100Mb/s Ethernet | 1 Gb Ethernet<br>10 Gb/s Trunks | 10 Gb Ethernet<br>100Gb/s to 1Tb/s trunks | 40 Gb |
| Board to Board | Research demos, 0.1 - 1 Gb/s<br>(all numbers are aggregate) | 0.1 - 1 Gb/s, Commercial | 1 - 10Gb/s, massively parallel | 10 – 100Gb/s |
| Chip to Chip | Research demos, 0.1 - 1 Gb/s<br>(all numbers are aggregate) | 0.1 - 1 Gb/s | 1 - 10Gb/s, massively parallel | 10 – 100Gb/s |

# Optoelectronics Gaps Identified

- **R & D Needs**
  - **Automation for packaging and assembly**
    - **yield and cost control**
    - **achieve higher volume manufacture**
  - **Need standard test sets for wafer level testing including optical testing**
  - **Integration and merging of active and passive optical components into electronic systems**
  - **Material and measurement standards**
  - **Thermal solutions for 1-2+ Watt packaged lasers**
- **Manufacturing implementation needs**
  - **Optical package/module standards**
  - **PWB features for use with emerging optoelectronic technologies**
  - **Critical considerations for optoelectronic assembly (e.g., optical connector cleanliness, fiber alignment, etc.)**

# Paradigm Shifts – Roadmap 2000

- With use of technologies such as integral passives and Higher Frequency IC's, PWB fabricator will be increasingly responsible for delivering electrical specifications.
- EMS providers are expanding their capabilities to include design, sourcing, repair, order fulfillment, etc.
- Supply Chain Management will be a key differentiator
  - Integrated response vs. functional expertise
  - Manage inventory in more elegant ways (Build to Order, Design for Postponement, improved visibility/planning)
- Chip level integration driving need for more layers of on-chip interconnect (up to 10 layers over 10 yrs. –moving functionality from PWB to chip).

# Paradigm Shifts (Cont'd)

- The Internet and distributed manufacturing enables small/highly leveraged companies to compete globally with traditional, larger companies.
- Mfg. productivity improvement focus will shift from materials conversion to efficient supply chain responsiveness.

# Packaging Industry Overview

- 1960-90 Package technology driven by large OEMs
  - Captive board and substrate/module R & D and manufacturing
  - New technology development almost exclusively from OEM
- 1990-2000 OEMs divest manufacturing to EMS
  - As manufacturing goes, so goes R & D for packaging
  - Industry relies on build-out of existing technology
  - Lone exception being CSP package
    - Is this an indicator of a new model to develop packaging?
- First level (chip) packages
  - Ceramic migrating to FR-4 HDI technology
  - Merchant pkg. companies address chip packaging
- Printed circuit boards gain new market - chip carriers

# 2000 Silicon Demands on Packaging

| YEAR<br>TECHNOLOGY NODE | | 2003 | 2005 | 2007 | 2013 |
|---|---|---|---|---|---|
| ***Package Pin count(Maximum)-*** | | | | | |
| Consumer | | **208** | **256** | **280** | **360** |
| Portable | | **324** | **400** | **424** | **480** |
| Office | | **1000** | **1200** | **1350** | **2000** |
| Business Systems | | **3364** | **4096** | **4356** | **5476** |
| Auto & Aerospace | | **1200** | **1350** | **1500** | **2000** |
| Memory | | **44–128** | **44–144** | **48–160** | **48–200** |
| ***Overall Package Profile (mm)*** | | | | | |
| Consumer | | **1.2** | **1.2** | **1.0** | **1.0** |
| Portable | | **1.0** | **1.0** | **0.8** | **0.65** |
| Office | | **1.0–1.2** | **1.0–1.2** | **0.8–1.0** | **0.65–0.8** |
| Business Systems | | **n/a** | **n/a** | **n/a** | **n/a** |
| Auto & Aerospace | | **1.0** | **1.0** | **1.0** | **1.0** |
| Memory | | **1.0** | **1.0** | **0.8** | **0.65** |

*Solutions Exist* *Solutions Being Pursued* *No Known Solutions*

***Connect with and Strengthen Your Supply Chain***

# Printed Wiring Boards

**PWB Suppliers have two, very different, markets:**

## Conventional PWB's

- **Four layer boards typical**
  - **Portable**
  - **Office Products**
- **High end boards**
  - **12 - 20 layers**
  - **Zo control**
  - **>0.1" thick**
  - **100's Amperes**
- **Auto Harsh Environment**
  - **Tends to be "standard size/layers"**

## Chip Carriers

- **May be single chip or few chip modules**
  - **Need HDI technology**
  - **Fine line/Spacing**
- **May be flip chip or wire bond**
- **Encapsulated**
- **Reliability equivalent to standard modules**
  - **Different from PWB testing**

# Board Assembly - Industry Overview

- **OEMs continue to divest board assembly plants**
  - **First tier EMS companies growing 40-50%/year until 2001, resuming rapid growth as economy climbs – 2003?**
  - **Little or no mfg. R & D left at OEMs**
    - **Leadership role transitioning to EMS companies**
    - **Suppliers expected to solution R&D shortfall**
    - **Industry consortia/academia increasingly important**

- **Few Chip Packages - Are they boards or substrates?**
  - **Board assembly, or**
  - **Module house responsibility?**

# Strategic Concerns

- Full potential of Supply Chain Management and Enterprise Information Technology requires "mind set change" from "cost center" to "value center".
- Restructuring causing significant shifts in R&D leadership (OEM => EMS => Suppliers) without sacrificing low overhead function.
- While product & technology complexity increases, design productivity is not keeping pace.
- North American firms continue to lag in volume HDI capability – impact to PWB market share.
- Cost effective methodologies for elimination of materials of concern and product take back.

# Summary

- Industry restructuring is changing traditional roles & responsibilities for all nodes of supply web (OEM, EMS, suppliers, industry groups).
- Focus on supply chain efficiency is changing the competitive landscape.
- Multiple models at play for outsourcing:
  - OEM to EMS
  - OEM to ODM
- PWB segment will evolve to meet needs:
  - Consolidation
  - Market presence to match customer needs
  - Leverage strengths to remain competitive.

# Summary

- **Innovation continues to be a driving factor for the expansion of electronics business**
  - **Lots of new products & services emerging**
  - **Made possible by new applications of technology**
  - **Increased functionality at lower cost**
  - **Growth can be impacted by investment climate and consumer confidence.**
- **Emergence of global markets raises the bar for manufacturing leadership**
  - **Ability to manage & leverage time/cost pressures**
  - **Orchestration of responsive supply webs**
  - **Adaptable strategy (response to new products/markets)**
  - **Flawless execution.**

# Key Recommendations

- Explore/promote efficient approaches for R&D in the Distributed Mfg. Model
  – Changing role of OEMs
  – EMS/supplier partnerships
  – Industry/academia/government partnerships.
- Leverage industry consortia/trade associations to deploy technology/business practices in a competitive manner
- NEMI should continue to focus environmental efforts as one strategy to create industry standard solutions.
- NEMI should continue to broaden agenda to include collaboration on supply chain and business practices.